Comments on: The Role of Feeding Systems based on Cereal Residues... by Chedly Kayouli

From: Dr E.R. Orskov <ero@rri.sari.ac.uk>

Comments on urea treatment (Kayouli's paper)

On the question as to whether urea is successfully used to upgrade straw in some areas and not in others, I would like to make a few comments based on my experience. Urea treatment of straw is a technology which like almost all technologies fits well to certain niches but not to others.

In my opinion, there are 3 important questions to initially ask to find out if urea treatment is suitable:

1. Is all straw in the area already used for feeding?
2. Is there a surplus of straw which could be used if the intake and thus the proportion of straw in the diet is increased?
3. Is urea locally produced or imported?

If the answer to question 1 is YES, then the cost of urea has to be recovered essentially through an increase in the digestible organic matter available and therefore, we must compare it with the cost of other supplements like wheat bran, rice bran or whatever high quality supplements which are available. If digestibility is increased by 10%, then 1kg of urea can produce about 2kg of DOM. As a rule, therefore, if the cost of urea is more then 2 to 3 times the cost of bran, then the economy of using it is questionable. This is the case in many countries in north Africa. There are however areas where urea is a more reliable supplement than others, such as Iran where several thousands of farmers use it.

If the answer to question 2 is YES, the possibilities for success is much greater as the cost of urea now can be carried both by an increase in digestibility and by an increased use of surplus straw. This is no doubt at least part the reason why an estimated 20 million of straw is treated annually in China using this method following an FAO project initiated in 1987. Dr Kayouli is right in pointing out that also the fertilizer value of the urine and faeces is increased which has seldom been recognized. There are of course also many other factors which may prevent uptake such as labour availability and whether the temperature in the area is high enough to ensure urea hydrolyses. The treatment also requires water which may be a constraint in some areas.

If the answer to question 3 is that urea is imported, then the use of urea for straw treatment may be incorrect to introduce as the technology then becomes very vulnerable to problems of foreign exchange.

Finally urea can also preserve wet straw so that, in rice growing area, another contribution to the cost of urea is possible. The impact of using urea can be quite complex: for 2 neighbouring farms, it may be appropriate for one but not for the other.

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From Jayasuriya Noble M.C. <Jayasuri@ripo1.iaea.or.at>
Comments on the upgrading of crop residues

I have been reading with interest the papers and comments that are being presented at the on-going e-mail conference. They are very interesting and I am sure that we all are learning a lot from each others experience.

I would like to make a few comments, from my own experience in the area of livestock feeds and feed resources.

Considering the vast resources of crop residues and by-product feeds available in many developing countries in the world and in spite of the `Residue revolution' of the 1980's, the farmer uptake of technologies for upgrading/improved utilization of crop residues and by-product feeds has been minimal. I stand to be corrected, but to my knowledge, hardly any developing country (perhaps except in China) has adopted any of these new innovations in a reasonably large scale. Some of these technologies have been considered to be `appropriate' and `farmer friendly'. Many of them have been tested on-station, on-farm and then on pilot scale in farmers fields. But yet hardly any have been taken up by the smallholder farmers.

I think we should give some thought to this and analyze as to why the farming community in general has been reluctant to accept new technologies. In other words we are talking of sustainability of the farming methods that we are developing and promoting. As many participants have pointed out, sustainability for who, where, when etc. as well as other factors involved in the sustainability of a system need thorough understanding and reviewing. One needs to realize that a technology by itself cannot be sustainable but requires many pre-requisites. For example, I am aware of a situation in Sri Lanka where, in 1982/83, straw treatment (using urea-ammonia) was practised in a fairly large scale in a certain area of the country by smallholder dairy farmers. But the technology never sustained (to the extent that we could be proud of). As anticipated, there was an immediate increase in milk production but what was not anticipated was the reaction of some farmers who saw little point in producing more milk as they had sufficient for their family needs and had no means of selling the surplus. The farmers were not close to a major city and there was no established milk collection network. It appeared that although the technology was appropriate from the point of view of increasing milk production, it was not in terms of existing infrastructure. The establishment of the new technology required some pre-requisites (e.g. a way of disposing the extra milk). Some might argue that there should have been a bottom-up approach, first to investigate the needs of the farmers and then to promote the activity, if it were at all required. But on the other hand this is a vicious cycle as one might also argue about the point of establishing a milk collecting network without producing the extra milk. Perhaps they must go hand in hand - quite often with the blessing of the politicians - which we have very little control of.

Here is a another example. In Africa (Malawi) through an FAO/UNDP project, we carried out a number of field trials with smallholder farmers, trying to improve body weight gain of stall-fed fattening steers, through improved utilization of crop residues and by-product feeds. In Malawi, cattle are fattened throughout the year, but stall feeding is most common during the dry period between May and November. During this period farmers fatten 2-3 animals by stall feeding maize, sorghum or millet stover and ground nut tops fed ad libitum as the basal diet (with little or no green material) and 2-3 kg of maize bran/animal per day. Under normal conditions animals grow at the rate of 500-600 g per day and they are ready for market in 6-7 months. But under the FAO/UNDP project we were able to demonstrate very clearly (with farmers' animals) that provided the animals receive ad libitum (no restrictions at all) stovers and ground nut tops and the same quantity of maize bran, live weight gains up to 1 kg/day can be achieved. This was possible simply by making sure that the animals decided their ad libitum intake and not the farmers. It was done by altering the structure of the fattening stall to enable the storage and availability to animals of stover and ground nut tops all the time so that they could select and eat. By increasing the daily rate of gain, steers were ready for market in 3-4 months allowing the farmers to fatten one more set of animals before the end of the dry period. However, a recent visit to Malawi showed that this new approach to feeding, which we thought was appropriate and did not involve any additional inputs (except that the farmers had to collect stover during a short period of time and store it rather than spread his collection as and when required), had not been taken up by the farmers to the extent that we would have liked it to happen. Where was the problem ?. It was not feed because there is always so much stover unused and left over in the fields. There was no need of extra inputs into the system because the modification we made to the stall was very simple and affordable. Wasn't the farmer interested in extra money ?. No he was very happy to have extra income. Then, where was the problem ? I am not sure of the actual answer but perhaps there weren't enough young animals for fattening or perhaps the slaughtering company could not (or would not) handle the extra animals. Were the farmers reluctant to adapt the new approach because it left behind a large amount of stubble due to selective feeding by the animals, which the farmers had to dispose of ?.

Therefore it is clear that we ought to be aware, not only that the technique should be appropriate and acceptable but many other pre-requisites need to be satisfied before any technology could be adapted and sustainable.

Perhaps this is the forum for further discussions on `sustainability' of farming systems so that the younger generation of scientists could learn new and better approaches to the problem and not repeat the same mistakes we have made in the past.

Noble Jayasuriya IAEA, Vienna, Austria

From Frands Dolberg in Bhutan
c/o <shetty.sheeba@smy.sprintrpg.ems.vsnl.net.in>
Comments on Kayouli's paper

Straw treatment has been successfully adopted in some countries and tried unsuccessfully in more.

In a quick examination of reasons for lack of success, I would list these factors, mainly based on Indian and Bangladesh experiences. However, these comments are written in Bhutan, where attempts at introduction have not been very successful either:

1. Insufficient straw at individual farm level. A macro analysis may well suggest plenty of straw, but skewed land-ownership etc., means that many farmers in fact have very little straw.
2. In India and Bangladesh - and Bhutan - farmers complain of the technology being labour demanding.
3. Inadequate training of and motivation in extension workers in systems, which are basically geared towards veterinary treatment and much less animal nutrition.
4. Too little appreciation of the importance of the small protein and energy supplement that would make the rumen exploit, the extra nutrients, treatment POTENTIALLY has made available. The result is disappointing animal response and a discouraged farmer - after all the effort. To treat or not to treat is not the only question. Equally important is correct supplementation.
5. Little appreciation and inclusion in research and extension work - and training of extension workers - of the subsequent better manure quality and crop yields that can be obtained. Kayouli's paper is the first, I have seen in support of the point. However, I am reminded of comments by Indian farmers for whom I did extension work as long back as 1968-69.

They also mentioned better crop yields as positive results of better feeding and better manure.

6. In short: lack of real constraint identification and too few well conducted pilot- and on-farm trials to generate feedback on the basis of which sound extension work can be planned. Such trials must be in the villages with farmers with less emphasis on out of context govt. or large farm initial testing.

7. Finally, I like to suggest, that the conference is updated on the efforts that are going on to breed good fodder qualities into straws and stovers. I understand some work is going on in India among other places at ICRISAT (the BAIF group should know). Wageningen was involved at a point and Dr. Orskov has been.

Frands Dolberg (frands@po.ia.dk)

From: Jayasuriya Noble M.C. <Jayasuri@ripo1.iaea.or.at>
Comments on urea treatment

Bob Orskov has rightly pointed out three criteria, crucial for adoption of a new technology such as straw treatment by farmers. Without a question, straw should be readily available and in surplus, and in close proximity to the operation site. Urea should be cheap enough and not an imported commodity. In monitory terms straw should also be cheap (even better if it had no monitory value), if treatment is to be beneficial to the livestock owner.

I am aware of a number of situations where just a successful demonstration of straw treatment lead to an increase in the cash value of straw in the area. While one may argue that this would bring in additional income to the man who is producing the (crop) straw, it could be disastrous to the livestock farmer, unless of course the man who is producing it is also the one to benefit from the treatment.

In addition to this, I feel that there are many other pre-requisites that one must consider before introducing a new technology such as straw treatment to rural communities. For example, in a situation where straw treatment is to benefit small holder milk production, the technology should not only be "appropriate" and "farmer-friendly", but one may also have to ask the question, "What are the consequences of increasing milk production within that existing infrastructure ?". If there is no outlet for the extra produce, such as milk, milk products, meat, calves and even manure, the technology will die a natural death. Initially the farmer and his family may want to consume the extra produce (or use the manure in the field) but invariably he will need to sell his produce to obtain cash.

Therefore, there must be a ready market for all the produce. This, I am sure we would all agree as a very important consideration. But how many of us have in the past given enough thought to such factors?

How many of us analyzed the real market situation before talking of improving milk production by straw treatment?

Perhaps we all did consider farmer's opinion but did we look into, say, the cultural, religious and even political implications of such an operation?

There is no doubt that new technologies such as straw treatment would have beneficial effects on production. But the question is, "How sustainable are they?". This will depend on many factors, that we all need to be well aware of before taking these technologies to the farmer. I feel that our lack of understanding of these pre-requisites was a major factor that contributed to the low farmer-uptake of straw treatment (except perhaps in China) by smallholder farmers in developing countries, in spite of the so-called "crop residue revolution of the 1980's".

Noble Jayasuriya IAEA, Vienna, Austria

From Miltos Hadjipanayiotou <miltos@arinet.ari.gov.cy>
Comments on C. Kayouli's paper

In the studies in Niger, 5 kg of urea fertilizer diluted in 50 l of water were sprayed on 100 kg of crop residues. Some further questions:

1. Could Chedly Kayouli comment on the possibility of reducing the amount of water, particularly in areas/countries facing severe drought? Why the amount of urea-N retained was greater in rice straw than millet stover (49.6 vs 35.5%)?

2. Am I right if I say that the author gives the impression to the reader that feeding urea treated roughage to ruminants will increase yields (main products and by-products) due to higher availability of draught power and soil fertility?
3. Are there experimental data supporting this? Indeed, somebody might support the view that by treating poor quality roughage with urea is not an efficient way of utilisation of scarce urea (fertilizers). In the present study, like many others, 35-50% of applied/sprayed urea-N is lost, not retained in the straw. (Is it worthwhile developing methods to trap and reuse urea-N lost as ammonia gas?). Possibly, application of this urea to a poor soil might increase at a greater extent yields (Greater output of DM, CP, digestible nutrients per unit area) thus leading to more/better dung, better animal performance etc... Certainly, I do not support the latter, I do not have data to support it, but in case there are no data supporting the opposite, we should be reserved.

Finally, I would like to ask the author, and others working in the same field, what is the proportion of farmers feeding treated roughage, especially when a project is over, and no incentives are given to the farmers?

These should be taken as a material for further discussion, and for making us to think of future steps to be taken towards wider application of the technique.

From Michel Chenost <chenost@sancy.clermont.inra.fr>

Comments on Miltos Hadjipanayiotou's comments on Kayouli's paper on urea treatment

In the case of poor quality roughages and treatment, I cannot however remain silent. Maybe the organisers already mentioned that a book (written by Chenost and Kayouli) will be issued very soon by FAO. A lot of comments and questions that arose from Chedly Kayouli's paper have of course been dealt there in.

In particular, regarding Miltos Hadjipanayiotou's question, on urea treatment enhancing the N value of faeces, this is not only a question of practical observation but also a scientifically demonstrated fact: faecal

N excretion is augmented with NH_3 (as such or via urea hydrolysis) treatment. This has already been published several times.

What is remarkable is that this fact has also been reported through small farmers' observations collected by Kayouli (e.g. in Niger, Cambodia and Laos). This shows the important impact of this scientific fact at small farm level.

Michel Chenost INRA, France

From E. R. Orskov <ero@rri.sari.ac.uk>
Comments on Hadjipanayiotou's comments on Kayouli's paper on urea treatment

I would like to make a few comments relating to Dr Hadjipanayiotou's comments on capture of urea N.

First of all if digestibility is increased, then the concentration of indigestible microbial N in the faeces will increase, as observed by Dr Kayouli and so the value of the faeces for crops is better. If there is an excess of N in the diet for microbes, it will be excreted in the urine. The question then is: Should we try to capture all the N from urea treatment and how?

It is possible for instance by adding more water to retain a bit more. It is also possible to add acid to retain more. In particular with anhydrous ammonia, it is possible to evacuate the stack and lead the evacuated air through irrigation water. This however does require airtight stacks.

If the excess N has to be passed through the animal so that microbial requirement is exceeded then as I mentioned before the animal has no choice but to excrete it in the urine. However here we have a problem. Excess urea in the blood can return to the rumen several times and be absorbed as ammonia and re synthesized to urea so that the urinary N may have been through the cycle several times. This is energetically a very expensive process. Therefore, I do not think we should try to preserve excess N in the urea treated stack if the option is to have it through the animal, unless the rest of the diet was manipulated so as to utilize the excess N.

I hope this will clarify some points raised by Dr Hadjipanayiotou.

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From Michel Chenost <chenost@clermont.inra.fr>
Comments on Orskov's answers to Hadjipanayiotou's questions

OK, Dr Orskov is fundamentally right. But, let us do it as simple as possible:

1. Straw is improved.
2. Animals' performances are increased.
3. On top of that, the bonus is in the faeces.

Is it necessary to go any further?

Michel Chenost, INRA, France

From Miltos Hadjipanayiotou <miltos@arinet.ari.gov.cy>
Comments on Orskov's and Chenost's comments on Kayouli's paper

I have no doubt that by feeding urea treated straw will result in straw richer in N, more digestible and palatable material leading to better nutrition of the animals, production of better quality manure and of course stronger draught animals. The result of better manure and of stronger draught animals will be greater yields.

My question is whether these increases (benefits) will be greater than those obtained when this scarce urea is given to an agronomist to be utilised as fertilizer.

Is the agronomist going to produce more (products and by-products)?
What the benefit will be then for animal and of course the farmer?
Are there any comparative studies?
Can somebody provide any information based on experimental data?

Miltos Hadjipanayiotou Cyprus

From E. R. Orskov <ero@rri.sari.ac.uk>

Answer to Hadjipanayiotou's questions on Kayouli's paper

The question of whether the agronomist should use the urea as fertilizer instead of straw treatment is one that is often asked.

If urea is utilized as fertilizer, the farmer in a profit maximization exercise will use urea until the last increment is no longer giving economic responses.

If a farmer uses urea for straw treatment, it has to be economical otherwise it should not be advised and farmers will soon stop using it.

The comparison with agronomic responses to fertilizer will depend on where you are on the response curve to fertilizer. I do not think therefore the comparison is all that relevant; both processes have to be economical to be recommended.

I hope this is of help but I am not an economist!

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From Rena Perez (70155.111@compuserve.com)

Comments on usage of urea for ruminants

Now that the question about the relative economic efficiency of urea usage has been raised by M. Hadjipanayiotou, I was wondering if the issue could be further complicated by asking the participants in this conference:

Has the relative economic benefit of urea for ruminants been compared in:

1) multinutrient blocks
2) straw treatment or
3) as fertilizer?

In addition, some countries are still using a mixture of molasses and urea. Would this merit a fourth treatment comparison?

From John Chesworth <101525.2643@CompuServe.COM>
General comments on by-products

I have been following with interest all of the papers that describe the use of by-products and treated by-products in animal nutrition. One of the purposes of gathering this type of information is to be able to use it in the planning of animal production. It seems to me that one piece of information that is generally absent in these reports is some indication as to the biological availability of the by-product. The literature on crop production in developing countries generally details the yield of the primary crop product, e.g. the grain, but ignores the yield of by-product. In the same way, the animal production literature tends to ignore this and often creates the impression that the material is infinitely available.

In terms of the simple modelling of potential production systems, what would be most useful is a series of guidelines as to the likely ratio of crop to by-product. Farmers often have a good idea as to the yields of grain that they achieve; these could be scaled to give a 'guesstimate' of the availability of by-products.

Could anyone suggest sources of such information? If collated information of this sort is as scarce as I suspect, would it not be a good idea to arrange for a future feeds conference to concentrate on this area where crop and animal production meet?

John Chesworth

From Jayasuriya Noble M.C. <Jayasuri@ripo1.iaea.or.at>
Comments on Chesworth's general comments on availability of by-products

The estimated availability of various by-products in many developing countries (often estimated on the basis of grain:residue ratio) is given in the FAO Publication "Better utilization of crop residues and by-products in animal feeding: research guidelines 1. State of knowledge" - Proceedings of an FAO/ILCA Expert Consultation held in March 1984 in Addis, Ethiopia. The reference for the publication is FAO Animal Production and Health paper No. 50, 1985.

Noble Jayasuriya

From Chedly Kayouli c/o <ADRAI@ramilamina.adrai.mg>
Answers to Hadjipanayiotou's questions

These comments are made from the Highlands of Madagascar where I could not unfortunately follow regularly the conference for the last three weeks. Nevertheless I have obtained some comments concerning my paper "The Role of Feeding System Based on Cereal Residues in Integrated Farming Systems in Sub-sahara Africa". Some questions have been raised by Miltos Hadjipanayiotou:

1. Is it possible to reduce the amount of water used for urea treatment, particularly in areas/countries facing severe drought?

The urea treatment technique is based on the transformation of the urea into ammoniac in the presence of water. The quantity of water to add to the forage is therefore a factor determining the success of the treatment. The totality of large scale research works, tests and observations have demonstrated that ureolysis is efficiently achieved when final moisture of treated forage is at least 30 per 100. We have found that the use of 30-35 litres of water is sufficient to treat 100 kg of dry straw in Sahel conditions when airtightness and compression of stored straw are satisfactory (with utilization of plastic on all sides). However:

- In Sahelian zones, the straw and the natural forage are very dry (often more than 92 per cent DM) and the air hygrometry degree is very low which favours an intense and rapid evaporation.
- The moisture facilitates the compression of the mass of forage and, consequently, a better evacuation of the air and a more homogeneous ammonia distribution.
- As plastic is too costly, the traditional ways of storing straw is used with locally available "airtight" systems.

Therefore, straw treatment using 50 litres of water has been recommended and it has been successfully applied by farmers.

The Sahelian regions are not only what can be seen on the television: desert, dromedaries and thirst. There are also agricultural and irrigated zones (Niger, Senegal rivers...). Urea treatment has been undertaken where water is not a seriously limiting factor especially when straw treatment is carried out just after the harvest, in November-December, when the water is still easily available.

2. Why the amount of urea-N retained was greater in rice straw than millet stovers?

During treatment and trampling, layers of rice straw are generally better compressed than in the case of millet and sorghum stovers. Therefore the mass of treated rice straw is more compact and the ammonia gas is more trapped. It is possible to treat 85 kg of rice straw per cubic meter but only 50 to 60 kg in the case of millet stovers.

3. Am I right if I say that the author gives impression to the reader that feeding urea treated roughage to ruminants will increase yields (main products and by-products) due to higher availability of draught power and soil fertility?

There are quite many scientific and practical works on urea and ammonia gas treatments that have been undertaken during the last two decades. These studies have been mainly concentrated on nutritional aspects and effects on animals with few interest on the role of this feeding system in integrated farming systems. Several scientific works have shown the increase of nitrogen content in the faeces of animals fed with treated straw (with ammonia gas as well as with urea). However, the impact of the quality of this manure as fertilizer on crops has not been reviewed by these scientific workers often enclosed in their laboratories, as myself. But there are observations of very experienced farmers who follow up with precision their crop fields in several countries: Niger, Togo, Cambodia, Laos. Practical measures indicated in the table confirm effectively these positive effect of manure. An entirely unexpected result has been also found on fishponds. Manure and urea 46N are traditionally used by most farmers in Laos so as to fertilize fishponds and promote the production of natural fish feed (plankton and zooplankton). When manure produced from animals fed urea treated rice straw was used, many farmers observed greener fishponds with more fish feed and a rapid growth of fish. Some farmers reduced the quantity of urea usually applied.

4. As 35-50% of applied/sprayed urea-N is lost, is it worthwhile developing methods to trap and reuse urea-N lost as ammonia gas?

I perfectly respect your opinion, but I do not share your arguments and your pessimism. I think that it is not necessary to open a debate on the fixing of nitrogen as all research works have practically indicated that the rate of N fixed is in average around 30 per 100 (Demarquilly *et al.*, 1989), either with the ammonia or the urea.

However, treatment improves significantly the nutritive value of poor quality forage as cereal straw which is a very basic ruminant feed in many developing countries (as observed in many studies): dry matter digestibility is significantly increased after treatment (an average increase of 20%), the nitrogen content is more than doubled and the intake is increased by 30 to 50% at least, reducing therefore the refusal and forage squandering.

It is obvious that this technique is first aimed to improve the ruminant feeding system, but nevertheless it has indirect positive effects on the economics of crop production through improvements of draught animal power and increased availability of organic manure of better quality. Yes, application of agrochemical fertilizer can improve poor soils, however most rural farm families are too poor to purchase sufficient quantities to obtain a significant effect. On the other hand, the application of the urea on non irrigated cultures, mainly in dry zones can burn the young plants when drought occurs and urea can evaporate. Whereas, manure remains the basic remedy to poor soils, not only as a supplier of nitrogen but also of organic matter which improves the structure and the texture of soils particularly those frequently sandy in the Sahel. Therefore, instead of applying one bag of urea (50 kg) as fertilizer, it is more profitable to treat one ton of cereal straw (5%) which is sufficient to feed, as a basal ration, one pair of draught animals for three months (2 Animals x 5 kg treated straw/day) when they are in greatest need (April-May-June). Thus, production of approximately half ton dry matter of nitrogen-rich manure (assuming that half of the consumed dry matter will re-appear as faeces) and improvement of animal body conditions for an efficient work are two results highly appreciated by farmers and this strengthens the role of ruminants in the farming systems.

Concerning the last Hadjipanayiotou's question, I think that Dr Orskov has brightly responded to it.

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From Tony Goodchild <t.goodchild@cgnet.com>
Comments on straw quality

Frands Dolberg's endorsement of breeding good fodder qualities into straws and stovers is very welcome. Since 1981, research on this aspect of barley breeding has been going on at ICARDA, whose mandate area includes West Asia and North Africa. Here, farmers are slow to adopt a new variety of barley if the nutritive value or yield of its straw is lower than what they are accustomed to.

Other CGIAR international research centres taking similar approaches include ILRI and ICRISAT, collaborating on sorghum and millet breeding. Some of the ILRI-ICRISAT work is in India (Email: icrisat@cgnet.com); contact people are Ercole Zerbini (ILRI animal nutritionist), Eva Weltzien-Rattunde (plant breeder), and Merle Anders (agronomist). Other ILRI work is at the ICRISAT Sahelian Centre (Niamey, Niger); Salvador Fernandez-Rivera is the contact person (Email: s.fernandez-rivera@cgnet.com).

At ICARDA (Aleppo, Syria), because of the need to follow up large year-to-year variations in straw quality, we are only now beginning to realise the potential of the approach (see below). Our work commenced with Brian Capper's Ph.D. studies, and has been continued with the work of Euan Thomson and myself (animal nutritionists). We are increasingly collaborating with Salvatore Ceccarelli, the barley breeder at ICARDA. Michael Baum (ICARDA biotechnologist) is evaluating marker-assisted selection of barley for traits including straw quality. The Email addresses are:

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For barley straw, one may summarize ICARDA's recent findings as follows. Weight gain of sheep fed straw with or without catalytic supplementation is closely related to the voluntary intake of straw (R^2=0.85). The composition and degradability of cell wall (but not the quantity of cell contents or nitrogen) are relatively stable across years, and are genotypically correlated with voluntary intake. Given $1000, we calculate that breeders can improve voluntary intake by at least 10% a generation using Near Infrared Reflectance screening, or by at least 6% a generation using ADF, in sacco, gas production or palatability tests.

I shall not even try to list work that has been conducted in Northern countries; we ourselves have been collaborating with Hohenheim University in Germany, Reading University in England, and the Rowett Institute in Scotland.

Tony Goodchild ICARDA Aleppo Syria

From Reg Preston <thomas%preston%sarec%ifs.plants@ox.ac.uk>
Comments on Hadjipanayiotou's questions

Regarding the question of urea or manure from urea-treated straw, we are setting up the following experiment.

On each of two plots $10m^2$ sown with rice (one with local variety and one with HYV) we will apply urea at rate of 140g N (300 g urea). The other two plots will receive effluent from a biodigester charged with manure from cows fed urea-treated straw (5% urea on straw DM). We assume intake of 6 kg/day of straw DM (which received 300 g urea [140gN) and that 3 kg of faeces are produced and that 50% of this is converted to methane and CO2 in the digester thus 1.5kg DM/day will appear in the effluent at a DM concentration of 2%. This effluent will contain on average 2.4% N thus the N available for application to the rice will be approximately 40g which is a recovery rate of 29%.

We will therefore compare:

- Urea on rice plot: 300g on 10m2 divided in two applications - at planting and one month later.
- Effluent on rice plot: 75 litres applied at 1.5 litres daily over first 50 days (the effluent is produced daily hence must be used daily as N will be lost if stored and anyway volume is too big to store).

The effluent treatment will receive only 30% of the N received by the urea treatment (70% of the original urea having been lost in the course of the animal feeding phase) but of course the mode of application and the form of the N will be different and will favour presumably the organic form. There will be other nutrients in the effluent but in the farmer situation the contrast is essentially urea of effluent.

We could give small amount of balanced fertilizer to the urea treatment at the beginning but local experience does not favour this.

We welcome comments and suggestions from readers of the conference.

Reg Preston plus post graduate students in Vietnam

From Michael Allen <ml.allen@auckland.ac.nz>
General comment and further note to Kayouli's comment

I am following the electronic conference with great interest. But I am concerned that animal nutritionalists are taking a similar narrow view of rural development to that taken by engineers! We need to address TOTAL sustainability. We need a SYSTEMS APPROACH. We need to consider the impact of population increase...

I have a couple of notes to add to the excellent summary provided by Chedly Kayouli in answer to Miltos Hadjipanayiotou. There is no doubt that water is essential for the efficacy of urea migration into dry forage and its subsequent breakdown to ammonia. Urease just cannot work in air! But how much water will depend upon losses to the environment.

The solubility of ammonia in water also ensures that there is a sufficient residence time for ammonia absorption and reaction to take place if there is enough water present.

What is rarely considered is the physical state of the dry forage being treated with urea solution. Because most drying grasses exhibit ptylosis, the surface absorption characteristics change as the plant material dries. In essence the plant is trying to conserve what water remains within its structure. The result is that much urea solution does not adequately wet the surface of the grass and soon drains away. Ammonia solution, in contrast, has a low surface tension and, due to its high pH, can also dissolve some of the surface gums and oils on the plant. May I suggest that small amounts of surface active agents such as detergents and soaps in the urea solution will greatly improve the capture and retention of urea solutions?

Perhaps one of the participants has some field data to support my observation.

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From Reg Preston <thomas%preston%sarec%ifs.plants@ox.ac.uk>
Comment on Michael Allen's comments

A good idea to add some detergent, which later into the dry season we will investigate. Just now the rice straw we are treating is still of relatively high moisture content. If we improve the efficiency of treatment then the quantity of urea could be reduced which would be very attractive.

Reg Preston in Vietnam

From E. R. Orskov <ero@rri.sari.ac.uk>
Comments on Michael Allen's comments

I would like to make some comments about the possible use of detergents as a method of wetting the straw. I used detergents some years ago to see if one could open up the waxy surface of straw to increase attachment sites for microbes. It did not work very well. I fear that including detergent may well interfere with the urease activity which is essential for the hydrolyses of urea. Anyway it is worth trying on a small scale.

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From John Chesworth <101525.2643@CompuServe.com>
Comments on water addition and urea treatment (Fifteenth paper, from C. Kayouli)

I am a little wary about the talk of adding more water when treating forages with urea. The big disadvantage (apart from safety) of many small scale caustic soda treatments is in the amount of water that this adds and the consequent high risk of moulding in the hay. The quality of the final product can in fact be lower than that of the starting material. Urea treatment avoids this problem.

An observation of ours in Zimbabwean winter was that there were enormous diurnal movements of water. The day-night shade temperature differential is usually greater than 25 degrees - immediately underneath a layer of black polythene the change will be much greater. At night, water tended to migrate to the outside of the stack and condense on the inner surface of the polythene. In the day time, the effect of sun on black polythene heated the outer layers, moving the water to parts of the stack that were still cold from the night. In turn, most of the stack spent some of the day at a higher than average moisture content. Even in the driest part of the stack, moisture exceeded 5%, much of which we assumed to be intimately associated with the surface layer of carbohydrates.

A possible chemical parallel is the association between stationary and support phases of a GLC column. This liquid stationary phase is still capable of dissolving the polar gas phase, giving an intimate association between ammonia and carbohydrate matrix. I suspect that the chemistry of this system is extremely complex and will yield only to heuristic treatment.

Does anyone know of any literature on the effects of changing the physical conditions of these stacks, possibly by shading them?

One practical technique that we did employ was to assume that a large diurnal mass movement of water vapour and ammonia existed and that this would treat stover that could not be reached by other solutions. Some of the chopped stover was put into very open-weave hessian sacks. These were then used as sand-bags to create an outer wall into which loose chopped stover was placed. The whole stack, sacks and all, was sealed into black polythene. After urea treatment, stover in the sacks appeared to be identical to that in the centre of the stack.

John Chesworth

Comments on: Role of multinutrient blocks for sheep production... by Dr. Ala D. Salman

From Jean S. Zoundi <zoundi@burkina.coraf.bf>

Comments on sixteenth paper "Role of multinutrient Blocks for sheep production..." by Dr. Ala D. Salman

I am really pleased with the topics covered by this second FAO electronic conference. They are very pertinent and well in line with scientists', extensionists and political decision makers' concerns related to the improvement of animal production.

The multinutrient block is a very interesting solution to the problem of nutritional deficiencies that animals are facing for a large part of the year and especially during the dry season.

In Burkina Faso, the blocks (molasses-urea) were tested on sheep with FAO assistance in 1987-88 and the results obtained were very conclusive. Taking into account these results, the Ministry in charge of agriculture and animal production launched a large scale campaign of production and extension of these blocks.

There are two concerns at the moment:

How to enrich the blocks?

How could these blocks be made more attractive to the producers through integrating locally available ingredients?

We are focussing our present research on looking for locally available ingredients which could be used to manufacture these blocks. These formulae will then be assessed on station and on farm on the animals. Several ingredients are available in the villages: millet and sorghum bran, legume straw, Nere powder (*Parkia biglobosa*), Pilostigma powder (*Piliostigma reticulatum*)... We are taking advantage of all these potential ingredients within our on-going research programme.

I am particularly interested in the effect of the blocks on the reproduction performances of ewes reported by Dr. Ala D. SALMAN and I would like to get more information on the experimental protocol and especially:

1. When the blocks were used? During the heat or at any time?

2. For how long this supplementation has been given?
3. How was this supplementation given: blocks offered ad libitum or during limited periods during the day?
4. Was this assessment made on farm or only on station?

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From Ala D. Salman c/o FAO-Iraq <FAO-IRQ@field.fao.org>
Answers to Jean Zoundi's questions on the effect of multinutrient blocks on the reproductive performance of ewes

I would like to comment on the questions raised by Dr. Zoundi on the effect of multinutrient blocks on the reproductive performance of ewes:

1. When the blocks were used? During the heat or at any time?

The blocks were used during summer time, which is the main mating season of Iraqi sheep which coincides with cereal stubble grazing.

2. For how long this supplementation has been given?

Ewes were supplemented with MB for 28 days prior to ram introduction and for 51 days post mating.

3. How was this supplementation given: blocks offered ad libitum or during limited periods during the day?

Blocks were offered at certain time during the day (evening, after the flock returned from stubble grazing). However, blocks were offered ad libitum during this time.

4. Was this assessment made on-farm or only on-station?

These experiments were conducted on-station. But during last summer (1996), we conducted on-farm experiments on three locations in Mosul area (northern part of Iraq). The early results of these on-farm experiments are promising.

Ala D. Salman, IPA Agriculture Research Center Baghdad, Iraq. Box 39094

From Rena Perez <71055.111@compuserve.com>
Comments for Jean Zoundi on MUBs for ewes

Since mid-1996, multinutrient blocks have been used in several reproductive (Pelibuey) sheep herds (on-farm) pertaining to the Cuban sugar industry. The blocks are placed, under cover, in the night paddock or the block mixture is placed in chicken troughs which are then hung from the roof beams. The animals graze in the cane fields during the day and have access to the blocks, or the mixture, during the mid-day rest or at night. The ewes have now begun to farrow (12/96) and the farmer's comments are:

1. "used to be that only 55-60% of the ewes farrowed, now between 90-95%"
2. "this year, more ewes are dropping twins"
3. "the young ones aren't dying anymore".

To answer the four questions:

1. When the blocks were used? During the heat or at any time?

The blocks are accessible year round. The animals regulate intake. In the wet season, when the grass is green, they tend to reduce block intake. The reverse happens in the dry season.

2. For how long this supplementation has been given?

Six or seven months, since May/June of 1996.

3. How was this supplementation given: blocks offered ad libitum or during limited periods during the day?

Basically at night, fodder and water must be available.

4. Was this assessment made on farm or only on station?

Only on-farm.

Because our work involves the sugarmills, there is a tendency to use either molasses or combinations of molasses and filter-press mud as a substrate for the urea. However, once I visited a region in South America where both molasses and filter mud were unavailable and humus, from worms, resolved the problem.

Rena Perez

From Malcolm Knox <mknox@chiswick.anprod.CSIRO.AU>
Comments on Jean Zoundi's questions on paper 16 (The Role Of Multinutrient Blocks For Sheep Production in Integrated Cereal-Livestock Farming System...)

I too have found this to be a very interesting conference and I am happy to be able to make a small contribution to the discussion. My field is primarily nematode parasite control in ruminant livestock but most recently through ACIAR Project 9132, I have been investigating the importance of low cost nutritional supplements in the development of parasite resistance/resilience in young sheep. Our work has employed urea-molasses blocks (UMB) for its obvious nutritional benefits as highlighted by many of the contributors to this conference.

One study in which I was involved with Peter Manueli and Faiyaz Mohammed of MAFFA, Fiji, looked at the benefits of UMB supplementation in young ewes 7 months prior to first mating through to weaning of their first lambs (16 months total). Blocks were available in small shelter sheds in the paddocks and animals could access them ad libitum. In this trial UMB supplementation almost doubled the numbers of lambs born (40 vs 24), increased the number of lambs weaned (39 vs 20) and almost doubled the total weight of lambs weaned (405kg vs 222kg) when compared to unsupplemented controls grazing low quality pasture. This nutritional treatment also substantially reduced the requirement for salvage anthelmintic treatment (treated if number of eggs per gramme of faeces over 3000) during the trial period (55 individual treatments vs 92 treatments) .

Therefore in the Fijian situation where low quality forages predominate and nematode parasites are an endemic problem UMB supplements are now a recommended part of the sheep rearing enterprise. Later trials on both sheep and goat farms have had a highly positive response from farmers due to increased productivity of their flocks. Increased adoption of UMB is assured particularly since MAFFA has introduced low technology block preparation methods through on farm field demonstration days.

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From Miltos Hadjipanayiotou <miltos@arinet.ari.gov.cy>
Comments on Salman's paper on blocks

First of all I would like to congratulate Ala Salman and his team in Iraq who managed to put into practice experience on urea block (UB) manufacturing and feeding gained within the FAO/UNDP/SYR/89/003 project and outside the region.

Indeed, UB manufacturing technology has been improved considerably in Iraq (mixer, moulding equipment etc). The type of mixer they use is more efficient than any concrete mixer, particularly when working on formulae without any molasses.

Date pulp, like molasses, is an excellent material for making good quality UB. In case this material is not abundant, it is essential to work on formulae with the minimum level of inclusion so that more UB of good quality will be produced.

In the on-farm studies UB intake was considerably higher than previously reported values. Indeed, if the intake of UB by a 40-50 kg LWT sheep is 346 and 416 g/head/day, then this is not a block, but another kind of supplement that when mixed in mash form with the other ingredients of the total daily feed allowance would most likely give similar results to UB.

Knowing that animals had access to UB after the day grazing, the importance of offering UB of good hardness and compactness for securing small and frequent meals is becoming greater. In the on-farm trials in the Mosul area (Nazah & Al-Jernaf), the use of UB did not improve performance (milk yield 342 vs 358 g/head/day, and 500 vs 362 g/head/day) compared to the control diet. Contrarily, in the on station trial UB and sunflower seed meal supplementation improved milk yield significantly (control 402, UB 888, sunflower 867 g/head/day).

Why these differences between tests/trials?

How hard and compact were the UB used?

Were the UB consumed in small and frequent meals?

From: Ala Salman c/o FAO-Iraq <FAO-IRQ@field.fao.org>
Answers to Hadjipanayiotou's questions

I would first like to say to Dr. Hadjipanayiotou that his encouragement and continuous support to the Iraqi team is highly appreciated. The Iraqi team gained a lot of experience from his work in the region and previous consultancy report to Mashreq Project (ICARDA/UNDP/AFESD. RAB.89/026).

Answering the questions raised:

1. Why these differences between test/trials?

Differences were mainly due to differences in the objectives of trials/tests in on-station and on-farm. In on-station trial, the objective was to use the block as a complementary supplement. On the other hand, the objective of on-farm trials was to set a formula for blocks according to the real need of the farmers because of the shortage of barley grain nowadays in Iraq. This is why block formulation and the outcomes were different between trials/tests mentioned.

2. How hard and compact were the UB used?

Both, the hardness and compactness were good in on-station trial whereas, hardness and compactness were medium in on-farm trial in order to increase block intake.

3. Were the UB consumed in small and frequent meals?

The block was offered after the flock returned from grazing in the evening. Blocks from then on were offered only from evening until the next morning prior to the flock moving out to grazing field.

Ala D. Salman, Ipa Agric Research Center, P.O. Box 39094, Baghdad, Iraq

Comments on: Excess feeding of stovers from sorghum and maize... by E.I.K. Osafo *et al*.

From Jean S. Zoundi <zoundi@burkina.coraf.bf>
Comments on seventeenth paper "Excess feeding of stovers from sorghum and maize..."
Crop residues are of primary importance for animal feeding in the tropics. Several research works carried out in Burkina Faso (Zoundi, 1994) show that the post-harvest period is similar to the rainy season (July to September, when good quality green fodder is available) in terms of Average Daily Live weight Gains. In the integrated livestock-agriculture production systems of the central plateau of Burkina Faso, the post-harvest period is generally chosen by the producers for finishing the long-term fattening of cattle and small ruminants.

The strategy of excess feeding of straw is not investigated at the moment in Burkina Faso. Nevertheless, there are many on-going research works on optimizing the use of crop residues. Sorghum and millet straws are the most commonly used.

Refusals are generally used for producing compost. In the integrated livestock-agriculture production systems, the producers have the objective of taking benefit from the organic fertilization. Because of this context, the quantitative and qualitative changes of the organic fertilization are always taken into account and carefully measured during the experiments related to animal production.

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Comments on: ...Livestock systems based on crop residues in China by Guo Tingshuang and Yang Zhenhai

From Bob Orskov <ero@rri.sari.ac.uk>

The paper by Guo Tingshuang and his colleague is of great interest to many and I therefore think that it would be useful if the authors could explain to others why it has been so successful.

No doubt the institutional support has been a great factor in the success story but no doubt there are many other factors not immediately obvious to others. For instance:

1. What is the cost of urea relative to other feeds above which it would be of no economic interest?
2. Can fluctuating prices of beef be a problem?
3. Are beef prices uniform so that farmers can be sure of a return on investment after a relatively long fattening period?

I am familiar with the work but I think it would be useful for the readers if the authors could give an explanation of their success.

E R Orskov

From Guo Tingshuang, China

Answer to Bob Orskov's comments on the paper (Eighteenth paper: New developments in livestock systems based on crop residues in China)

More details on our experience can be found in our paper delivered at the International Conference on Increasing Animal Production with Local Resources, Beijing, 1993.

The support of central government is one of the main factors of the success. After many years' efforts, we have made the top leaders believing that the use of crop residues is the only way to increase animal production with non-grain feed resources in China. From 1992 to 1996, we held four national conferences (in the name of the State Council), calling for the extension of "animal production based on crop residues". We also established 164 demonstration counties with central government's funds. In 1996, the "National Development Programme for Livestock Production Based on Crop Residues Project 1996-2000" was issued by the State Council. Therefore, our technical extension with administrative means is the most important successful factor.

With reference to Bob Orskov's questions:

1. The current price (in Chinese "Yuan" per ton) for urea and other feeds is as follows:

Urea	2,000
Soybean cake	3,080
Corn	1,370
Fish meal	5,860
Cottonseed cakes	1,400

Urea (market price) is not expensive as compared with other feeds. Its price can be even lower (1350 Yuan.ton) if urea is used for technical extension. Therefore farmers do get profit from urea-treated straw.

2. and 3. Beef prices are fluctuating in China but with less changes than for other animal products. Farmers can be sure of a return on investment after a relatively long fattening period. Because the labour cost is very low, cotton seed cakes are cheap (1,400 Yuan/ton) and the straw is even free of charge if the herd is not big and if the farmers just use their own straw.

Guo Tingshuang

From: "E. R. Orskov" <ero@rri.sari.ac.uk>

Supplementary question on paper by Guo Tingshuang (Eighteenth paper: New developments in livestock systems based on crop residues in China)

I wish to thank Dr. Guo Tingshuang for giving us the price ratio of urea to that of other feeds which, together with the surplus and therefore cheap straw available on many small farms, helps to make the treatment economically interesting for the farmers.

One of the most impressive aspects which needs commenting upon is the ability of the Chinese yellow cattle to consume straw in large quantities as they virtually fatten on 80% treated straw diets.

I would like to ask a supplementary question relating to supplements. In the original work you have published in 2 papers in Livestock Research for Rural Development, a mixture of wheat bran and cottonseed cake 2:1 was used at the rate of 1Kg per day and the animals had growth rates between 650 and 800g/d, which is impressive for the small cattle. In some areas or provinces, cotton seed cake is cheap and available and can be used in a high proportion. In other areas, it is not available or not cheap.

What are the present recommendations as to level and type of concentrate to be used in different regions as supplements to treated straw diets for fattening Chinese yellow cattle?

I think this will be of interest for many readers as few types of so-called improved cattle can consume and fatten on such a high proportion of straw.

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From Guo Tingshuang
Answer to Bob Orskov's supplementary question on his paper

1. The ability of Chinese yellow cattle to consume straw in large quantities has been proven by lots of Chinese farmers' practice. But there is no strict feeding test to compare such ability between yellow cattle and western cattle.
2. Originally, the supplement was a mixture of wheat bran and cottonseed cake 1:2 according to FAO experts' recommendation. Later, it was changed to 100% cottonseed cake on other FAO experts' suggestion. The performances of the two supplements are just similar. It seems that 100% cottonseed cake is a little better. Some feeding tests reported in my

published papers showed that the daily gain was 504-602g when 1 kg per day supplement is fed to cattle. The daily gain did reach 650-800g.
3. Cottonseed cake or rape seed cake is available and cheap in most parts of China except northeast (very cold area) and south China (tropical area).
4. We recommend "ammoniated straw + cottonseed cake" as the basic diet for most parts of China. The quantity of supplement per day per head is 1-2,5 kg according to the market price of cottonseed cake, straw, urea and fattened cattle.
5. Improved cattle can consume and fatten on high proportion of straw. Still, the concentrate should be a little more. Usually the market price for improved cattle is better than local yellow cattle. We still have to do some feed tests to compare the ability of consuming straw between yellow cattle and western cattle.

We will be pleased to answer any supplementary questions.

Guo Tingshuang

From George Chan <100075.3511@compuserve.com>
Additional comments on Guo Tingshuang's answer to Bob Orskov's supplementary question on his paper

The best use of cottonseed wastes is as substrate for simple mushroom growing in the backyard of the farmhouse, and then the enhanced residue can be used as livestock feed. This allows the farmer to make a good income while breaking down the lignocellulose and making the crop residues more digestible and even more palatable as a feed. This is what we are doing in our Integrated Biomass Systems in the UN University Zero Emission Research Initiative (ZERI) program, with the World Authority on Mushroom helping us.

I seize this opportunity once again to remind everybody that livestock and fishery should only be fed with crop and processing residues which are not suitable for human consumption, after enhancement with microbial processing at the grass root level. It is sheer lunacy to use produce and raw materials suitable for human consumption or value-added processing as livestock or fishery feed, when we have so many people dying of hunger and malnutrition every day around the world.

In other words, NO land should be used just to grow livestock feed, as it is needed for food production first, and whatever residue unfit for human consumption or for simple processing into useful products for profit will then be fed to animals, birds, fish and shellfish.

For 32 years, this is what I have been doing in the field, and not just talking about it. There is also too much talk and not enough action.

George Chan

Comments on: Stubble grazing by sheep by T.Treacher

From Timothy Treacher <pa1treac@uco.es>

Further comments and questions from Timothy Treacher on stubble grazing

The submission of the paper on stubble grazing by sheep was prompted by the papers by Chedly Kayouli and Ala Salman discussing supplementation in dryland farming situation.

1. There is a very large area of cereals in the Mediterranean basin and throughout Asia, which is an important feed resource for ruminants. For example, in the Mediterranean Basin from Morocco to Portugal there are 28.8 million ha of wheat and 16.8 million ha of barley. After removal of the cut straw following combine harvesting, which is increasingly common, there must be approximately 1 t DM/ha.

2. There is no indication that stubble is not fully utilised under dryland farming. However, in west Asia cereal stubble on irrigated land is very often burnt, because of the pressure to plant another crop quickly in June. Could cereal stubble, with more knowledge, be utilised more effectively?

3. The limited information on stubble quality indicates that the CP/ME ratio would be expected to limit intake and it is likely that some supplementation with nitrogen or protein would improve intake. This contrasts with the flockowners experience that body condition and oestrus activity increase after the start of stubble grazing. It is possible that the breeds in the region are more efficient in nitrogen use.

Any information or comments on this would be valuable. There is a little data in ICARDA.

4. It is important to emphasise the lack of research on grazing of cereal stubble under dryland conditions in the Mediterranean basin, north Africa and Asia regions. The Australian research in the 1970 s and 1980 s showed very low intakes of straw itself and most intake on stubble being of the green weed fraction. This clearly not the case in the "Old World" systems.

5. More information is particularly important as stubble is used in the mating period and may/does critically affect the annual performance of the flocks.

If there is some unpublished data, it would be extremely valuable to know where it is.

6. Two of the experiments reported in the paper demonstrate large responses in performance to small amounts of supplementation, when the level of utilisation of the stubble was greater than 90%. This suggests that flockowners might greatly improve annual performance by supplementing, at a low level, in summer and improving the body condition of their flocks before the winter. This could reduce the need for high levels of hand feeding in autumn and winter, which is increasingly common, at least in west Asia.

7. The rooted cereal plants have an important role in preventing or reducing wind erosion in late summer and autumn. At present high levels of utilisation by flocks results complete removal leaving the ground bare. Intakes in the final days on an area are also low.

There is need for information on an acceptable balance between utilisation, intake and soil protection to improve the integration and sustainablity of the crop and livestock systems.

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Comments: on: Tree mixtures within Integrated Farming Systems by M. Rosales and M. Gill

From Chris Wood <Chris.Wood@nri.org>

Comments on Rosales and Gill's paper

Dr Rosales refers to work done in Nepal on tree fodders. In many Nepalese farming systems a major role of livestock is to provide manure to fertilize their fields as fertilizer is considered too expensive. Farmers have a two scale quality evaluation system, the chiso-obano (obhano) scale referred to by Dr Rosales and the posilo-kam posilo scale where posilo means palatable and production-enhancing. A recent study conducted by the Natural Resources Institute, Pakhribas Agricultural Centre and the University of Wales has indicated that posilo feeds are good sources of dietary protein while the chiso-obano scale appeared to be related to dung characteristics. Obano feeds, which were considered to be palatable and voraciously consumed but sometimes caused constipation, were of low in vitro digestibility. Hence there was the unexpected finding that farmers considered tree fodders of low digestibility, which would have been expected to be of little value, to in fact be of considerable use to them. It was unclear whether this was related to dung quality or was perhaps related to the avoidance of antinutritive factors in more digestible fodders. However, an important point is that feeds must be evaluated in the context of the farming system as a whole. In this case ranking in terms of in vitro digestibility would have been highly misleading.

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From: Chedly Kayouli and his laboratory group
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Comments on fodder trees and the use of PEG

We have read with interest the papers of Mauricio Rosales and Margaret Gill, Ali Nefzaoui and comments from Thomas Acamovic. The subject is original and we understand that little is known about the functioning of secondary chemical compounds of fodder tree species especially in ruminant feeding. We would like to add some results and reflections about the use of PEG for condensed-tannin-rich plants from our own experience.

As shown by several researchers, PEG has an affinity for tannins and reduces their negative effect. Even though the effects of PEG on intake and digestibility of diets based on tannin-rich plants are inconsistent, several researchers showed a positive effect on nitrogen use by ruminants. In our laboratory, we supplemented Acacia cyanophylla (11-13% CP and 4-7% condensed tannin) with PEG (about 25 g /day) for feeding sheep. Results showed a positive effect of PEG on digestibility and retention of nitrogen, a higher N-NH3 and VFA concentration in the rumen and an increased concentration of total protozoa (see abstract below).

Most recent studies concerning tannins were based on chemical PEG. This alternative offers several advantages such as the control of the dose of PEG in relation to the tannin concentrations in plants and the ease of treatment (watering, spraying, in concentrate and in nutritional blocks). However, we think that it is actually difficult to develop a feeding system based on fodder trees and shrubs using PEG particularly in developing countries because it is very expensive. Furthermore some questions might be raised:

1. Is the current knowledge sufficient to take up this option?
2. Are all the natural PEG analogues identified in each species of fodder tree (class of chemical, concentration in plant, specific effects...), especially in developing countries where laboratories are under-equipped?
3. Does the positive effect of natural PEG analogues meet the eventual positive effect of the mixture (nutritional complementarity or synergistic effects)?

Use of Multi-Nutritional Blocks for the Improvement of an *Acacia cyanophylla* Lindl. -based Diet for Sheep

C. Kayouli and his laboratory group, Institut National Agronomique de Tunisie

In this paper we report results of an experiment dealing with the improvement in the quality of an *Acacia cyanophylla*-based diet using multi-nutritional blocks where energy, nitrogen, minerals and PEG are added.

Six sheep where used to test diets (double 3*3 Latin square design). All diets included 400g of oat-vetch hay, dried *Acacia cyanophylla* leaves and twigs *ad libitum* (D1) and supplemented with two types of block: D2 (10% urea, 10% molasses, 5% NaCl, 5% MVS, 5% Ca2PO4, 10% cement, 20% olives cake and 35% wheat bran) or D3 (10% PEG 4000, 10% urea, 10% molasses, 5% NaCl, 5% MVS, 5% Ca_2PO_4, 10% cement, 15% olives cake and 30% of wheat bran) *ad libitum*. Each experimental period lasted 33 days (21 days for adaptation and two 5 day periods of measurements separated with 2 days rest). Intake of Acacia and blocks was measured by difference between that offered and refused, while digestibility was measured by the total faecal collection method.

The two kinds of blocks improved significantly ($p<0.01$) the DM intake of *Acacia*. Block dry matter intake was similar for the two kinds of blocks (D2 and D3). Dry matter intake of the whole diet increased significantly ($p<0.01$) on both diets. Blocks did not affect DM and OM digestibility of the diet. Nitrogen digestibility was very low for D1 but was significantly ($P<0.01$) improved on D2 and D3. Nitrogen retention was significantly different ($P<0.01$) for the three diets. For D1, Nr was negative, while clear improvements were noted with D2 and especially when PEG was added (D3). Supplementation with block improved the nutritive value of the diet; this positive effect was most marked on D3.

In conclusion, energy, nitrogen and mineral supplies given in blocks improved the nutritive value of an *Acacia cyanophylla* Lindl - based diet. A supplementary specific effect of PEG is observed for nitrogen retention and digestible crude protein.

Diets	D1	D2	D3	SE
DM intake(g)				
Acacia	569.68b	760.42a	773.42a	29.65
Block	0	271.88a	260.89a	11.81
Diet	929.5b	1392.1a	1394.08a	12.94
Diet digestibility (%)				
DM	48.49	47.15	49.49	0.96
OM	51.75	50.24	52.4	0.95
CP	30.45c	51.26b	64.18a	1.4
Nitrogen use (g)				
Nr	-0.39c	4.11b	7.73a	0.71
Nutritive value of dietsg/LW$^{0.75}$				
DOM	25.75b	34.24a	35.75a	1.05
DCP	1.75c	6.65b	7.95a	0.312

a, b, c; Data in the same line with different superscripts differ (p<0.01)

From: Tony Goodchild (PFLP) <t.goodchild@cgnet.com>

Reply to Chedly Kayouli's comments on the use of PEG

It was good to see that Chedly Kayouli's results on *Acacia cyanophylla*, particularly the response to multinutrient block supplementation. No-one can argue with his conclusion that "energy, nitrogen and mineral . . . in blocks improved the nutritive value of an *Acacia cyanophylla* . . . based diet" even without PEG, but it would be good to know which of the nutrients he supplied had the greatest effect.

Work was reported in Australia in the 1970s for merino sheep consuming a rather similar shrub, *Acacia aneura* (mulga). Feeding supplements containing sulphate, such as Na_2SO_4, $CaSO_4$, molasses and the ash of molasses, increased the sheep's voluntary DM intake by about 40% (Hoey *et al*. 1976; see also Gartner and Niven 1978). Phosphorus supplementation increased mulga intake by 20% (McMeniman 1976).

Mulga may be lower in DM digestibility than *A. cyanophylla*, but seems to be similar in tannin and apparent nitrogen digestibility.

Kayouli's 50% increase in DM intake should be seen in this light.

This E-mail conference seems to have neglected the role of minerals in improving the efficiency of animal production. Surely, if a specific micronutrient is limiting, the response to correcting the deficiency is usually enormous in comparison with the cost, and work to locate problem zones will have potential benefits for even the poorest producers.

I look forward to meeting you all again, either in TFConf3 (please!) or in person,

Tony Goodchild, ICARDA, P.O. Box 5466 Aleppo, Syria (t.goodchild@cgnet.com).

References:

Gartner,R.J.W. and Niven, D.R. (1978) Australian Journal of Experimental Agriculture and Animal Husbandry (AJEAAH) 18:768-772.

Hoey, W.A., Norton, B.W. and Entwistle, K.W. (1976) Proceedings of the Australian Society of Animal Production 2:377-380, McMeniman,N.P. (1976) AJEAAH 16: 818-822.

From Chedly Kayouli <101763.2164@compuserve.com>
Reply to Tony Goodchild's comments on the use of PEG

Thank you for reading with interest our results concerning supplementation of *Acacia cyanophylla*. We absolutely agree with you that the role of mineral effects in improving the efficiency of animal production seems to be neglected. In our trials we added minerals through the different nutrients, cement, bicalcic phosphate, NaCl, and mineral-vitamin supplement. Minerals were not studied for their specific effect, and the most important factor that we considered for its greatest effect was PEG 4000.

We believe, as reported by Jansman (1993, Nutrition Research Reviews, 6, 209-236) that information on interaction between tannins and minerals is hardly available. The research work you referred to provides little but precious information about this aspect. It seems that tree leaves are generally very rich in calcium and poor in phosphorus, so a negative phosphorus balance is frequently shown by animals fed on tree leaves. Most studies we have seen on the interactions between minerals and tannins concerned especially phosphorus (tannins do not seem to affect phosphorus) and sulphur (because of the sulphur amino acids). The presence of high dietary tannin has been found to be responsible for a decrease in wool growth due to the reduced sulphur amino acids absorption.

In this respect, Pritchard *et al*. (1992, J., Agric, Res, 43; 1739-1746) showed that sheep fed Mulga (*Acacia aneura*) retained more N and S when supplemented with 24 g/day PEG. These results were further enhanced when a mixture of nitrogen, phosphorus and sulphur was added in conjunction with 24 g/day PEG.

A few years ago, we carried out some research (unpublished) where we studied the effect of minerals on *in vitro* fermentation of some by-products. We hope to do the same with acacia in combination with PEG effect.

Chedly Kayouli, Institut National Agronomique de Tunisie

Comments on Scavenging Poultry and Ducks (Papers 25 to 28)

From Hans Askov Jensen <askov@ibm.net>

Comments on the role of Scavenging Poultry (twenty-fifth and twenty-sixth papers)

It is encouraging to read papers on scavenging poultry keeping where information is field documented, as in the papers of Dr. Saleque and D. Tadelle. I can agree on the conclusions and recommendations given in the papers but I wish to make some comments on the choice of breeds and awareness.

Choice of Breeds

It is of paramount importance to have a precisely defined role of the breeds before any genetic alteration is planned. Tadelle and others, reference is made to papers presented at the XX World Poultry Congress, indicate that the purpose of traditional poultry keeping is more than anything else related to reproduction of the flock.

Through natural selection local birds are perfectly developed for reproduction. The egg yield - clutch size - is just enough for one hatch and the egg size is small which increase the number of eggs which the hens can incubate. The production cycle comprising laying, incubation and brooding of the chickens has an optimum length for maximising the reproduction capacity.

The more precise the purpose of keeping poultry can be formulated, the more specific the breeding strategy can be formulated and thereby selection of the most suitable breeds.

As long as the target is to improve the offtake from traditional poultry keeping, it will often be useless, if not harmful, to change the genetic potential either by a cockerel exchange programme or by using improved breeds.

The semi-scavenging model from Bangladesh, as described by Dr. Saleque, is an integrated model which includes artificial incubation. Consequently, egg production traits are of more importance than brooding traits, which again lead to a different breeding strategy. The breeding target is to increase the genetic potential for egg production under semi-scavenging conditions. This is done by using improved breeds. A cross between Fayoumi and RIR has proved to be superior to commercial hybrids under semi-scavenging conditions.

Although, not formulated in the breeding strategy, the smallholders themselves have developed a system where they have a few local breeds used to hatch and brood chickens based on eggs from the improved hens. The mix of breed (local and improved breeds) have proven to be an essential element in the sustainability of the model.

It is stressed that scientific documentation for the best breeds under scavenging or semi-scavenging conditions is scarce. In particular scavenging and survival traits are seldom included in characteristics of breeds tested under field conditions, not even for local breeds.

Awareness

Scavenging poultry account for by far the largest number of livestock in developing countries, but is more or less neglected as an income generation activity by institutions and by the poultry holder themselves.

Awareness goes for institutional staff as well as for the smallholder. The smallholders shall change their views of poultry from " just something there is around" and which can be useful for festive occasions and when there happens to be surplus for consumption, to recognising poultry as an economic resource with a substantial income generating potential. The development community shall be aware of this potential and in particular the scope for using a poultry programme as poverty-breaker for the poorest section of the rural population. Awareness is as such much more important than sophisticated breeding programmes.

From Andrew Speedy <andrew.speedy@plant-sciences.oxford.ac.uk>
Comments on scavenging poultry

We have had quite a number of papers on scavenging poultry and ducks, plus fish-poultry systems, but few comments except from Hans Askov Jensen.

It is a serious indictment of the system if there is so little interest from institutions, animal production workers and nutritionists in the most numerous and important form of livestock in the world. In Africa alone, there must be literally billions of birds. We know little of their natural diet, and particularly how to improve it.

On a recent trip to Vietnam, I was struck with the idea of using manure or similar to stimulate insect larvae production. Has this ever been tried? The only serious review on insects as human and animal food was "The Human Use of Insects as Feed and Animal Feed" by Gene R. Defoliart. Bulletin of the Entomological Society of America 1989, vol.35, no.1 pp.22-35 66.

It must be that insects, insect larvae and other invertebrates (worms etc.) are the most important source of protein for scavenging chickens. Colleagues have told me that there are local practices to encourage maggots by burying rotten food, etc. Does anyone know of deliberate attempts to 'farm' invertebrates for poultry food? We know of earthworm cultivation, of course.

Defoliart mentions: "The development of economical mass-harvesting strategies, controlled mass production, insect recycling systems for converting organic wastes into high protein animal feed supplements, and mass-harvesting strategies for *Locusta migratoria*, grasshoppers, Mormon cricket and other pest species that form destructive aggregations..."

He also summarizes protein quality for rats and poultry which is of course very good.

Andrew Speedy

From "Hammond, Keith (AGAP)" <Keith.Hammond@fao.org>
Comments on scavenging poultry

1. Where scavenger poultry are in common use they may offer the most significant, readily available avenue of untapped potential for low-cost, rapid genetic development of animal protein production.
2. Little is known of the relationships between primary fitness traits and production traits in Scavenger poultry populations.

Keith Hammond FAO

From Stephen Swan <swans@wave.co.nz>
Comments on Rural Poultry Development Priorities

I have worked in the field of village poultry development since 1974, in the Pacific, Asia and Africa.

Maybe Andrew Speedy (comment of 27 January) is right. But maybe we poultry people are so busy we hardly have time to read the papers let alone respond. I found most of the papers very interesting. I sincerely wish I had more time to digest them and respond more carefully. Here is the result of a relatively off-the-cuff contribution.

I would like to throw in something for thought bait, especially after Keith Hammond's comment (of 27 January responded to in para 2 below).

1. While this conference is about, keep in mind that feed is not the most important issue with poultry development, it is disease. It was good to see this emphasised in Rangnekar and Rangnekar's FAO TFCONF2 Short Communication of 20 January Genetics and breed improvement rank after these and after housing and management.
2. We should not assume village farmers cannot understand the concept that commercial poultry lay many eggs but make poor mothers. This is the result of a well-known negative genetic correlation between egg number and broodiness. Farmers quickly realise: that these "foreign egg laying machines" can't look after themselves very well, but will produce many eggs if fed and cared for properly; and the local hens can be used as incubator machines to produce more "egg machines" or various

mixtures. In Hans Askov Jensen's comments of 16 January you read that village farmers are supplementing natural brooding with artificial incubation, probably using the traditional rice husk incubator. His research input into the Bangladesh situation has touched the surface of the interesting problem of "which is the best breed combination for profit maximisation?" within the village farming system.

Farmers are usually well aware of the risks involved in losing mothering and survival ability to gain egg number. Thus the concern about loss of local genetic material is not fully justified.

Bangladesh is the best example (FAO TFCONF2 Paper 25: BRAC) of a successful village poultry development programme, and there is no chance that they will run out of local broody hens.

From the population genetics point of view you may picture the village poultry population as a pool of genes under pressure from many directions. Disease, predators, lack of feed, poor housing and poor drinking water are the main pressures. Throw a few "high egg number" genes into the pool and what happens? Their correlation with low broodiness will reject them when they try to multiply. Even before this happens, other correlations of high egg number with lack of alertness to predators, poor colour camouflage against predators, and legs too short for fast running will likely cause their number to quickly reduce in the gene pool. If the farmer provides them with expensive food, and accommodation, they may reward him/her with income generated from eggs and meat. The farmer protects them from the natural exposure to the environment which has given us the village chicken.

3. The farmer is unlikely to do any of these things unless he can reduce the scourge of Newcastle Disease, which seems to have very little genetic resistance against its attack. Vaccine is required. The biggest single development in rural poultry has been the advent of heat tolerant Newcastle Disease vaccine. Availability of this vaccine in most developing countries is very low. Peter Spradbrow, of Queensland University, has recently been most effectively active in Asia and Africa in promoting the low-tech production of his I2 strain of this vaccine.

Development projects which include poultry should concentrate first on a stable supply of this vaccine and its distribution and use in the

village, BEFORE looking at other factors such as feed, water, and housing.
4. A farmer will put no efforts/investment towards poultry if he is going to lose 80-90% of his flock every second year. This is why this terribly high-risk sector of the village farming has been left to the women and youth of the village. Developers who succeed with vaccination programmes should take good care to ensure social pressures are available to keep poultry in the hands of women and youth. Emphasis on traditional roles and rights may be effective here. It would be very interesting to learn about the strength of such factors operating in the villages in Western India covered by Rangnekar and Rangnekar's FAO TFCONF2 Short Communication of 20 January. The recent (September 96) Rural Poultry Symposium as part of the Worlds' Poultry Science Congress in New Delhi, had some interesting papers on this of women in rural scavenger poultry development.

Stephen Swan <swans@wave.co.nz>

From Manuel Sanchez <manuel.sanchez@fao.org>
Comments on the use of insects as poultry feed
In order to answer the question of Andrew Speedy on the production of insect larvae for poultry, I can give the example of the activities which have been promoted by the FAO project in Honduras in support of Rural Women (GCP/HON/017/NET). Apart from the support given to womens' organizations, the project is using rural poultry production as the main activity to increase income generation and to improve nutritional standards. The main technology is the construction and operation of a functional poultry house, where birds spend the night, lay and incubate their eggs, get vaccinated, etc. If it is well constructed, this "gallinero" as it is called in Spanish, makes all the difference in terms of bird survival and egg yield. The "jaula criadero" or "rearing cage" for the first few weeks of the life of chicks, which could be associated to the poultry house, require providing feed appropriate for the adequate chick's growth. And what better than earth worms, insect larvae and termites. Insect larvae are produced with kitchen and vegetable residues placed in a set

place to decompose where the various insects come to lay their eggs. Termites are not only collected from nature, but they are also kept near the house in order to gradually take some slices off to feed the chicks. There are even attempts to feed the termites with branches of the trees they use to eat (Francisco Oviedo, Honduras, personal communication).

There is certainly a need to do research in the culture of insects such as cockroaches and termites, both of which have the unique ability of digesting cellulose and synthesizing essential amino acids from non-protein nitrogen. In fact, we are now looking for a researcher who would be interested in this subject.

In some countries in West Africa they already have a primitive way of rearing termites on crop residues (on inverted clay pots or baskets) for poultry supplementation. These practices should be well documented and expanded to other regions.

Concerning the use of insects and other invertebrates as feed, useful information, such as short communications and literature reviews, is available in the Semestrial Bulletin of Information on Mini-Livestock edited by Prof. Honor. Dr. Ir. J. Hardouin (BEDIM, c/o Unite d'enseignement et de Recherche en Zoologie Generale et Appliquee, Faculte Universitaire des Sciences Agronomiques, 2 Passage des deportes, B-5030 Gembloux, Belgium). In this bulletin, the following reference was quoted:

Ravindran V. and Blair R., 1993. Feed resources for poultry production in Asia and the Pacific. III. Animal protein sources. World's Poultry Science Journal, 49, 219-235.

This paper gives some information on the nutritive value of locusts, crickets, termites and other insects as adults, larvae or pupae as source of protein for poultry.

In Volume 1, No 2, 1992 of this bulletin, some information is also given on termites as feed: it reports on the traditional use in many developing countries to supply day-old chickens or guinea fowls with termites and it is even reported that in Togo termites are bred for this purpose.

Manuel Sanchez FAO

From Aichi Kitalyi <fspzim@harare.iafrica.com>

Comments on feed resources for scavenging poultry in the villages of Africa

I am writing in response to Andrew Speedy's remarks on feeding the scavenging chickens.

I have been following with keen interest the contributions on scavenging poultry in developing countries. The role of scavenging chicken as presented by Tadelle Dessie is representative of most African countries. Further, the symposium on rural poultry development at the recent XX world poultry congress in New Delhi underscored the importance of rural poultry in household food security, income generation, employment and gender equity in developing countries. These are all reasons for concern on the little research conducted in this sector.

Little has been done on the scavenging feed resource for village chickens in Africa. This area was forgotten because most poultry scientists wanted all chickens to be fed concentrates or grain based diets for higher production per bird. However, to-date 80 - 100 % of the daily ration of the scavenging poultry is derived from the scavenging feed resource.

Gunaratne *et al.*, 1993, found out that scavenging village chickens of Sri Lanka were getting over 72% of their daily diet from the scavenging feed resource. Roberts (1992) developed a simple model of the scavenging village chicken production system in Sri Lanka. One basic fact from the Sri Lanka research is that the scavenging feed resource base can be the most limiting factor in village chicken production when major diseases such as Newcastle Disease have been taken care of.

Currently there are bilateral and multilateral development programmes working on Newcastle disease control in a number of African countries. Parallel to these disease control programmes, there should be farm-level applied research work on the improvement of the quantity and quality of the scavenging feed resource base.

What constitutes the scavenging feed resource base?

Generally, the scavenging feed resource of village chickens depend on the agricultural production system prevailing in the village. This includes the cropping pattern, the animal production system and more specifically the eating habit of the society. Tadelle and Ogle, 1996a and b, reported that the scavenging feed resource is highly variable in quantity and quality. Protein is a critical nutrient in dry season whereas energy is limiting in wet season. These findings call for research cost-effective technologies to increase the quantity and quality of the scavenging feed resource base in the villages.

Ravindran and Blair (1993) give an in-depth review of animal protein sources for poultry which include the invertebrates. The review which has 122 refs. gives the chemical composition of the different sources including, insect meals (housefly larvae, housefly pupae, soldier fly pupae, silk worm pupae, bee, Mormon cricket and grasshoppers). Other sources included in the review are termites, earthworm and snail meals. The review is very interesting because it also gives some harvesting techniques.

Farina *et al*., 1991, reported on research on production of termites in villages in Togo. The harvesting technique is as follows: a hole in the termitary is covered with an earthware pot filled with moistened fibrous waste and protected against excessive heat and desiccation. Termite larvae develop in the humid atmosphere and are collected after 3 to 4 weeks. In field visits to Gambia and Zimbabwe, a few farmers indicated that they collect termites for their chickens.

No doubt the population of the invertebrates in the soil can be manipulated by changing the physical and chemical composition of the soil. This is shown by Alvaro Ocampo's contribution to this electronic conference. There is increased access of invertebrate food to scavenging chickens in agro-pastoral systems as you find the chickens scavenging this in the kraals, bomas or any piles of manure. The worm cultivation for fishing in Zimbabwe is another indication of possibility of introducing such technology for scavenging poultry.

It seems the farmers are ahead of the scientist. It is high time researchers and rural development workers come up with appropriate technologies for harvesting and using such novel feed resources. Probably the newly launched FAO/SIDA regional programme, Farm-Level Applied Research Methodology in Eastern and Southern Africa (FARMESA) will look into this area.

Various techniques have been tested in Asia and Latin America but there seems to be little research in Africa.

In view of the recent developments in livestock production and sustainable agriculture and its relationship to poverty alleviation among the poorest of the poor, I am optimistic that this area will receive due consideration.

Dr. Aichi J Kitalyi FAO Andre Mayer Research Fellow (AGAH).

References

Farina, L., Demey F. and Hardouin, J. 1991. Production de termites pour l'aviculture villageoise au Togo. Tropicultura, 9, 4, 181-187.

Gunaratne, S.P., Chandrasin, A.D.N., Mangalika Hemalatha, W.A.P. 1993. Feed resources base for scavenging village chickens in Sri Lanka. Tropical Animal Health Production. 25. 249-257.

Ocampo, A. 1996. The African oil palm in integrated farming systems in Colombia: new developments. Eight Paper, FAO Electronic Conference on Livestock Feed Resources within Integrated Farming Systems. http://www.fao.org/waicent/FaoInfo/Agricult/AGA/AGAP/FRG/

Ravindran, V. and Blair, R. 1993. Feed Resources for poultry production in Asia and the Pacific. !!!. Animal Protein sources. World's Poultry Science Journal, Vol. 49, November 1993. 219 - 235

Roberts, J.A. 1995 Assessing the scavenging feed resource base for sustainable smallholder poultry development. Draft. Department of Biomedical and Tropical Veterinary Sciences, James Cook University, Australia.

Tadelle, D. and Ogle, B. 1996a. A survey of village poultry production in the central highlands of Ethiopia. Msc. Thesis, Swedish University of Agricultural Sciences.

Tadelle, D. and Ogle, B. 1996b. Nutritional status of village poultry in the central highlands. A survey of village poultry production in the central highlands of Ethiopia. Msc. Thesis, Swedish University of Agricultural Sciences.

From David Farrell <farreld@dpi.qld.gov.au>
Comment on paper by Tadelle Dessie on scavenging poultry (Paper 26)

This is hugely complex topic not least of all the socio economic implications. Villagers may not view the role of these chickens in the same way as we do. There have been many small projects looking at how production can be improved without any inputs into the system. Others have cost time and money and are usually not accepted by the farmer. By making small changes in management, saleable eggs (as opposed to total egg production) can be increased simply by reducing the numbers of eggs brooded. Irrespective of numbers brooded, traditionally only 3-4 birds reach maturity. Although this is an interesting and an important area, village chicken production is not necessarily only scavenging chickens. In many countries there are small rural chicken production systems which may use improved technology, management, breeds etc and quite successfully. If one looks at the predicted protein demand in developing countries it will come largely from poultry as is already happening. It is clear that in the long term the modern, large scale integrated poultry units are not sustainable. There will not be the feed resources necessary by the year 2010 to meet estimated demand. The long term view is to encourage small-scale poultry farming systems based on local resources as far as possible. This might include the use of native chickens favoured greatly for their meat and eggs and later crossed with improved breeds (see comment by Keith Hammond) that would produce a dual purpose bird. This is a fascinating topic which has exercised the minds of many with limited success but is still worth pursuing because of the enormous potential to assist rural-based communities and to encourage them to stay in villages rather than to migrate to cities.

David Farrell University of Queensland and Queensland Poultry Research and Development Centre

Addendum:

Alternative protein sources for poultry such as insect larvae, earthworms, are great ideas, the problem is harvesting the end product and then fitting the process into a viable production system. I have seen it work in China but not practised widely. (See article on 'Fly pupae as a protein source' in World Poultry - Misset Vol. 12 (10) p69 1966).

From Steven Slippers <sslipper@pan.uzulu.ac.za>
Comments on scavenging poultry

1. In response to Dr. Speedy's question about "farming" invertebrates as poultry food:

Smith (1990) described a technique for growing maggots (larvae of *Musca domestica*) as a food source for poultry, developed by the Kusasi tribe of north-eastern Ghana. Cultivation of earthworms as protein supplement for scavenging birds is also discussed briefly.

[Reference : Smith, A.J., 1990. Poultry. Macmillan Education Ltd, London, in co-operation with CTA, Wageningen. p 186-187.]

2. Regarding few comments on scavenging poultry as an indictment of the system:

The scavenging poultry system is an important component of the farming system of smallholders in South Africa (as in many other parts of the world). So the indictment is rather of us as research fraternity that has either failed to investigate scavenging poultry systems adequately (if at all) or has failed to report our results (for lack of time, as one excuse!).

Published information about the role of scavenging poultry systems in South Africa is scant. A survey was recently conducted in the north-east of Kwazulu-Natal province in South Africa, to investigate the scavenging poultry systems amongst smallholders in the subsistence sector (Nhleko et al, 1996).

[Reference: Nhleko, M.J., Slippers, S.C. & Lubout, P.C., 1996. Poultry production amongst subsistence farm households in Paulpietersburg, Northeastern Kwazulu-Natal. Proceedings of Joint Symposium on "Local community involvement in breed conservation and utilisation" by the Developing Areas Branch of South African Society of Animal Science, Rare Breeds International and Association for the Conservation of Early Domesticated Animals of Southern Africa. Pilanesberg, 30 September

1996 - 3 October 1996.]

Some of the results of Nhleko *et al.* (1996) are summarized below. Six to eight households per induna ward (ngesigodi) were randomly selected from fourteen wards (izigodi) in the Paulpietersburg district. Thus 96 households were surveyed. All households surveyed kept one or more species of poultry. The species distribution by household was:

Species	No of Households	% of Households
Chickens (indigenous)	96	100
Ducks (muscovy)	12	12.5
Geese	6	6.2
Pigeons	2	2.1
Turkeys	1	1.0
No of households surveyed	96	

The species distribution by number of birds was :

Species	No of birds	% of bird numbers
Chickens	2135	95.0
Ducks	47	2.1
Geese	40	1.8
Pigeons	23	1.0
Turkeys	2	0.1
Total	2247	

Results indicate that 81.2% of households kept a single species (indigenous chickens); 15.6% of households kept two species (9.4% chickens and ducks, 4.2% chickens and geese, 2.1% chickens and pigeons); 3.1% of households kept three species (2.1% chickens, ducks and geese, 1.0% chickens, ducks and turkeys). Indigenous chickens clearly play a dominant role in poultry production in the survey area, with waterfowl favoured as secondary species (ducks or geese or ducks and geese, in descending order of priority). There seems to be considerable (technical) potential for further integration of waterfowl in the poultry production systems of subsistence households, in view of the much higher foraging capacity that waterfowl enjoy over chickens (a major advantage in systems where scavenging for food is the rule). However, the cultural acceptance of waterfowl must be carefully considered. For example, the followers of the Shembe religion in Kwazulu-Natal do not keep ducks for religious reasons.

In those households which kept a particular species (one or more), the average flock size was 22.2 sd ± 13.8 (indigenous chickens), 20.0 sd ± 14.1 (pigeons), 3.9 sd ± 1.4 (ducks), 3.7 sd ± 1.6 (geese) and 3.0 sd ± 0 (turkeys).

Women were responsible for poultry husbandry in 74 households (77.1%), with men responsible in 22 households (22.9%). The average age of poultry keepers was 45.7 years (sd ± 11.8) for women, and 49.8 (sd ± 14.0) for men.

Such factors, especially the gender issue, should be considered by policy makers and development agencies, when allocating extension workers and targeting receivers, for poultry development projects in the survey area.

The dominant role of women in poultry husbandry was also evident in other countries, as reported earlier in this conference, by Rangnekar & Rangnekar (India; third short communication); by Tadelle (Ethiopia; twenty sixth paper, part one); by Saleque & Mustafa (Bangladesh; twenty fifth paper, part one).

The predominant poultry keeping systems can be described as follows, in 50 households:

System	% of households
Scavenging, without housing, with nests	50
Scavenging, with housing, without nests	22
Scavenging, with housing and nests	18
Free-range (confined scavenging), with housing & nests	10

The supplementary feeds used in 50 households, were mainly white maize (70% of households), yellow maize (24% of households), or a combination (1:1) of white and yellow maize (6% of households). In a few cases commercial concentrates were fed, mainly for chicks in a creep system. Reasons quoted by farmers for using white maize, included:

- It is always available and is planted by them (12%)
- Traditional use by ancestors (26%)
- Fattens chickens and ensures good growth (58%)
- Ensures high hatchability of eggs (4%)

Reasons quoted by farmers for using yellow maize, included:

- Chickens grow well (10%)
- Fattens chickens and makes them lay more eggs (60%)
- Can be planted and is resistant to drought (30%)

Other aspects covered by the survey, include reasons for keeping poultry, mortality rates, prevalent diseases, egg hatchability, and predators. The results will not be presented here, for brevity's sake. The survey was followed up with on-station and on-farm experiments. The results are currently being analysed.

In conclusion, the scavenging poultry production scene in north-east Kwazulu-Natal appears to correspond in many respects to that of other countries, judging from the papers, short communications and comments contributed earlier in this conference.

Stephen Slippers, Senior lecturer, Animal Production Department of Agriculture, University of Zululand, Private Bag X1001, Kwadlangezwa 3886 South Africa

From Stephen Swan <swans@wave.co.nz>

Comments on Aichi Kitalyi's comments on scavenging poultry

1. The use of unusual feed resources to expand the scavenger poultry feed resource base is very useful in terms of meeting the needs of farmers (as Dr Aichi Kitalyi says in her comments) because *"... the scavenging feed resource base can be the most limiting factor in village chicken production when major diseases such as Newcastle Disease have been taken care of."*

2. I would again like to take an opportunity to emphasize that while (again from Dr Aichi) "Currently there are bilateral and multilateral development programmes working on Newcastle disease control in a number of African countries", there is often a conflict because of resource limitation.
3. I have worked with projects in many countries which try to develop the full package of feeding, management and genetic improvement programmes ALONGSIDE those aimed at Newcastle vaccine production and distribution. Often what suffers, as limited resources try to cover all aspects (and while the veterinary department (vaccines) are giving some of their valuable large-animal time to these "relatively unimportant" small-sized little chicken animals) is the vaccination aspect.
4. Another factor working against the success of vaccination programmes is that sustainable vaccine supply lines extending to village level are not visible or easily evaluated. In contrast, poultry structures (houses) for genetic improvement programmes, and live poultry distribution programmes, which are often given away or heavily subsidised, are VERY visible and popular with the village farmers. The farmer will always accept a gift which can be quickly sold if sickness visits the compound.
5. However the priority for the farmer is first to prevent the regular disease outbreaks which make poultry such a high-risk element of the farming system.

Stephen Swan <swans@wave.co.nz>

From Alessandro Finzi <finzi@unitus.it>
Comments on scavenging poultry

I am surprised only Keith Hammond underlined the importance of primary fitness traits and production traits when discussing on scavenging poultry. In fact genotype must be considered when nutrition problems are under examination.

I have observed that in hot climates lighter hens (local or Leghorn type) are much more active than heavier birds (Rhode Island Red or other breeds producing brown eggs). Light birds are still scavenging when the heavier ones are already standing panting in the shadow and they also begin early to scavenge in the afternoon. This means that lighter breeds have both lower maintenance needs and a higher capacity to nourish themselves by scavenging in the hot hours of the day. This is one of the reasons we indicated to explain the failure of a project in Somalia aiming at the substitution of local chicken with Rhode Island Red (Good and Finzi, 1987). In fact morphological traits of R.I.R. were not maintained in the flocks and the brown colour of the shell also disappeared rapidly from the eggs which also become smaller as at the beginning of the project. In the meantime the number of the birds was regressing to the original one of about three for each human family in the villages and six to twelve in the rural areas. This standard number was explained according to quantity of feeding resources scavenging poultry can find around each inhabited hut.

If these observations are confirmed, it should be advised not to try to substitute local scavenging breeds until scavenging is considered a worthwhile management practice for poultry (see comment by David Farrell). When some feed integration is offered to the animals, the perspectives are better if the goal is to increase individual productivity than to increase the number of the raised animals (Finzi *et al.,* 1985).

References

Good A. and Finzi A., 1987. Contributo allo studio dei problemi del miglioramento genetico nell'allevamento rurale avicolo in Somalia. Boll. Sci. Fac. Zoot. e Vet., Muqdisho, 8, 49-53.

Finzi A., Barre H. G. and Sabriye M.C., 1985. Dhaqshada digagga ukunta ce xaasaka soomaaliyed (Breeding lying hens in the rural system in Somalia). Ed. Univ. Naz. Somala, Muqdisho.

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From Rena Perez <71055.111@compuserve.com>
Comment on feeding poultry with earthworms

1. Many years ago a Cuban ambassador to the Philippines told me an interesting tale about how a small-scale, near-Manila, farmer fed his chickens. The farmer had three plots of earthworms and morning and night he simply opened the gate and let his 20-30 chickens into the area to fend for themselves!
2. Several years ago while visiting CIPAV in Cali, Colombia, I was taken to the sugarcane/animal farm of Didimo Guzman some 2000 metres up in the mountains. Didimo produced earthworms on cattle dung and fed his 30-40 chickens on cane juice, *Trichanthera gigantea* forage and 3 wheelbarrows of digested cattle dung/worms/humus, which he simply dumped on the earthen floor of the chicken yard. The chickens devoured the worms and at the same time their pecking and scratching dried out the humus which he collected daily for use as organic fertilizer for planting sugarcane.

Rena Perez, Cuba

From Bayer <wb.waters@link-goe.de>
Comment on scavenging poultry and pest control

I'm following with great interest the contributions and discussions on scavenging chickens and ducks. What a change over recent years! Five or six years ago it was very difficult to find anybody to work in this area. I still miss one aspect. Poultry can control pests. In the BOSTID book on micro-livestock (National Academy of Science, 1991, Microlivestock - little known Small Animals with a Promising Future. Washington: National Academy Press), it is mentioned that Canadian farmers achieve a 80-90 percentage fly control in enclosures such as calf rooms or piggeries with muscovy ducks. The economics are very good. A 35 cows dairy farm needs $ 150-390 worth of chemicals to control flies - a muscovy chick costs about $2 - and can be sold or eaten after some time.

I observed myself how chicken in cattle kraals eat ticks. I even saw chickens jumping up to a cow, taking off ticks. Grasshoppers, and flies around houses are eagerly eaten both by ducks and chicken, reducing the insect pressure on land. Ducks can be used to control snails in fields etc. I myself have not made any detailed studies of these effects, but I wished to mention it. More intensive housing of poultry would impair this function.

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From Rene Branckaert <Rene.Branckaert@fao.org>

Comments on feeding poultry with earthworms and on scavenging poultry and pest control

1. Feeding poultry with earthworms:

Various experiments have been conducted on the use of earthworms for feeding poultry, especially in Benin (see Vorsters) and in the Philippines (see Barcelo and Barcelo, University of La Union). Most results were disappointing: the reason is that earthworms are intermediate hosts for Cestodes, like Davainea or Railletina. There are two possibilities:

- To kill and dry the earthworms before using them as feed.
- To deworm poultry on a regular basis.

2. Scavenging poultry and pest control:

Ducks can be used for the control of snails in rice fields, especially the Golden snail which is rapidly spreading throughout South-East Asia but also Limnea sp. which is the intermediate host of cattle liver fluke. An interesting trial is presently conducted in Central Luzon University (Munoz, Philippines) by Ms. A.G. Caguan.

Rene Branckaert FAO

From David Little <little@ait.ac.th>
Comments on scavenging poultry

The comments on scavenging poultry have all been very interesting so far and I have found Stephen Swan's comments a real education.

Over the last few years we have looked at the scavenging poultry interactions and their potential integration with fish culture in Northeast Thailand. We followed 7 households in detail through an annual cycle after they expressed interest in using the poultry waste as a pond fertilizer. Whether these two minor parts of the farmers' livelihood systems reinforce each other and lead to further productivity increases was our main interest.

What became quickly clear was that in the context of the farmers we worked with, both are minor elements in terms of cash but have important roles within the household.

Although mixed poultry flocks were the norm, village chickens dominated.

Disease was a major issue. Over the year farmers lost around 60% of their poultry, 17% were eaten by the household and 23 % sold (usually within the village on a reciprocal basis). Of these mortalities, over 85% were just hatched or starters, so, on a weight basis the loss was much less (22%). Over 70% of mortalities were related to diseases and parasites, with accidents and animals (chiefly dogs) taking care of another 12 %.

50% of poultry is consumed at these gatherings which are intimately linked to agricultural activities and more than 20% to other "parties, ceremonies or festivals". Less than 20% are eaten as everyday food. Among the households followed they produced over 90% of their own needs.

Perhaps this part of Northeast Thailand, or Thailand generally, is atypical of others in the region in that the broiler industry is so well developed and might be expected to reduce opportunities for marketing village chickens - but the opposite appears to be the case. Farm gate prices for village chickens are high and in addition to a healthy demand in the village, middlemen scour rural areas to buy them for urban consumption.

Vaccines are available, although purchasing and using them for small batches of naturally incubated chickens makes their adoption sporadic and efforts to promote them, as Stephen Swan said, are undermined in many ways. Diseases apart from Newcastle appear to be important so even if the heat tolerant vaccine was available it would surely not be a magic bullet. Ectoparasites were also an important source of mortality in young birds, but one that farmers could to some extent control through easily available drugs and changes in husbandry and management can alleviate.

Surely a critical point is that if there was improved survival of scavenging poultry chicks in the village - would there be adequate supplementary feeds to support them?

From the perspective of the Northeast Thai situation, it is clear that paddy grain and ricebran, the key feeds used, would be insufficient to support a larger flock size. As it is, farming households appear to allow for high early mortalities, and the productivity of the surviving breeding birds allows an average production of between 1-2 birds per week in all of the households followed. This appears to satisfy the farmers' needs. A major role of the poultry is to provide convenient and high quality "feast food" to serve/support agricultural work that requires contracting of labour. Culturally, hiring labour for rice transplanting, or field crop harvest requires the farmer to lay on good food. Village poultry, and farmed fish are conveniently available nearby and are considered high quality.

The point here is that profit maximisation is not an issue, for either poultry or fish subsystems, but rather the cultural value attached to ensuring good relationships with hired agricultural labourers, who may often be neighbours and friends. This is particularly important in the context of high demand for manual labour during the peak agricultural periods (transplanting, harvest). Labour is now scarce and expensive and the land owner can ill afford time to go off-farm to obtain wild fish and poultry from local sub-district markets - at this time home produced food is of especial value.

Surely the point is that any attempts to "improve" poultry systems probably needs to consider both the overall needs of the farming households and off-farm context, in addition to disease and feed issues.

From Farrell David <FarrelD@dpi.qld.gov.au>

Comment on paper by B.X. Men on the role of scavenging ducks, duckweed and fish in Vietnam (Paper 27)

I was most interested in this paper. The description of the system is essentially the same as many integrated duck/wet land rice producing systems elsewhere (South China, Indonesia). My information from duck farmers in the Mekong Delta region is that the improved breeds (Cherry Valley, Khaki Campbell) were in fact coping very well with the local environment and capable of foraging in the rice fields, despite differences in physical characteristics compared to local breeds. Their productivity was better but this may also reflect better management, feed etc. My information is that the majority of ducks in Vietnam are kept for eggs. While meat ducks are raised mainly during the post rice harvest period when they collect fallen rice.

A major problem with scavenging laying ducks is a regular supply of calcium. They can obtain snails, shell fish, etc in the flooded fields but not after harvest. Thus strategic feeding should complement what ducks are obtaining from scavenging i.e. high energy grain after harvest should require protein/Ca, and conversely when the fields are flooded.

Mr Men has identified a major problem. Changes in rice cultivation practice, new cultivars, high inputs of pesticides, fertilisers as well as the introduction of threshing machines in the Mekong Delta. This will tend to concentrate fallen rice. The current traditional duck raising system is under threat and this will probably lead to greater intensification at increased cost. The traditional scavenging systems depend on low inputs and cheap labour. Inevitably duck products will increase in price. These small duck farmers, perhaps with flocks of only 50-100 ducks need assistance. They have no voice at a national level but their sole livelihood may depend on duck eggs or meat. Like village and scavenging chickens it is a complex problem, requiring a detailed knowledge of the whole system. I wrote an article recently on these systems and nutrients requirements of table eggs laying duck (see Poultry and Avian Biology Reviews 6(1) 55-59 1995) because this has been an ongoing interest of mine for 15 years. Duck meat is the fastest growing poultry meat; it increased by 25% each year over the past two years.

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From Bui Xuan An <an%sarec%ifs.plants@ox.ac.uk>
Comments on scavenging poultry

I agree with the conclusions and recommendations given by Tadelle and Men. As you know, Vietnam ranks second in the world in the number of domestic ducks raised. Traditionally domesticated ducks are kept in paddy fields and production is closely integrated with rice cultivation. This system have been applied in many southeast and east Asian countries and the system has several advantages (Men's paper).

In recent years, farmers have been encouraged to adopt modern farming systems using high-yielding rice varieties, chemical fertilizers and agricultural chemicals, and modern breeds of duck. As a result, a lot of serious issues have been raised, including lowering land productivity, health hazards and environmental pollution. At the same time, the traditional combination of rice culture and duck farming is disappearing.

The time has come to reassess the value of the Asian duck-rice farming system. There were some on-farm experiments on this system in Vietnam carried out by VACVINA (Vietnam Integrated Farming System Union). According to Tran Van Nhu (VACVINA Haiphong SAP-center, 1995), the result was a [rice] yield of 120% and farmer's income of twice as much as that of the ordinary farming system.

The question is how to disseminate the information. There are many problems and constraints. The development needs to be based on the whole system including not only rice and ducks, water and soil, but also socio-economic factors, institutional and organisational ones.

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From Stephen Swan <swans@wave.co.nz>

Further comments on points raised by David Little on scavenging poultry

Concerning scavenging poultry and fish culture, David Little states that they are minor elements in terms of cash but have important roles within the household. I would like to add that small animals represent easily liquidisable assets, and are attractive because of this.

David Little's figures on poultry mortality sound typical. Poor nutritional status of baby chicks leaves them more open to disease attack. Also Tadelle comments heavily on this in his MSc work in Ethiopia where I was also able to work with him. This can be overcome with a creep feed system using the fish trap shaped like a cone, made of bamboo cane strips with gaps large enough for a chick to get through but not the mother hen.

Concerning the high farm gate prices for village chickens reported by David Little, I think broilers are soft and tasteless to the "village" -chicken- educated palate. Thus it must appeal to a different market niche. Village chicken usually attracts a big price margin per unit of body weight.

Concerning the vaccines, surely the Newcastle Disease (ND) heat tolerant vaccine IS available in NE Thailand? Peter Spradbrow <P.Spradbrow@mailbox.uq.oz.au> should be able to tell where. He is providing his non-commercial I2 seed heat tolerant strain to our FAO TCP project in Myanmar (I hope).

I think ND *is* the single most important cause of mortality in village poultry, and the other diseases can be resisted with a better nutritional status provided to the chicken, compared to ND which rips into the healthiest chicken regardless.

Concerning ectoparasites, leg mites can be treated with a mixture of waste engine oil and kerosine painted onto the legs and mothballs mixed with ash as a dust bath is a good feather mite treatment.

David Little asks: *"If there was improved survival of scavenging poultry chicks in the village - would there be adequate supplementary feeds to support them?"*

Or alternatively, from the farmer's point of view, if the chickens would only stop dying from ND, it might even be profitable to invest in some grain/oilcake to supplement their scavenged feed. Evening supplement of a choice of either will allow their very accurate diet awareness to select whichever was lacking in their day-time foraging.

If there is no place for supplementing in the farming system, which is certainly the case in some refugee resettlement camps, then at least with a controlled ND situation, one can be sure that the chickens are fully utilising the Scavenger Feed Resource Base and birds surplus to this available supply can be sold.

David Little states: *"Surely the point is that any attempts to "improve" poultry systems probably needs to consider both the overall needs of the farming households and off-farm context, in addition to disease and feed issues."*
Agreed, but I think this traditional system has evolved around the need to live with the high losses associated with ND and poor baby chick nutrition, and I see nothing too invasive about offering options which allow the traditions to continue, but having a greater cash flow.

Feed supplementation of scavenger poultry offer an income generating opportunity to Extremely Vulnerable Individuals (EVI) in the village situation (such as widows, women-headed households etc.) to start into the livestock field, adding this important element to their farming system.

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Comments on: The integration of fodder shrubs and cactus... by A. Nefzaoui

From Claudio A. Flores Valdez <caflores@taurus1.chapingo.mx>
Comments on the efficiency of water use of *Opuntia* compared to alfalfa
Apart from the well-known use of Opuntia as a drought feed, is it a major fodder all year round in your area? If not, what are the constraints impeding this happening considering its very efficient use of water compared to other traditional fodders?

Some reports from South Africa on the productivity of *Opuntia* versus alfalfa are:

1. De Kock, G.C.1965. El mejoramiento de nopales sin espinas (*Opuntia* sp), como forraje resistente a la seca. Anales 9no. Congreso Internacional de Pasturas. Sao Paulo, Brasil. 2:1459.
He found that *Opuntia* produced more TDN than alfalfa per unit of water provided.

2. Havard-Duclos, B. 1969. Las plantaciones forrajeras tropicales. Ed. Blume. Barcelona, España. 380 p.
He reports that with 3,000 cubic meters of irrigated water, given twice during the dry season, he can irrigate 1.17 ha of alfalfa or 17.55 ha of a combination of *Opuntia*-Atriplex (irrigation by rows), and the nutrients yields per ha are similar. Thus, this combination produces 15 times more nutrients than alfalfa with the same amount of water.

3. Monjauze, A. y Le Houreou,A.N. 1965. The role of *Opuntia* in the agricultural economy of North-Africa. Bull. Ecole Sup. Agric. Tunis. Nos. 8-9:85-164.
They consider the irrigation of *Opuntia* as an interesting possibility, since it produces seven times more energy than alfalfa per unit of water.

Opuntia is used as forage in the north of Mexico, where there are dairies producing all year round with *Opuntia* based-diets.

There is also beef production on rangelands where the amount of *Opuntia* used depends on the drought conditions. During the last drought, there were ranches where *Opuntia* was used for 30 months, by burning the thorns directly on the plant in the field.

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Comments on: ..Networking 24 Latin American and Caribbean Countries by E. Murgueitio and R. Espinel

From: Dr E R Orskov <ero@rri.sari.ac.uk>

Comments on Network in Latin America (thirty fourth paper)

I would like to ask a question related to the interesting article on the network on integrated use of sugar cane and local resources.

The authors outline a very successful network of scientists and refer to many interesting technologies that have been developed. The feeding to animals of sugarcane juice, etc., has, as the authors pointed out, been researched for about 25 years. What I feel is missing from the article is an impact statement similar to that provided by Guo Tingshuang on the number of farmers using a technology in China.

How many thousands or millions of farmers are currently using the technologies in Latin America?

These statistics may not be readily available but they are useful for the readers. It is all very well to know how many meetings have taken place and how many books have been published. The proof is how many farmers are benefitting and using the technologies. I am very impressed by the work so I hope this question is taken in a positive way. I am sure the authors have the information.

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From: Frands Dolberg <frands@po.ia.dk>
Comments on "the Outcome of Networking 24 Latin American and Caribbean Countries on Integrated Use of Sugar cane..."

On Networking:

I had the same thoughts as Bob Orskov. This networking seems to have gone very well according to a number of indicators. However, if we want to be critical - in a constructive sense - we also need to say that all these indicators (number of technologies demonstrated, books and videos produced, etc.) were all controlled by the "Networkers".

Adoption of technologies is not controlled by the networkers, but rates of adoptions are of course in a sense the final proof. But that is not all. Rates of adoption may also tell something about Government policy (conducive or not) including the institutional situation to back up adoption: Are extension services Govt or NGO in place?

Finally, this conference has shown many very interesting and fruitful examples of developing technologies in interaction with farmers. Our next step is now to see if such technologies can be adopted on a much wider scale and if not, why not? Thus we must move on to inclusion of these variables as well.

Frands Dolberg

From Reg Preston <thomas%preston%sarec%ifs.plants@ox.ac.uk>
Reply to Bob Orskov's question on how many farmers are feeding sugar cane juice and comparison with the China "straw programme"

Certainly the number of farmers using sugar cane juice can be numbered at most in hundreds (mainly in Vietnam and in Philippines) and certainly not in thousands. Sugar is a subsidized commodity in Colombia (Government fixes the price) and in most developed and developing countries (Philippines and Vietnam are exceptions) so the playing field is not level.

By contrast, we have the opposite situation where cereal grain is subsidized for animal feed in Europe and USA. There are thousands of farmers in developing country that use cereal grain to feed to ruminants.

Do we take this as proof of adoption meaning that the technology is an appropriate one?

Concerning the China "straw programme", China is China and very different from the rest of the world. The straw treatment programme was executed and supported by Government. This support, partially subsidized, helped to secure implementation and facilitated the gathering of the statistics.

It is much more difficult to have similar data for other "new" technologies which have not had such strong institutional support. A related question is: *How many farmers outside of China have taken up straw treatment and do we have statistics about this?* I think the answers are probably "very few" and "none", respectively.

I think there are various issues to consider. And until the practice of economics takes into account the real cost of fossil fuel and damage to the environment, technologies that are ecologically sound will always be at a financial disadvantage.

This does not mean that we should not do research on sugar cane juice (or other non-conventional feed resources). The reasons for promoting sugar cane have more to do with self-reliance (using efficiently free solar energy) and the environment (it improves soil fertility) than with short term economics. Natural resource management and use of local resources is the goal of all of us. But it is a long haul and the opposition to change is well endowed both politically and financially, and the vested interests are many.

Reg Preston from Philippines

From: Frands Dolberg <frands@po.ia.dk>

Comments on Reg Preston's reply to Bob Orskov's question on how many farmers are feeding sugar cane juice and comparison with the China "straw programme"

We have added miles to the research typically carried out in labs and on-stations, but getting out on farms as demonstrated in the contributions in this conference.

I argue the next step is to direct more attention towards reasons for adoption or non-adoption, where Government policies (subsidies etc, certainly are crucial). Such analyses may - in future - become part of livestock projects.

We should certainly do our best to distinguish between technologies which are good per se and policies, which distort or promote them.

In the early days of straw treatment work I understand it was tried in at least 30 countries and basically failed.

I suppose it is a lesson for all of us that factors both at farm, institutional and policy level are responsible.

Frands Dolberg

From: "E. R. Orskov" <ero@rri.sari.ac.uk>

Comments on Reg Preston's reply to Bob Orskov's question on how many farmers are feeding sugar cane juice and comparison with the China "straw programme"

Dr Preston has raised an interesting question which we must if possible discuss further.

First of all it would seem that all of us participating in this interesting e-conference could agree that our research should be problem led and identified clearly as the constraint or constraint which need to be alleviated to assist the small farmers in increasing prosperity and security. For this purpose PRA has been used and many other means of identifying farmers problems. Sometimes the problems can be solved directly with on farm trials with farmer participation sometimes the problems have to be solved on station to gain more control of the variables and to add extreme treatments to increase understanding which cannot readily be done on farms.

Then we have another angle. All of us are keen on sustainable technologies, environmental issues figure high on the agenda as indeed they should. So while some research may be the optimal environmental solution the fact that few farmers use it must mean that it is not the optimal solution for them given the present structure, including price of products, land tenure arrangements, market conditions, extension set ups, training of extension officers, policy makers etc.

We may therefore have a dilemma which we must face squarely. If the solution to constraints we have identified and which of course must in part be related to many other factors is not the optimal environmental solution what do we do?

Do we create an environmental research fraternity which is not plugged into farmers problems but seek to find solutions to perceived future problems rather than present problems. If so can this be adequately funded? I like to have more debate on these interesting issues raised by Dr Preston. Frands Dolberg pointed towards some solutions but I think it is an important issue which need further discussion.

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From Andrew Speedy <andrew.speedy@plant-sciences.oxford.ac.uk>
Adoption of technologies

In response to Bob Orskov, Reg Preston and Frands Dolberg:

There is a danger of 'expecting' the adoption of technologies and, indeed, this is often held as a measure of success of a 'project'. The 'livestock project' is itself top-down focussed. A better approach (advocated by Robert Chambers, Anil Gupta, etc.) is the 'basket of choice' or 'portfolio' approach. Yes, we develop technologies with on-farm research, then we make information widely available and it is the choice of the farmer to select the appropriate ones for his or her environmental and economic circumstances. The role of enablement should be included.

This is the philosophy behind Tropical Feeds (and also LRRD and other communications): to increase the knowledge and awareness of appropriate and environmentally sound ideas and to 'make them available'.

Governments and agencies need to change their approach to allow diversity of systems and not to push 'the project'. It is the antithesis of current 'accountability'! There is also the adverse effects of subsidies on not only cereals but also cheap oil.

I am reminded of my 9 years in extension in the 70s. I was surprised at good technologies that were only being adopted 20 years after the research was carried out (eg. parasite control in sheep and cattle). I learned that time and opportunism are factors too. And the proper development of whole farm systems.

Information published in Tropical Feeds will be made widely available and may be adopted in different locations and at different times. But diversity is an objective in itself.

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From: Marco A. Esnaola MESNAOLA%eapdzo@sdnhon.org.hn
Comments on Reg Preston's reply to Bob Orskov's question on how many farmers are feeding sugar cane juice and comparison with the China straw.

With regard to this discussion on farmer adoption of some of the technologies we have been discussing in this conference, as a member of the Network at Zamorano in Honduras for almost 4 years, pushing forward the integrated technologies of using sugar cane juice for pigs and ruminants. We have produced some results that confirm that with proper protein supplementation growing pigs can get from 550 to 650 g and that pressed cane stalks and tops fed freely, again properly supplemented, can produce on steers or water buffaloes gains ranging from 450 to 550 g/day. We have presented these results to farmers and technicians in a number of ways: technical meetings, training courses, magazines and even articles in newspapers, but still I have to recognize that nowadays not many farmers, either big or small, in Honduras are using these technologies. Why is this? I agree with Dr. Preston's comments that political and economical reasons can explain this, but in my personal view working with these technologies there are some other reasons that we have to consider.

1. How much demanding on hand labour are these technologies?
2. Is the farmer really prepared to pay or spend his own time in something that is physically very demanding, tedious, dirty and time consuming as cutting cane by hand? (At the moment Zamorano students with the help of some hired labour are helping me in cutting, crushing and milling cane for a 60 pigs and 15 steers feeding experiment and they complain a lot of the amount of work involved)
3. Don't you think that if the farmer has to do this daily (I mean the crushing and milling of the cane), he will not be very happy? and maybe he will be thinking that it is much easier either to buy a bag of a balanced concentrate for the pigs or to have the steers grazing in a paddock?
4. Don't you think that we have to look more closely at these issues, and try in our research to measure these things, or alternatively to look for ways of making things easier for the farmer?

I do not have the answers to these and many other questions that you brought up with regards to this subject, but surely you would agree with me that it is something that we should consider, when we talk about farmer's adoption.

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From: Frands Dolberg <frands@po.ia.dk>

Comments on Adoption of technologies

Comment to Andrew Speedy:

True the concepts of "baskets of choice" or "menus" of possible alternative technologies among which farmers can pick and choose have much merit.

I have come to think of integrated systems as such "baskets" or "menus". When in early 90s farmers in Vietnam across the country were exposed to a number of technologies they chose and rejected according to site.

In the Mekong Delta and around Ho Chi Minh city the plastic biodigester found uptake probably aided by Govt legislation (manure and human waste were not allowed into water bodies) and good technical backup (see Mr Bui Xuan An's paper in this conference).

In the remote hills in the North the sugarcane juice technology found acceptance as it was difficult to transport cane to the market. Close to good roads where transport access was easy and cane prices good it found less acceptance.

Frands Dolberg

From Rena Perez <71055.111@compuserve.com>

Comments related to sugarcane as animal feed

Dr. Orskov's question related to *"how many thousands or millions of farmers are currently using the (sugarcane feeding) technologies in Latin America?"* perhaps should be first addressed by asking *"how many thousands or millions of small-scale farmers in Latin America can read and write?"* Much less attend lectures, conferences and seminars where they would be scared by the use of such words as "digestibility" and "metabolizable energy" and all that.

I live and work in Cuba, I suppose one of the few countries in Latin America with a 94-96% literacy rate, with hundreds of agriculture-oriented institutes, but I continue to be amazed at how little farmers really understand about feeding animals.

Our agronomists, vets and animal nutritionists attend all kinds of meetings, write in sophisticated journals, are computer literate, but as Dr. Orskov also intimated, is it getting down to grass roots?

I hope we don't kid ourselves by assuming that because some of us now communicate by E-mail, publish in the diskette-journal, LRRD, and are participating in this marvellous FAO-inspired E-mail conference that small-scale farmers are any more aware of us.

How do we address the increasing "intellectual/technological" gulf between small-scale farmers and the rest of us, or perhaps put bluntly in another way, how many farmers have participated in this conference?

The question of "extension" and/or "technology transfer", i.e., how to get all this beautiful material and/or technologies down and out, as Andrew Speedy has further emphasized "make them available", has yet to be addressed.

Furthermore, Marco Esnaola from Honduras has brought up a good question: sugarcane for animal feed is hard work. Floyd Neckles from Trinidad-Tobago would surely second that, and also agree that most small-scale farmers, with access to cane, would prefer to buy a bag of feed upon returning home from their city job. My experience in several Caribbean islands in trying to promote the use of sugarcane for animal feeding has been that, in most cases, individual small-scale farmers do not have sufficient capital to invest in the required equipment: a juicer and a forage chopper. They like the technology because the cane is theirs, however, the two pieces of equipment, the juicer and chopper, can easily represent five thousand US$ while a bag of feed can be purchased on the way home for eight US$.

In several outlying semi-rural communities near Havana, where the FAO-promoted sugarcane/protein tree/molasses block/soybean forage technology is gaining in "intellectual" popularity, particularly with those who have several pigs and a cow or two, the local authorities are studying the idea of organizing communal areas for growing cane, protein trees and even soybean forage. In addition, in Barbados, one has read of new interest in developing communal areas for grazing cows. Perhaps these ideas could be further exploited in other countries with similar problems.

Rena Perez

From Enrique Murgueitio <cipav@cali.cetcol.net.co>
Answer to Bob Orskov's question on his paper "The Outcome of Networking 24 Latin American and Caribbean Countries on Integrated Use of Sugarcane..."

1. We do not know the exact number of farmers who are using sugarcane, fodder trees, aquatic plants, plastic biodigestors and other tropical resources in integrated farming systems in Latin America.

2. The main objective of the Network is to provide information on recent advances related to these topics (research and application at farm level) in Latin America and the Caribbean, in order to encourage the planning and funding of specific mechanisms for the dissemination of ideas that can be introduced into existing production systems and with different cultural and socio-economic backgrounds. The Network does not aim at technology transfer based on direct interventions with farmers and financial incentives for promoting the technologies. It is an informal exchange of experience, knowledge and training aimed at influencing all the people involved in decisions related to the technologies that are proposed to the farmers: scientists, professionals, technical assistants and leaders of a very heterogeneous range of governmental institutions, ONGs, private firms, community groups and some farmers.

3. In Latin America and the Caribbean, they are various reasons for giving priority to this sector as it is a critical one where changes can have future knock-on effects on the thousands and millions of farmers that Dr. Orskov is looking for:

a. Those who plan and make decisions are the professionals and the technicians. In most countries, except Cuba and certain agricultural schools in other countries, the agricultural training curriculum is based on the specialized non-tropical production system model (concentrates, cereals, extensive grazing for cattle, use of chemical fertilizers and pesticides). The region is full of people that think and decide without knowing about tropical resources and indigenous knowledge.

b. In recent years, the macro-economic decisions that have been imposed on Latin American countries by the industrialized countries (structural adjustment, neo-liberalism, payment of the external debt, reduced attention to the agriculture sector, breakdown of food security) have encouraged the "invasion" of subsidized cereals from large north American monopolies. The attempts to build production systems based on local resources are competing unfairly with industrial animal production models. In these countries, the social and environmental cost is serious and nobody is paying for it. It is necessary to change the mentalities of those who favour and approve these so harmful decisions: scientists, professionals, technicians and leaders are playing a major role and are more difficult to convince than farmers, because they were educated in universities with a different vision.

c. The centralized technology transfer systems are in crisis: the role of the state in the rural sector is being increasingly reduced. The programmes of technology transfer and technical advice are spread among hundreds and thousands of private groups, ONGs, local governmental entities, most of them without resources and without knowledge on the sources of research results appropriate to our agro-ecological, social, economical and cultural reality.

d. The poor farmers' social organizations have very little power in most countries. They represent a social sector looked at with disdain by the politicians. They do not receive financial resources and their priorities are focused on fundamental rights such as peace, democracy and land tenure (Latin America is one of the places where the access to land is the most unequal, the "latifundios" (large land holdings) dominate). The decisions related to how and with which resources to produce are not the priorities for most corporative movements, unions' leaders and popular organizations that are preoccupied with more critical problems related to their survival. The possibility of achieving major success through popular organizations (fragile themselves) with appropriate technology proposals is limited.

3. The technology promoted by the Network is a modest contribution which takes into account the fact that there are structural problems much bigger in most regions of Latin America and the Caribbean, where it is not possible to have influence in a modest project with few people, little financial resources and limited time. Despite the difficulties met through the official and bureaucratic pipelines of every country, our results are flattering, considering the response obtained.

4. To use the number of farmers as an indicator of technology adoption is not appropriate for the Network because it is not its principal objective. What we have now is an increasing critical mass of professionals who can carry out projects of multiplication and transfer of the appropriate technology, and with the resources of every country and this is already taking place.
5. Latin America and the Caribbean is a complex environment which great biological and cultural diversity. We are well aware that it is not possible to carry out general proposals which are as sustainable as we would like them to be. The comparison with China using only the indicator of adoption is simply not appropriate.

Enrique Murgueitio, Director, CIPAV

From Ruben Espinel <cipav@cali.cetcol.net.co>
Answer to Bob Orskov's question on his paper "The Outcome of Networking 24 Latin American and Caribbean Countries on Integrated Use of Sugarcane..."
Concerning the number of farmers who work with technologies based on sugarcane and other locally available resources in Latin America and the Caribbean, we would like to add the following points:
1. All of us working with these technologies in the tropics have as our main philosophy the development of technologies which are easily obtained and applied. The farmer should not simply copy, but should be a co-researcher who understands, modifies and replicates the proposals, in such a way that the presence of academic professionals is not indispensable to guarantee that the technology persists, reproduces itself and evolves.
2. The development of the proposed technologies has involved the exchange of scientific and local knowledge. This has been continually enriched by capitalizing on experience and success does not depend on the technology itself but on the interactions between geographical, climatic, cultural, social, economical and political factors.

3. We hope, considering the above, that one can understand that it is difficult to get statistics on the number of farmers who adopt the technologies and it would be unfair to refer to the farmers as 'users' because they are not given a technological package but a range of flexible options to apply and modify according to the local conditions.

This does not signify that there is no massive dissemination of the technologies, and I would like Dr Orskov to share his large experience with us by indicating what would be the appropriate and sure method to follow up and obtain accurate statistics on the number, not only of farmers from the rural sector who are participating in this process, but also of the decision makers, professionals and technicians that are aware of, involved and committed to the adequate sustainable development of the rural sector in Latin America.

Ruben Espinel, Researcher and Coordinator for Extension, CIPAV

From E. R. Orskov <ero@rri.sari.ac.uk>

Comments on the answers to his questions to Enrique Murgueitio and Ruben Espinel (34th paper)

I would like to thank Drs Murgueitio and Espinel for their replies. I take your point and look forward to hear in the future of a real fast uptake by farmers. A network as Dr Dolberg pointed out can, if you are not careful, give the impression of a top down approach which seldom works. We hand it to the farmers and hope they use it! I sympathize with your comments re specialized education systems emanating from the west and causing many problems when we want to see livestock in their holistic interaction between plants and soils. We have to influence decision makers or some of you better be decision makers yourselves in the future. I also sympathize with the poor farmers social organization. But I also have experience that if you have the right message and take a bottom up approach then a technology can spread with very little cost and effort as the farmers teach each other. I think you have the right philosophy and that is the most important. We have to remember that we are the servants of the farmers and not their masters so we have to listen to the needs of our clients.

I would like also to make a comment to Dr Rena Perez when she says that she is amazed at how little farmers know about feeding animals. I have to admit that I am amazed on the whole as to how much they know and I have to admit that I have learned a lot from illiterate farmers in Asia and Africa probably more that I have taught them!

A final thing I like to add to this is that in my experience there is not a single technology which has universal application. As scientist we often get exited about a technology we have been closely involved with and perhaps even developed or modified so we push it perhaps too arrogantly assuming it is good for everybody. This is perhaps an extreme point but each technology has its niche or niches which we must recognize otherwise we will not help our client who is the final arbiter.

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Final Comment

From Lylian Rodriguez
<Lylian%sareclr%sarec%ifs.plants@ox.ac.uk>

Comments for the conference

I would like to make some comments on different aspects that have been mentioned during the last days of the conference.

We, as people involved in development of feeding systems using local resources, should think more deeply. I have been working in different projects in Colombia and Vietnam. In Colombia, with CIPAV, mainly on a 35 ha integrated farm, and now in "Finca Ecologica" in Vietnam, a small 0.35 ha integrated farm.

After having lived in the mountainous central part of Vietnam and having visited some places around Vietnam, Cambodia and Bangladesh, I have the feeling that work load is not the problem when the question "What will we eat today?" comes every day for the poorest people. It is the reason why these people have to go to work "really hard" in the forest to get even "war metals", risking their own lives. Therefore, if someone shares with them ideas and gives them some opportunities as credit and some technology and if they can afford to have some chickens, pigs and sugar cane, cassava and why not an "integrated farm", this means a lot of work but this also means building an enterprise that will give them food security. Then I don't believe that in that case work load is a major problem. For example, work is not a problem for the Cambodian farmers who climb the sugar palms to get the juice twice a day because if they stop doing it, may be the next day the palm stops juice production. It is different for someone working for someone else.

Integrated farming means work but means recycling and means biodiversity and low inputs from outside. It is the same with knowledge, to try to understand situations from an interdiciplinary point of view means hard work and hard thinking.

Again the "basket of choices" must be full of alternatives for different places, different socio-economical and socio-ecological conditions and even different seasons because we have to realize that we should develop appropriate systems even for different periods of the year according to harvest times, agro-ecological conditions, market, policies, etc.

Technology transfer is definitely an important aspect and we should look for the way to get farmers to know these technologies all over the world. Without going so far, in this excellent conference, there have been many interesting papers and discussions around many aspects. We have the responsibility to reach farmers. "On farm research" is very important in this field because it is a real way to know farmer's situation and usually farmers will get rid of the technologies that are not useful for them under certain circumstances. On farm research is also excellent to get scientists down to the field and try to exchange ideas with farmers and develop systems.

We have to change, to be open-minded and to contribute to change people specially the young people, who will be the future of the world. The potential of the tropic is so big; we just have to try to live in harmony with it and to WORK HARD!

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Comments on: The sugar palm tree as the basis of integrated farming systems by Khieu Borin

From Rena Perez (71055.111@compuserve.com)

Comments to Dr. K. Borin

Concerning a lack of sows: why don't you use the "gilt production system" and get away from even thinking about sows. Fifty percent of a litter will be females. Breed them early, aim for second oestrus, obtain a litter, after weaning, sell or slaughter. Even though the gilt produces fewer piglets, something like half-piglet per litter, she is, statistically speaking, a better mother compared to the sow. Another important factor: a sow requires, at least, one ton of dry matter, yearly. The gilt system combines "reproduction" and "production" in the same animal.

With respect to other problems, that of insufficient energy to condense the sap to syrup in order to prevent fermentation, why not convert the sap to meat. Perhaps, I am getting back to the problem of insufficient piglets, however, by implementing correctly a gilt system you could breed the gilts in order to make coincide the fattening phase of their offspring with the period of maximum sap production. In Cuba, we are using fresh soybean forage as a protein supplement for pigs, fed before the presence of the trypsin inhibitor. Has anyone at this conference any comparative data on the nutritive value of cowpea as compared to soybean forage for swine? Dr. Borin, as you have mentioned, there are lots of interesting problems to resolve, and from the tone, sometimes, of this conference some great chemists, available!

Rena Perez, Cuba

From Khieu Borin <borin@forum.org.kh>

Comments on Rena Perez' comments (sugar palm)

I would like to thank Rena Perez for her comments on how to get enough piglets for fattening them with sugar palm juice.

The problem is not only referred to the lack of sows. There are many factors involved in this matter. It is much more related to the religious belief of our people. The belief is that before rearing sows, they should have first married any daughter or son. But rearing fattening pigs are very common and popular among the farmers. This is why it makes the system unbalanced. However in some areas I have observed that they do rear sows. Each family rears up to 5 sows including the one without having married any son or daughter. The sow is kept until 7-8 parturitions when she is a good mother and then she is sold to the slaughter house.

The other problem is the high mortality rate of piglets from 1 day to 60-80 days. This happens due to the diseases including parasitic diseases, feed (quantity and quality), early weaning, etc. The government only supports the vaccination of the large animals (cattle and buffaloes) but not for pigs and poultry. Vaccines are not produced locally but they are imported. That is why there are problems in controlling diseases. The feed provided to pigs depends mainly on the poor quality rice bran (over 50% rice husk is included) and sometimes the quantities are insufficient. Early weaning is also a big problem. After weaning, piglets are transported far from the village to be sold. Most of them die between the first and third week after being sold to the second person. The reason could be that pigs are only dependant on milk from the sow before weaning, the stress of transport and the quick change of feed.

Rena Perez' suggestion of converting sugar palm sap to meat is really a very good one. We (myself and Dr Preston) have worked on it since 1993 (during FAO/TCP/CMB and the later SAREC projects). A good profit was made by feeding sap to pigs (for more details, please see Borin et al, 1996 "A study on the use of the sugar palm tree (Borassus flabellifer) for different purposes in Cambodia").

At present I am carrying out another trial financed by IFS to use cow peas as protein supplement with sugar palm juice based diet. But we do not intend to use fresh cow peas because farmers will grow other crop after harvesting cow peas. So until now we ensile cow peas.

Concerning Rena Perez' comments related to tapping palms, we have been looking for other ways of extracting juice from palm trees. But we are not sure that we can get juice from the trunk of Borassus flabellifer. There are other people that can collect juice with the same method as you have described. It is a good idea that we hear something from Dr Saadullah from Bangladesh. He told me about that when we met in China. Farmers also told me that it is possible to get juice from the root system by digging the soil around the trunk (1 metre deep) and putting fertilizer. Later they will get a new root system which will be used for tapping juice. They can get a much higher quantity of juice. But there are reasons why it is inconvenient to practice this system. One of them is that the palm will stop producing juice for several years.

Khieu Borin Integrated Sustainable Livestock based Agricultural System. DAHP, Ministry of Agriculture, Forestry and Fisheries. PO Box 177, Phnom Penh, Cambodia.

From Rena Perez (71055.111@compuserve.com)
Palm Sap As Pig Feed (comments on Khieu Borin's comments):
Khieu Borin's beautiful comments revealing my ignorance concerning "before rearing sows, either a son or daughter must be married" have served to confirm the need to continue these electronic conferences, definitely conducive to a greater interchange with respect to the appreciation of cultural values and their affect on agriculture. Can anyone imagine his comment in a hardcopy, scientific contribution? Thanks again to the FAO/HQ coordinators.

I thoroughly understand the reasons for the high mortality rate of piglets up to 60/80 days: parasites, early weaning, stress of transport, etc. Has Khieu Borin tried removing the sow, rather than the piglets, in order to maintain the litter as an integral entity for several days before transport. This cuts down on stress. My experience in commercial piggeries showed that by treating the litter as a "family" during post weaning, the measurement or indicator for post-weaning mortality could be reduced by some 30 percent.

Related to Khieu Borin's comments on the use of cowpea silage and sugar palm juice for pigs - some of our cane coop farmers in the eastern part of the country intend to compare a feeding system based on free-choice sugar cane juice and either fresh soybean or cowpea forage. They find that cowpeas do better and will plant a 7-row plot of cowpeas, every week. Let's compare results.

Rena Perez, Ministry of Sugar, Havana, Cuba

Introductory paper

A.W. Speedy, C. Dalibard and R. Sansoucy
Animal Production and Health Division, FAO, Rome

Background

The first FAO electronic conference on Tropical Feeds and Feeding Systems was held in 1995 (Speedy, Dalibard and Sansoucy, 1996). About 200 participants took part from over 50 countries with more than three-quarters being from developing countries.

In this first conference, the evaluation of the nutritive value of tropical feeds for ruminants was reviewed by Leng (1996) and extensively discussed by the participants. To summarize, there are many data on the chemical analysis and calculated nutritive value of animal feeds but the emphasis has been on grains and supplements used in temperate systems. Far fewer data exist on the less conventional feeds and forages, especially those found in the tropics. Yet, for example, Tanzanian farmers use some 200 species of fodder trees for their livestock (Komwihanilo *et al.*, 1995). But even given sample data on alternative feeds, caution must be applied to their use in developing rations and feeding systems.

Firstly, samples of heterogenous materials like forages and fodders are subject to enormous variation. Plant age, component, location and season are among the many factors which may influence the composition. Even if the actual material were analysed, if the animal is given choice, it may select a part of the material which differs from the remainder which it refuses. Secondly, nutrients are NOT additive, especially in ruminant diets. Thus rice straw may have a very low feeding value on its own but when combined with a protein or simple nitrogen source such as urea, can give markedly improved animal performance. Urea treatment of straw can actually improve the availability of energy, which is not reflected in the chemical analysis. Thirdly, many plant materials contain compounds other than nutrients which influence digestion and metabolism of the feed. Non-nutritional factors, such as phenolic compounds, are of principal concern in the case of many tropical plants. They form complexes with proteins and carbohydrates, and in the former case, this includes enzymes. This may be, but is not always, detrimental to the digestion of nutrients.

In short, it was concluded that animal feeding trials are the only sure test of the value of a feed, within a defined system. And the whole ration must be considered, as there are optimal and sub-optimal mixtures of available plant materials, in terms of digestion, metabolism and animal performance.

These basic yet fundamental concepts have been stated by Leng (loc. cit.) but are not yet widely accepted among nutrition chemists who continue to rely on 'feed analysis'. For this reason, a more descriptive approach has been adopted in the FAO Tropical Feeds database (Gohl, 1981; revised Speedy, 1994), together with considerable reference to animal trials and published results.

Other papers in the first conference included those on the strategy for use of renewable natural resources, roughage intake, the treatment of poor quality roughages, use of molasses-urea blocks, forage trees, the African Palm, aqualculture feeds, and examples of feed information on a variety of plant materials. It was decided to extend the scope of the second conference by considering livestock feed resources in the context of integrated farming systems.

Integration vs. Specialization: Historical Context

In colonial times, traditional farming systems which combined crops and livestock production were replaced in many tropical countries by large scale plantations of export crops (cotton, sugar, groundnut, palm oil, rubber, etc.). They relied heavily on imported technologies and inputs, increasing the dependency on the countries which supplied them. Multinationals have now taken over control of the system, and many developing countries are caught in the vicious circle of requiring commercial production to generate the hard currency needed to pay for the inputs.

Agricultural education and training in both the developed and developing world put much more emphasis on specialization than on integration. Institutions separate crop and animal production at all levels (extensionists, researchers and decision makers), and the two groups ignore each other and struggle separately for power and budgets. They develop separate projects instead of cooperating with each other and exploiting the benefits of integration.

As the demographic pressure is increasing rapidly in the developing world, new priorities are emerging: food security, sustainable management of resources, slowing down the drift from the land and improving welfare of the rural poor. The commodity-oriented production system is now being called into question. Much more emphasis is put on integration within production systems and this is reflected in the new FAO Food Security Special Programme. Recently, World Bank projects aimed at strengthening the extension services in developing countries have begun to train general extensionists able to intervene in the different components of the farming systems: crops, livestock and forestry. Furthermore, participatory approach methodology is now adopted by most developers and greater emphasis is placed on indigenous knowledge and the needs of the rural population. New educational programmes have focused on integrated systems (e.g., the SAREC MSc Programme on Sustainable Systems of Livestock Production in Vietnam), and many NGOs are following the same line as CIPAV (Centro para la Investigación en Sistemas Sostenibles) in Colombia which has developed expertise in many components of integrated farming systems (from crop production, to animal production, energy, forestry and wild fauna).

Farming Systems

The emphasis in this conference is therefore on feeds as components of systems. It is essential to define 'the system' when reporting results and conclusions. Furthermore, it is concerned not just with the 'feeding system' but also with the feed plants as components of the 'farming system' which includes soil, water, crops, livestock and their interactions. The system may rely on external inputs (fertilizer, chemicals, etc.) or be self-sufficient (with minimal external inputs). The concept of 'sustainability' adds the dimension of time: whether the system can continue indefinitely without soil or environmental degradation. It is important to judge the system not only in terms of is self-sufficiency but also in terms of its long-term viability.

Caution must be applied to the definition of the system. For one thing, 'systems' may be defined within a wide range of boundaries. In this context, it refers to the whole farming system, and the land, labour and economics of that system. The boundaries of the system may be further extended to include the environment, market, economic and social factors. Such considerations are vital when considered in the context of 'sustainable development'.

There are many instances where 'improvements' are reported in terms of yield, performance or financial margins, resulting from genetic, dietary or management changes. But such 'improvements' must be questioned in the context of environmental, market and social effects (indicators of sustainability'). The classic case is the 'Green Revolution' in which high-yielding varieties of rice and maize were introduced, with major effects on production and food supply. But these varieties required high inputs of chemicals and fertilizers. And the additional supply had serious market implications so that the poor farmers, who did not have access to land, capital and chemicals needed to use the new crops, suffered reduced prices and incomes (Greenland, 1990).

Such effects also occur in livestock production. Many developed countries have achieved big increases in milk production from dairy cows by genetic and technical improvement, with high usage of grain and a high level of subsidy. The result is a reduction in the number of cows and dairy farmers and the need to apply production quotas to limit supply.

Also, the high performance systems now operating in Europe are causing serious pollution problems as a result of high concentrations of animals in small geographic areas, e.g. Belgium, Brittany, the Netherlands, etc. In these systems, the feed base is often completely dissociated from animal production, with imports of cereals, cassava and soya from other regions or countries. The expansion of production based on non-local feed resources has proved to be environmentally unsustainable.

Brazil has increased production and exports of pig and poultry meat by applying modern production methods and meat technology. This is in direct competition on the world market with supplies from France, USA, etc. Pig meat prices are currently (July 1996) low and small-scale production is uneconomic. Production is also based on corn and soya. The 'feed conversion efficiency' is good but corn prices have gone up and profits disappeared. The majority of producers are small and the risk is that more will abandon the rural areas and move to the cities. Furthermore, pollution from pig and poultry units is becoming a serious problem, as in many countries. Although this does not affect the economics of the pig enterprise, it has wide implications for human health and the environment. It represents an 'externality' which economists now take as a type of cost.

Much attention has also been paid by scientists to increasing beef production from extensive systems (by pasture improvement and improved management), especially in Latin America. Higher stocking rates mean higher profits per hectare. Economically, it benefits only the large cattle ranchers. And the world beef market is already saturated so increased supplies mean lower prices. It is also claimed to increase meat supplies to the cities. But the rich already consume protein in excess of requirement and the poor remain unable to buy beef.

So the consideration of 'livestock systems' which are environmentally, economically and socially stable must take account of factors beyond the farm level.They are likely to be environmentally non-destructive, not to contribute to saturated markets (although they may provide other products which are currently required) and to account for family labour and satisfaction within the small-farm sector.

System Definition

The question arises of what constitutes an environmentally sustainable system. Such a system is likely to be as near to, and therefore a modification of, the natural ecosystem of the area. This is proposed as a fundamental principle of environmental sustainability and should be borne in mind throughout the discussion. In the various agro-ecological zones, the following systems would apply:

- pasture-tree systems in arid or semi-arid savannah
- multi-layer perennial (tree) systems in humid forest environments
- pasture-palm systems in wet savannah
- multi-layer pond systems in wetland areas

These systems are polycultures rather than monocultures and involve trees and/or nitrogen fixing species. Food crops and animal feed resources can be chosen which replace the natural species but fulfill a similar role in the ecosystem. However, annual crops like maize and beans are unlikely to constitute sustainable options on tropical soils with a low cation exchange capacity (CEC) and where nutrients are mainly held in the organic matter (Weischet and Caviedes, 1994).

In such areas, the maintenance of soil organic matter and fertility are primary concerns. The integration of livestock itself may help the cropping system to become sustainable through the use of residues, animal power and recycling of nutrients. But if the cropping system is based on inputs of fertilizer and chemicals from outside the system and subject to long-term reduction in soil fertility, then the whole system, including the livestock element, should be regarded as unsustainable. Much attention has been paid in the past to crop byproducts, treatments (e.g. urea) and supplementation. Materials such as straw, husks, cakes, etc., are available and may be used for animal production but the integration of livestock per se does not guarantee the principle of long-term sustainability. More emphasis is likely to be placed on alternative perennial crops and multi-strata systems which conserve and replace the soil organic matter.

Even on fertile soils, there should be more attention paid to mixed farming systems (where byproducts are used), including integrated systems with legumes (especially multi-purpose trees), mixed livestock and return of nutrients through nitrogen fixation and use of manure.

Descriptions of feed use within systems must therefore be justified in terms of the environmental, as well as the economic and social sustainability of the system, together with the feeding value and animal performance.

The Programme

Papers were requested within the following subject categories:

1. Integration in small-scale farming systems.
2. The poultry component in integrated farming systems.
3. Integrated farming systems with a major fodder crop component.
4. Integrated farming systems with a major tree/shrub component.
5. Feed resources from cereal production.
6. Feed resources from large scale plantations.
7. Alternatives to industrial exploitation of plantations.
8. Fertilizer and energy components in integrated farming systems.
9. Networking for circulating information on integrated farming systems and promotion of these systems.

In addition, a number of short communications were requested and it was expected that participants would contribute to the discussion with data, experience and further contributions. Following from experience of the last electronic conference, a number of changes were made. The conference was fully moderated and all contributions and discussions wereconsidered by the moderators before release.

It was hoped that contributors would add information on feed and feeding systems that are not currently included in FAO Tropical Feeds. Such information should include full description, as well as brief exemplary chemical analysis and, where possible, animal performance results. Details of farming systems are particularly important and contributions should take account, as far as possible, of indicators of sustainability: environmental, social and economic.

Additional Information

FAO Tropical Feeds may be obtained on diskette by application to R. Sansoucy, FAO-AGA, 00100 Rome, Italy (Tel: +39 6 52253559 Fax: +39 6 52255749 E-mail: rene.sansoucy@fao.org) or from the world-wide-web.

The Proceedings of the First FAO Electronic Conference on Tropical Feeds and Feeding Systems can be obtained on diskette at the above address or from the www.

There are many articles on sustainable livestock systems and feed resources available from the electronic journal Livestock Research for Rural Development. A full list of papers will be sent to participants on request. The journal can be obtained in the same way as the above.

A special www site was set up where these can be obtained.

References

Gohl, B. (1981). Tropical Feeds. FAO, Rome. (Revised by Speedy, A.W. (1994) as FAO Tropical Feeds, 4.2 mB on diskette).

Greenland, D.J. (1990) Agricultural research and Third World poverty. In: Developing World Agriculture. Speedy, A.W. (Ed.). Grosvenor Press International, London. pp. 8-13.

Komwihangilo, D.M. *et al.* (1995). Indigenous knowledge in utilization of local trees and shrubs for sustainable livestock production. Livestock Research for Rural Development 6:3 Paper 7.

Leng, RA. 1996. Evaluation of Tropical Feed Resources for Ruminant Livestock. In: Proceedings of the First FAO Electronic Conference on Tropical Feeds and Feeding Systems.

Speedy, A.W., Dalibard, C. and Sansoucy, R. 1996. Proceedings of the First FAO Electronic Conference on Tropical Feeds and Feeding Systems.

Weischet, W. and Caviedes, C.N., 1994. Persisting Ecological Constraints of Tropical Agriculture. Longman, London and New York.

Comments on: Integrated Farming Systems... in Colombia by P. Sarria and M.E. Gomez

From: Patricia Sarria <cipav@cali.cetcol.net.co>

Answers on questions raised on their paper "Integrated Farming Systems in the Andean Foothills in Colombia"

1. Why did they change from crushing the cane to chopped feeding?

The reasons were:

- Change of emphasis of the enterprise to concentrate on reproduction and sale of weaners rather than fattening: it is more profitable. Fully grown pigs are able to extract juice from cane stalk and to consume the same quantity of juice.
- Crushing the cane requires an electrical machine and this kind of energy is expensive for the farmer.
- Now, farmer's sons do not live in the farm, so he needs to save work.

2. Can the swine excreta mixed with spilled bagasse still be used for biodigesters?

No, now the biodigester in Cipres farm receives cattle manure and household waste water. Other farmers use pig excreta but they use a "trick" to collect bagasse, before it goes into the biodigester. Bagasse causes a problem in the biodigester, it makes a hard layer at the top and gas production is decreasing.

3. How much food and energy (biogas) is produced in this system?

The data are still being processed for the integral system.

4. What other test apart from soil fertility can be used to determine sustainability?

- Quality and quantity of water from water source.
- Quantity of soil in the water source, specially in the rainy season.
- Balance of inputs and outputs in the system.

Patricia Sarria and Maria Elena Gomez

Local Feed Resources and Indigenous Breeds: Fundamental Issues in Integrated Farming Systems

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Abstract
The tropics present great opportunities for sustainable development thanks to the enormous cultural and biological riches of these regions. The rational exploitation of local feeds and local breeds of livestock will support much more sustainable production systems in the medium and long term. These have received insufficient attention in the past and have not been considered seriously because of the introduction of "exotic" systems based on high inputs, high technology and "breeds of high genetic merit". As a result, local breeds of pigs and cattle in many tropical countries have disappeared or their population is decreasing drastically.

On-farm research has shown that small scale farmers in Vietnam and in many parts of the tropical world continue to work with local breeds because of their good adaptation to the prevailing conditions. A project was carried out in two villages in a rainfed hilly region in Central Vietnam, involving the use of local Mong Cai pigs, local feeds supplemented with duckweed, and plastic biodigesters to produce energy for cooking and the nitrogen-rich effluent as fertilizer for the ponds in which the aquatic plants were grown. A study of the nutrition of Mong Cai, Large White and crossbred pigs showed that the indigenous breed would eat greater quantities of duckweed and use it more efficiently than the exotic breed. Local sows fed duckweed were also more prolific than exotic breeds on small farms with feed resources of low nutrient density.

The studies were carried out with a participatory approach which identified the importance of the local pigs and feed resources and the enthusiastic adoption of the biodigester technology and the production of duckweed based on the fertilized ponds. The priorities of the farmers were identified and a proposed intervention based on restricted milking of local cattle abandoned because it was considered too long term.

Parallel studies in Cambodia led to the development of pig feeding based on juice from the sugar palm (Borassus flabillifer) supplemented with boiled soya bean seed and water spinach. Biodigesters were also integrated into the farm.

The various studies demonstrate that the appropriate use of local feed resources and indigenous livestock breeds requires the close integration between crops and livestock within the system. The excreta is recycled on the farm to produce energy and effluent used for fertilizer to produce protein supplements for the livestock.

KEY WORDS: Local feed resources, on farm research, recycling, biodigesters, genotype-environment interactions, indigenous knowledge, local breeds, integrated farming systems

Feed Supply and Population Growth

There is a growing disparity between the expanding world population and the earth's food producing capacity, the rate of increase of which is less than the rate of population growth. As a result, food supplies per capita are decreasing (Brown and Kane 1994). However, an important issue here is the role of livestock. As living standards rise, so does consumption of livestock products. But the feeding systems to produce these products, especially in the industrial countries, use the same feed resources as are eaten by humans, namely cereal grains and soya bean meal. It is estimated that almost 50 % of the world grain supply is consumed by livestock (FAO, 1993). It has been argued (Preston 1995) that if all the world's grain production was reserved for human consumption then there would be enough to feed the 10 billion inhabitants at which point the world population is expected to stabilize.

Alternatives to Cereals as Livestock Feed

The strategy that is proposed is that not only are there many alternatives to cereal grains as the basis of feeding systems for livestock production but that many of these systems result in a more efficient and sustainable use of natural renewable resources. The first step in this strategy is to recognize that the production of cereal grains for livestock feed, as practiced in the industrial countries, is not sustainable because it depends on the inputs of massive amounts of energy derived almost exclusively from fossil fuel. According to the data from Pretty (1995), the production of rice in the USA requires that some 65% of the energy value of the rice is imported into the system in the form of fossil fuel derived inputs. The energy need for maize is less (about 25%) but still substantial.

The examples of alternative energy-rich crops proposed by Preston (1995) include sugar cane, cassava, sugar palm, oil palm and coconut palm. The yields of all these crops expressed in terms of grain equivalent exceed what can be expected from cereal grains. Moreover, many of them, for example the palm trees, can be grown in association with other crops in multi-strata systems and are much less demanding in terms of energy input for cultivation. The limitations of all these alternative crops, as sources of feed for livestock, are in the imbalance of nutrients and specifically protein. On the other hand, they are all low in fibre. In fact, the energy from sugar cane, and the palm trees (oil and sugars) contains no fibre at all.

The feeding systems designed so far, using these new resources, have relied mainly on conventional sources of protein such as soya beans, groundnuts and fish meals (Sarria *et al.*, 1992; Ocampo *et al.*, 1994; Khieu Borin *et al.*, 1995). This is obviously a major constraint as these conventional protein-rich meals are relatively low yielding and soya beans, which is the major protein crop, are not well adapted for growing in the tropics where they yield much less than when grown in sub-tropical regions.

Alternative sources of protein were also proposed by Preston (1995). These include the leaves of many trees and shrubs and several water plants as examples of truly tropical feed resources capable of very much higher protein yields than soya beans. The major nutritional limitation of these feed resources is that they are relatively high in fibre, especially the leaves and foliage from trees and shrubs which puts a constraint on their digestibility, especially by monogastric animal species. Thus the characteristics of these alternative sources of energy and protein, when combined into feeding systems, can be summarized as follows:

- High productivity and efficiency in use of natural resources (eg: land, water and solar energy).
- Relatively low input needed for cultivation.
- Low nutrient density and low digestibility in the case of tree leaves
- Limited shelf life in the fresh state (eg: juice from sugar cane)

Production Systems from Locally Available Resources

These features have important implications for the design of livestock feeding systems. It means that:

- The feeds are not suitable for incorporation into the conventional "balanced rations" in a feed mill, as is done with cereal grains and protein meals
- For maximum economy, the livestock must be located close to the source of the feed as the high volume and short shelf life of the fresh product makes transport expensive
- The feeds are less suitable (compared with a conventional maize-soya mixture) for livestock of high genetic potential in view of the relatively low nutrient density and constraints in protein supply
- More of the original feed will be excreted in the faeces than in the case of cereal-protein meal feeds, because of the lower digestibility (which may be an advantage when manure is an essential component of the production system)
- Genotype-environment interactions will be accentuated

All of these features favour the use of these feed resources in integrated farming systems where there is a close association between crops and livestock. Small scale producers who live on their farms will benefit more from these feeding systems than "corporate" farmers. There will be opportunities for self sufficiency in fuel (in the form of biogas) and fertilizers because of the ready availability and relatively larger amounts of manure. Local breeds and crossbreeds of local with improved strains are likely to have comparative advantages over "exotic" high performance genotypes.

It is evident from this analysis that the feeding and farming systems that need to be developed in order to take advantage of the opportunities offered by these alternative feed resources will be quite different from those currently practiced in most industrial countries. This in turn has implications for research, training and acquisition and transfer of knowledge. Appropriate knowledge will rarely be found in the scientific publications emanating from institutions in the "North". Farmers who over generations have learned how to use the locally available resources will be more valuable sources of information.

Similarly, appropriate germ plasm is more likely to be found in local ecosystems than in the laboratories and experiment stations of the animal and plant breeders in the industrial countries. There are many examples of where indigenous breeds and local feed resources prove more appropriate than exotic types and imported technologies. Crossbred (F1) Holstein-Zebu cattle were more efficient producers of milk and meat in a tropical environment in Brazil (Madalena 1989) and in Colombia (Rodriguez and Cuellar 1994) than the purebred Holstein. Leaves from the Jack fruit tree (Artocarpus heterophyllus) supported higher liveweight gains in indigenous goats in Vietnam than the more digestible foliage from Trichanthera gigantea (Keir *et al.*, 1997). Hybrid broiler chickens quickly succumbed to disease and malnutrition when they were put in an environment where "scavenging" local chickens were able to produce normally (Preston T R 1995, unpublished observations).

Local Resources in Integrated Farming Systems in Central Vietnam

A study was carried out in two villages (Binh Dien and Xuan Loc) in a rainfed hilly region in Central Vietnam (Rodriguez *et al.*, 1996). The areas were visited in 1994 and the researcher lived in the villages during 1995. Discussions were held with the People's Committee and the Women's Union to discuss and develop the ideas. The priorities of the farmers were identified and a proposed intervention based on restricted milking of local cattle abandoned in the light of the insistence of the farmers that the expected benefits were too long term and they had more immediate needs. The participatory approach identified the importance of the local pigs and feed resources and the enthusiastic support for the introduction of low-cost biodigesters and the production of duckweed based in ponds fertilized with the nitrogen-rich effluent.

As a result of the project activities in the village and farmer expectations, research to document the local breeds became a priority. A survey was done to get some baseline data. Local pigs proved more prolific than "exotic" breeds in the households of poor farmers in these areas where available feed resources are of low nutrient density, and especially low in protein (Nguyen Thi Loc *et al.*, 1997). The survey demonstrated a mean weaning rate of 10.3 pigs per sow in Binh Dien and 9.59 in Xuan Loc. The farrowing interval was 181 days. Mortality to weaning was less than 10%. These observations at village level about the efficiency of the Mong Cai breed in the use of local resources were the basis for carrying out an on-station experiment.

The Mong Cai pig of Vietnam appears to have comparative advantages over imported "exotic" strains when the need is to be able to consume large quantities of a voluminous feed such as duckweed (Rodriguez and Preston 1996). Nutritional studies were carried out using a diet of sugar cane juice and duckweed (grown in ponds fertilized with biodigester effluent) fed to local (Mong Cai) pigs, Large White pigs and crossbreds. The purebred exotic (Large White) pigs failed to adapt to the use of duckweed and had to be eliminated from the experiment. In that study, the nutritive value of duckweed was found to be high when fed to indigenous pigs and their crosses. Half the pigs were able to consume enough fresh duckweed to provide a diet with more than 10 per cent protein. This local resource was not useful with the poorly adapted exotic breed.

The excreta produced by the pigs was a valuable resource that could be used in low-cost, plastic biodigesters. The potential benefits of this technology were enthusiastically received, especially by the women. It was calculated that at least 1000 T of firewood were used annually to cook feed for pigs and 678 T of firewood used to cook food for the 364 households in Xuan Loc Village alone. As part of the project activities, more than 50 biogas digesters were installed in Binh Dien and Xuan Loc villages, with an average cost (for materials) of USD 29.00, including two burners. These provided biogas for cooking of both human and pig food.

There was also a potential connection between the biodigesters (being installed primarily as a source of fuel) and the need to improve the diet of the pigs. Conventional protein supplements are only available in the market in Hue City and are expensive. The proposal was to grow duckweed in ponds fertilized by the nitrogen-rich effluent produced from the biodigesters. Duckweed can contain up to 40% protein in the dry matter when raised in this way (Leng *et al.*, 1995) and can be grown almost anywhere in the tropics where there is water. Farmers quickly learned to grow the plant and to keep it in good condition, and they also learned that it could be used as a high quality protein supplement not only for pigs, but also for ducks and chickens. Common ducks in Vietnam also appear to be able to eat greater quantities of this water plant than do "improved" Muscovy ducks (Bui Xuan Men *et al.*, 1996).

The combined development of the pig, biodigester and duckweed technologies led to an integrated approach which was adopted and refined by the farmers. However, a negative' aspect of the project was that original proposals to develop a milk programme with the local cattle was abandoned because it was not acceptable to the people and too many costs and constraints were anticipated.

Pig Production from Sugar Palm in Cambodia

The use of the sap (or juice) from the sugar palm tree (*Borassus flabillifer*) as feed for pigs is another excellent example of a technology developed from indigenous knowledge (Khieu Borin and Preston 1995). This tree grows wild in Asia from the Persian Gulf to the Cambodia-Vietnam border and cultivated in India, Malaysia and occasionally the southern USA. It is used locally for sugar production from the inflorescence and many byproducts from other parts of the tree.

In the study cited above, the fresh juice was fed to crossbred (Yorkshire x Duroc x Haiman) pigs in 14 farm households in a village in the Takeo province of Cambodia. Each farmer had 6 pigs and access to at least 12 sugar palm trees; housing was constructed from palm trunks with roofs thatched with palm leaves and solid concrete floors. Each farm had a plastic biogas digester installed to utilize the effluent.

The pig diet consisted of ad libitum sugar palm juice, together with 400 g/day boiled whole soya bean seed with added lime and salt and 500 g/day water spinach. Liveweight gains ranged from 350-450 g/day. More importantly, the system was more profitable than sugar production which needs much more wood for concentrating the juice. The system was less labour- intensive and the pigs produced effluent as fertilizer for fish ponds, water plants or rice and fruit trees, with no harmful effects on the environment.

The results will be reported more fully in a subsequent paper in this Conference.

Optimizing the Total System

The farming system must be fully integrated in order to optimize the use of locally available "alternative" resources. Strategies for sustainable livestock production in the tropics had been developed in Colombia and elsewhere (Preston and Murgueitio, 1992). Integrated systems were originally based on sugar cane and its byproducts as the source of energy, with legume trees and water plants as sources of protein, for feeding pigs, ducks, sheep, goats and cattle.

The simple biodigester technology had been developed and refined at CIPAV and the principle of using the effluent as a fertilizer for ponds and also in the production of earthworms for compost and/or feed had also been applied.

The results reported here demonstrate that the basic model has many variants but the principles are the same. It is important to identify local feed resources and the preferences of local people for different types of livestock. In all cases, there should be minimum "waste" in the system. By-products and residues originating in one component of the system become inputs for another "productive" activity.

The Beneficiaries

The beneficiaries from a strategy based on local resource use in integrated farming systems are many.

Women will benefit when there is close integration within the farming system. Firewood, the collection and use of which is done by women, can be replaced by biogas when livestock are confined and the biodigester will be more productive when local, less digestible (by the animal) feed resources are used.

The existence of genotype-environment interactions will have commercial significance when local feed resources are used. They have significance in other ways. They certainly contribute to biodiversity and have positive effects on the environment. They give empowerment to farmers who may be economically "poor" but who are "rich" in knowledge of local resources.

References

Brown L and Kane H 1994 Full house: a reassessment of the earth's population carrying capacity. Earthscan Publications Ltd: London

Bui Xuan Men, Ogle R B and Preston T R 1996 Use of restricted broken rice in duckweed based diets for fattening Common and Muscovy ducks. Livestock Research for Rural Development. Volume 8, Number 3: 20-25

FAO 1993 Agriculture Towards 2000. Document C93/24. November 1993. FAO, Rome.

Khieu Borin and Preston T R 1995 Conserving biodiversity and the environment and improving the wellbeing of poor farmers in Cambodia by promoting pig feeding systems using the juice of the sugar palm tree (Borassus flabellifer). Livestock Research for Rural Development. Volume 7, Number 2: 25-29

Keir Brenda, Preston T R, Orskov E R, Nguyen Thi Duyen and Dinh van Binh 1997 The nutritive value of tree leaves for goats. Livestock Research for Rural Development. Volume 9, Number 1 (in press)

Leng RA, Stambolie JH and Bell R 1995 Duckweed - a potential high-protein feed resource for domestic animals and fish. Livestock Research for Rural Development. Volume 7 Number 1, 36kB.

Nguyen Thi Loc, Preston T R and Ogle R B 1997 Evaluation of protein supplementation of traditional diets and cassava root silage for local crossbred pigs under village conditions in Central Vietnam. Livestock Research for Rural Development. Volume 9, Number 1 (in press)

Madalena F E 1989 Cattle breed resource utilization for dairy production in Brazil. Revista Brazilena de Genetica 12,2: 183-220 (Supplement)

Ocampo A 1994 Utilizacion del fruto de palma africana como fuente de energia conniveles restringidos de proteina en la alimentacion de cerdos de engorde. Livestock Research for Rural Development. Volume 6, Number 1:1-7

Preston T R 1995 Research, Extension and Training for Sustainable Farming Systems in the Tropics. Livestock Research for Rural Development, Volume 7, Number 2:1-8.

Preston TR and Murgueitio E 1994 Strategy for Sustainable Livestock Production in the Tropics. 2nd Edition. CONDRIT Ltd. Cali, Colombia 89pp.

Pretty J N 1995 Regenerating Agriculture: Policies and Practice for Sustainability and Self-Reliance. Earthscan Publications, London, England pp32

Rodriguez Lylian and Preston T R 1996 Comparative parameters of digestion and N metabolism in Mong Cai and Mong Cai Large White cross piglets having free access to sugar cane juice and duck weed Livestock Research for Rural Development, volume 8, number 1:72-81

Rodríguez Lylian, Preston T R and Dolberg F 1996 Participatory Rural Development: Experiences in Binh Dien and Xuan Loc Villages in Central Vietnam. Livestock Research for Rural Development. Volume 8, Number 2: 1-39

Rodríguez Lylian and Cuellar P 1994 Evaluación de la Hacienda Arizona como Sistema Integrado de Producción. CIPAV: Cali, Colombia

Sarria Patricia, Solano A y Preston T R 1990 Utilizacion de jugo de cana y cachaza panelera en la alimentacion de cerdos. Livestock Research for Rural Development Voume 2, Number 2: pp 92-99

On-farm Experiments in the Use of Local Resources for Pigs in Vietnam

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Abstract

In Vietnam, pig production plays an important role. There were 15 millions pigs in 1995, of which 95% were raised by small scale farmers. They are a very important source of income for the family. Protein is still a very important constraint in the traditional diet for pigs because of the high price. On-farm research has shown that protein intake is very low in traditional diets (94 - 98 g/pig/day).

On-farm feeding trials were conducted in two villages in Central Vietnam, Binh Dien and Xuan (which raise c. 2000 pigs annually).

Fourteen crossbred (Mong Cai x Large White) weaner pigs were fed traditionally and 12 similar pigs on a similar basal diet but given supplements of groundnut cake and fish meal to provide an additional 100 g/day/pig of crude protein. The mean daily live weight gain of pigs under the traditional feeding system was low (202 and 230 g/day in each of the two villages) but was significantly increased to 363 and 366 g/day ($P<0.001$) by giving the protein supplement. The net economic benefit after deducting the cost of the protein supplement was VND 800/day equivalent to VND 135,000 for the 150 day fattening cycle.

Trials were conducted in the two villages to evaluate the effect of processing methods on pH and HCN content of ensiled cassava roots. The HCN content of the ground whole cassava root after ensiling for 60 days was reduced from 109 ppm to 64 ppm, while ensiling the chipped root reduced HCN from 111 to 71 ppm.

Further feeding trials examined the effect of different levels of A molasses replacing cassava root meal or ensiled cassava root on the performance of growing-finishing pigs. The optimum levels of A molasses to replace cassava root (ensiled or dried) in pig diets, with protein supply kept constant at 200 g/day, was from 15 to 20% in terms of live weight gain and economic return. Mean live weight gains were 465 g/pig/day for the cassava root meal diet and 453 g/pig /day for the ensiled cassava root diet replaced by 20% of A molasses. Feed costs/kg gain for the 20% molasses diet with dried and ensiled cassava root were 11% and 27% less than for corresponding diets without molasses.

Sugarcane juice was fed to 40 pigs on 20 farms in the two villages. The results from feeding sugar cane juice with 200 grams CP supplement derived from fish meal and ground cake in farm households in two villages were good.

KEY WORDS: pigs, local feeds, traditional diets, protein supplement, cassava root silage, "A" molasses, sugar cane juice

Introduction

Cassava and sugar cane are the main crops in the upland areas of Central Vietnam. Cereal grains are needed for human consumption and cannot be spared for feeding pigs. Cassava and sugar cane, on the other hand, have several advantages compared with other carbohydrate sources. They give high yields under marginal climatic and soil fertility conditions, which results in a low cost raw material. The most under-utilized feed resource is fresh cassava root which is the cheapest feed in these areas. During the harvest season, the price of fresh cassava roots is only 180-280 VND per kg but it cannot be stored fresh.

The total production of fresh cassava root was 702,000 tonnes and of sugar cane 1.4 million tonnes in Central Vietnam in 1994 (Nguyen Sinh Cuc, 1995). The potential disadvantages of cassava roots are rapid perishability, their low protein content and the presence of cyanide in all root tissues. However, through simple processing, the disadvantage of perishability and cyanide can be overcome. The two most widely used processing methods are sun-drying and ensiling. In the humid tropics, especially in the wet season, sun drying is difficult and may result in the production of a low quality product with severe Aspergillus and related aflatoxin contamination. Artificial drying significantly increases the cost which makes the use of the root meal non-competitive with cereal by products such as broken rice and bran. Ensiling of the cassava root appears to be a more viable alternative.

Approximately 60% of the sugar cane crop is processed by artisan methods in the villages, giving rise to sugar-rich "A molasses" - the main by-product from artisan sugar manufacture. The total quantity of molasses resulting from the processing of the sugar cane has been estimated at around 35,000 tonnes per year. The prices on a dry matter basis of both fresh cassava root and "A" molasses are usually less than those of rice, maize and cassava root meal (Duong and Ngoan, 1993).

Protein is a very big constraint in the traditional diet for pigs because of the high price and lack of experience of using protein supplements.

Experiment 1
Effect of protein supplementation of the traditional diets on the performance of growing-finishing pigs

Materials and Methods

On-farm feeding trials were carried out from May to October 1995.

Animals, diets and management

a) The pigs were Mong Cai x Large White crossbreeds, belonging to the farmers. The farmers also provided their normal management, drugs and vaccines. A total of 14 pigs owned by 5 farmer households (2 or 4 pigs on each farm) with initial live weights of 10.7 to 20.0 kg in the two villages (3 farmers in Binh Dien; 2 in Xuan Loc) were fed on a traditional (control) ration which consisted of 48% rice and rice bran; 45% cassava root meal and 7% vegetables (DM basis). Protein (N*6.25) concentration ranged from 5 to 7% in the DM.The amounts of the individual feed ingredients fed varied between farms and with time, depending on current availability and price. Details of nutrient intake are given in Table 1.

Table 1. Nutrient intakes on diets for Large White x Mong Cai crossbred pigs from 15 to 50 kg in Xuan Loc and Binh Dien villages.

	Standard*	Xuan Loc**	Binh Dien**
DM (kg/pig/day)	1.40	1.29	1.35
ME (MJ/pig/day)	18.1	17.2	17.6
CP (g/pig/day)	213	94	98

* Source: Nguyen Van Thuong, 1992

** Source: PRA survey in the two villages

b) Twelve pigs owned by 6 farmer households (3 in each village), but of similar genetic background and initial live weight from 9.6 to 23 kg, were fed on the traditional diet supplemented with 190 g/day of groundnut cake (39% N*6.25) and 60 g/day of fish meal (42% N*6.25). It was calculated that the supplement would raise the overall protein supply to 200 g/pig/day. The pigs were fed three times per day. The groundnut cake was soaked overnight and then mixed with the boiled basal feed. The fish meal was fed in the morning after being mixed with the rest of the dietary ingredients.

Data collection

The pigs were weighed in the early morning once a month using a 100 kg capacity portable scale with an accuracy of 0.5 kg. Feed intakes were recorded using a 20 kg capacity portable scale. These records were collected every two weeks, and additional random checks were also made. The major feed resources were identified and representative samples were collected and analyzed for dry matter (DM), crude protein (N*6.25), crude fibre (CF), ether extract (EE) and ash (AOAC 1985).

Results

The mean values for initial and final live weights and daily gains of the pigs on the traditional and supplemented diets, in each of the villages, are shown in Table 2.

Table 2. Mean values for initial and final live weight and daily live weight gain for pigs fed on traditional diets with and without a protein (groundnut cake and fish meal) supplement in Binh Dien and Xuan Loc Villages.

	Xuan Loc		Binh Dien		
	Tradi-tional	Supple-mented	Tradi-tional	Supple-mented	SE
Live weight,kg					
Initial	15.3	11.6	15.9	14.7	±2.0
Final	45.6	66.5	50.5	65.1	±4.2
ADG	0.202	0.365	0.230	0.363	±0.02

The results were similar in the two villages indicating little difference in the nutritive value of the basal feed resources. Protein supplementation increased live weight gain (adjusted for differences in initial weight) by 83% from 204 to 375 g/day (P<0.001) and final weight from 46 to 68 kg over the 150 days fattening period.

The value of the additional 171 g/day live weight due to supplementation was estimated at VND 1,700 for an additional feed cost of the supplement of VND 800, giving a net benefit of VND 900 per pig per day (VND 135,000 per pig for the total fattening period).

There was some variation in growth rates of pigs between households. This phenomenon is quite common and has been reported previously from Vietnam by Dolberg (1993). The differences are normally ascribed to variations in management practices among households, which may warrant further studies in order to identify them and explain them more precisely. In the analysis of the management factor, Ostergaard (1994) points out that the interactions between farm households are an important aspect to consider, as the decisions about the management of biological or financial subsystems are strongly influenced by the social structure of the farm household and the cultural framework in which it exists. In this case, the trial intervention, which consisted of an equal supplement of protein with variation in energy supply between farmers may therefore be an important factor in explaining the differences.

Experiment 2
Evaluation of Processing Methods of Whole Fresh Cassava Root.

Material and Methods

Ensiled cassava root (ECR) was produced by washing and grinding (or chipping) the fresh roots and adding salt (0.5% of the fresh weight of the root). The material was ensiled immediately after processing, either in pits dug out of the ground, in a cement container or in plastic bags. These were filled with ground or chipped cassava root as quickly as possible and compacted properly to eliminate air, so as to minimise the loss of nutrients by oxidation. Usually a polyethylene sheet was used to cover the ensiled material, to create anaerobic conditions for fermentation. The time taken for preparation of the cassava roots and the ensiling process was recorded.

Chemical analysis

Samples of the freshly processed root were taken on the day of ensiling and after 30, 60, 90, 120, 150 and 180 days for analysis of DM, hydrocyanic acid (HCN), organic acids and pH in laboratories of the Animal Nutrition Department of Hue Agricultural University and the Biochemistry Department of Medical University. HCN was analysed by the method of Easley *et al.*, (1970). Organic acids (acetic, lactic and butyric acids) were determined according to the method of Lepper *et al.*, (1982).

Results and Discussion

The ensiled whole cassava root had an acceptable aroma for pigs with no mould growth and kept its white colour.

HCN in the root component after processing and before ensiling is shown in Table 1.

Table 1. Physical composition and HCN content of fresh cassava root,and preparation time for ensiling. Cassava Fresh weight DM HCN Preparation time

	(% of fresh whole root)	DM (%)	HCN (ppm)	Prep Time (minutes)
Fresh whole root	100	36	114 ±5.2	104 ±15(*)
Fresh thin peel	3.1 ±0.49	21.5	212 ±2.0	133±13 (**)
Fresh thick peel	13.6 ±0.38	21	238 ±3.6	350 ±32 (***)
Fresh pulp	83.3 ±0.80	38	91 ±2.6	

(*) The time taken to pull up, cut , wash and grind 100 kg of whole fresh cassava root and mix with salt. (**) if the thin peel is removed the process takes 133 minutes more , (***) while removing the thick peel takes an additional 350 minutes

The HCN content was highest in fresh thick peel (238ppm) and lowest in fresh pulp (91 ppm). Tewe and Lyayi (1989) analyzed Nigerian cassava and found that the HCN contents of fresh thick and thin peel were much higher (364-815 ppm), while HCN in fresh pulp was only 34-301 ppm (air dry basis). They considered that these differences of HCN were probably due mainly to the variety and the time of harvest of the cassava. They further showed that the concentration of HCN in the cassava root, when the thin peel was removed, was reduced by only 5 % and there was a 3% reduction in content of energy and farmers spent 256 % more time on peeling compared with no peeling.

Effect of processing methods and time of ensiling on DM, HCN content and pH

The data (Table 2) indicate that the effect of both processing methods (grinding or chipping) was to increase the dry matter content, with increased length of the ensiling period from 0 to 30 days and 60 days, although this difference disappeared at 180 days.

Table 2. Effect of processing methods and ensiling time of fresh cassava root on DM content and pH.

Whole cassava root

Days ensiled	Ground DM,%	Ground pH	Chipped DM,%	Chipped pH
0*	36.2	6.2	34.7	6.3
30	40.8	4.0	37.0	4.0
60	41.8	3.9	38.3	3.8
90	43.0	3.7	41.3	3.7
120	43.0	3.7	42.0	3.7
150	41.8	3.7	41.7	3.7
180	41.0	3.7	41.0	3.7

*Samples were taken 2 hours after harvesting

The increase of DM content in ground ensiled cassava root was higher than in chipped ensiled cassava root from 0 day to 30 days. Almost certainly the grinding (by machine) exposed a greater surface area to the air which facilitated loss of moisture. Chipping was by hand and thus the particles were larger and less likely to lose moisture. The ensiled material had some 10% more dry matter (after 150-180 days of ensiling) than the freshly processed root. A similar effect was reported by workers at CIAT (1978), who found that the dry matter content increased from 35 to 39% during the space of 25 weeks of ensiling.

The pH was reduced to about the same level (pH=4.0) for both processing methods after 30 days, and then decreased slightly to 3.7 at 90 days and remained at this value.

Effects of processing methods on cyanide content are shown in table 3. The HCN content was affected by the processing method and was lower at all stages of ensiling in the ground root than in the chipped root ($P<0.001$).

Table 3. Effect of processing methods and ensiling time of fresh cassava root on HCN composition.

Ensiling time, days	Total HCN (mg/kg)		HCN,% of initial concentration	
	Ground	Chipped	Ground	Chipped
0	109	111	100	100
30	76	88	70	80
60	64	71	59	64
90	61	68	56	61
120	59	66	54	59
150	58	61	53	55
180	56	60	51	54

HCN levels for both processing methods decreased very quickly up to 30 days and then continued to decrease more slowly up to 180 days. Ensiling ground cassava reduced HCN content to 70, 59 and 51 % of the initial value after ensiling periods of 30, 60 and 180 days respectively,while ensiling cassava chips reduced the HCN content to 80, 64 and 54% of the initial value, respectively. Similar findings were reported by CIAT (1981) and Gomez and Valdivieso (1988). These results shown that ensiling ground cassava procesing was slightly better in reducing HCN.

The reported levels of reduction of cyanide content are sufficient to make the ensiled cassava safe as a feed for pigs according to Gomez and Valdivieso (1988) who fed roots ensiled for 60 days with a residual cyanide content of 56ppm. Bolhuis (1954) proposed that the toxicity of cassava cultivars could be rated as follows:

(*) Innocuous: less than 50 ppm HCN in fresh peeled tuber.
(**) Moderately toxic: 50-100 ppm HCN in fresh peeled tuber
(***) Dangerously toxic: more than 100 ppm HCN in fresh peeled tuber.

However, Ikediobi *et al*.,. (1980) have reported that cassava containing 144 to 164 ppm HCN after processing can be used for livestock in Nigeria.

The HCN level of ground ensiled cassava root after 60 days ensiling (64 ppm HCN) apparantly caused no ill effect in the pig used in the experiments on farm and on station.

Organic acid content in whole ensiled cassava root

The effect of the ensiling time on organic acid levels in cassava root is shown in Table 4.

Table 4. Effect of ensiling time on organic acid content of whole cassava roots (% of DM)

Ensiling time, days	Acetic acid%	Lactic acid%	Butyric acid%
30	0.81	4.55	0.23
60	0.79	5.62	0.14
90	0.74	5.70	0.06

The content of acetic and butyric acids decreased with increased ensiling time, while that of lactic acid increased. The results are fairly similar to those reported by Serres and Tillon (1972) who recorded levels of acetic and butyric acids in ensiled cassava after three months of 0.3% and 0.09%, respectively.

Experiment 3.

Effect of Different Levels of A Molasses Replacing Cassava Root Meal Or Ensiled Cassava Root on the Performance of Growing-finishing Pigs

Hypotheses

An on-farm survey (Nguyen Thi Loc *et al*., 1997) in two villages in the hilly areas in Central Vietnam indicated that the cheapest feed resources with potential for pig feeding were fresh cassava roots and A molasses. The hypotheses to be tested in the following experiment were: 1. Ensiling would be a convenient way of processing cassava root and that the feeding value for pigs would be similar to that of cassava root processed by sun-drying. 2. There would be advantages from incorporating low levels of A molasses in the basal diets of dried and ensiled cassava root

Materials and Methods

Choice of families

The families were selected in cooperation with the local Womens Union, and the criteria taken into consideration for selecting the families for the on farm trials were

- Farmers willingness to participate in research trials
- Importance of pig production as a source of income in the household
- Experience with pig rearing
- Availability of a closed pig pen with cement floor of adequate size
- Cassava and vegetables were planted on the farm
- Number of family members supported by farm

Experimental design

The experiment was carried out from May to November, 1995. Pigs were purchased by groups of farmers with the assistance of the researcher and Women's Union of the villages.

Seventy two crossbred (Mong Cai x Large White) pigs of 18 kg initial weight were randomly assigned to 12 treatments with 3 replicates per treatment and 18 farms (10 in Xuan Loc and 8 in Binh Dien). Each farm had 4 pigs fed the same A molasses level, but 2 pigs per pen (1 castrate and 1 gilt) were fed cassava root meal and 2 pigs were fed ensiled cassava root. The design comprised 2 factors :

- Level of molasses (0, 5, 10, 15, 20, 25% of diet DM)
- Ensiled whole cassava root (ECR) versus cassava root meal (CRM)

Diets and feeding

An adaptation period of 25 days was used to change to the experimental feed. Experimental diets were given for 5 months.

Diet composition and amounts of dry matter supplied per pig per day are given in Table 5 and 6. Feed samples were taken for analysis of dry matter (DM), crude protein (CP), ether extract (EE), ,crude fibre (CF) and ash at the laboratory of the Animal Nutrition Department of the Hue Agricultural and Forestry University using AOAC procedures (AOAC 1985).

Table 5. Dry matter (DM) intakes of the dietary ingredients, kg/day

Live weight,kg	10-30	30-50	50-70	70-90
Intake (kgDM/day)				
Cassava+-A Molasses	0.35-0.82	0.82-1.21	1.2-1.71	1.71-2.04
Fishmeal+Groundnut	0.42	0.42	0.42	0.42
Sweetpotato leaves	0.06	0.06	0.12	0.12
Total diet	0.83-1.30	1.30-1.75	1.75-2.25	2.25-2.58

*Two hundred g crude protein (CP) supplement obtained from 384 g of a 39 % CP of groundnut cake (GC)and 120 g of a 42 % protein fish meal fortified with salt per day per pig, this being kept constant throughout the experiment

Table 6. Chemical composition of the experimental diets (% fresh basis)

	*CRM	ECR	AM	FM	GC	SL
DM	87	42	75	87	83	12
N*6.25	2.9	0.95	1.75	42	39	2.4
EE	2.2	0.42	-	9	10.2	0.6
CF	3.84	1.05	-	-	4.3	2.6
Ash	2.52	0.85	4.5	30	4.6	1.4
ME MJ/kg	12.5	4.7	6.9	11.6	14.1	1.3

*CRM, cassava root meal ECR,ensiled cassava root AM, Amolasses FM, fish meal GC, groundnut cake SL, sweet potato leaf.

Details of the methods of processing the cassava root are given in Experiment 2. The A molasses was purchased from an artisan factory in Binh Dien village. On the basis of the results of Ospina *et al.*, (1995), the ad libitum feeding of the cassava root was complemented by 200 g protein/day derived from a mixture of 75% groundnut cake and 25% fish meal. The required weekly amounts of molasses (according to treatment) and cassava root were weighed and put into plastic bags to facilitate the work of the farmers. The farmers mixed these two ingredients immediately prior to feeding three times per day, estimating the quantities needed at each feed according to indicated guidelines provided by the researchers which were revised weekly. The protein supplement was also weighed in weekly amounts and given in two feeds per day. The daily amount remained constant (384 g groundnut cake: 120 g fish meal) throughout the experiment.

Measurements and statistical analysis

The pigs were weighed in the early morning every 30 days using a 100 kg capacity portable scale with an accuracy of 0.5 kg. Records of feed consumption were kept by the farmers and checked twice weekly during visits to the farms.

All data collected were analysed by analysis of variance using the General Linear Model (GLM) procedure of Minitab statistical software.

Results and Discussion

The pigs on all dietary treatments readily consumed the diets with no palatability problems or digestive upsets, except for a few cases of diarrhoea. Cassava diets have often been found to be of low palatability due to the powdery nature of the root flour (Balagopalan *et al.*, 1988).

Growth performance

Overall treatment effects are shown in Table 7.

Table 7. Effect of location, cassava processing and A molasses levels on live weight gain of pigs , feed conversion ratio and feed costs

	Live weight gain (g/day)	FCR kgDM/kgLW	Feed costs VND/kg gain
Villages			
Xuan Loc	433	4.12	8520
Binh Dien	436	4.09	8440
SE/P	3.50/0.621	0.04/0.578	70/0.450
Processing			
Ensiling	429	4.16	7550
Drying	440	4.05	9420
SE/P	3.50/0.027	0.03/0.022	64/0.001
A molasses levels			
0	417	4.27	8910
5	423	4.22	8720
10	435	4.09	8520
15	442	4.03	8330
20	458	3.90	8000
25	432	4.13	8400
SE/P	6.30/0.001	0.60/0.001	110/0.001

The major parameters of biological performance in finishing pigs (rate of gain and feed conversion) were significantly better for dried cassava root meal than for the ensiled root, although the absolute differences were relatively small (2.5 and 2.6%, respectively, for gain and feed conversion).

Live weight gains of pigs fed ensiled cassava roots were lower than of pigs fed cassava root meal for A molasses levels from 0 to 15%.

Live weight gains of pigs fed ensiled cassava roots were similar to those of pigs fed cassava root meal for A molasses levels from 15 to 25%.

The response to A molasses appeared to be curvilinear with optimum performance in terms of growth and feed conversion being observed for levels of between 15 and 20% of A molasses for both methods of processing the cassava root.

These results agree with those of Vinas and Cisneros (1990) who found that mean daily gains of pigs were significantly greater for a group given 15-20 % molasses than for the controls.

In addition, the taste and consistency of the ration can be maintained by the addition of molasses (Gomez, 1979). The average growth rates of the experimental pigs were quite satisfactory considering the genotype (exotic*local) and the restricted protein level (200 g/day).

Average daily gains of pigs in Binh Dien village (436g/day) did not differ (P=0.62) from those on farms in Xuan Loc (433 g/day) and there were no interactions between village and the dietary treatments (P>0.70).

This is evidence for the reliability of data from on-farm experiments of the kind described in this study.

Economic Comparisons of the Dietary Treatments

In contrast to the results for growth and conversion, feed costs per unit liveweight gain were much lower (20%) for ensiled cassava root than for the sun-dried meal (Table 7) and followed a similar pattern as growth performance for the effect of molasses level, with the lowest feed costs corresponding to molasses levels of 15 to 20%.

Experiment 4.

Sugar Cane Juice for Pigs

A trial with cane juice was conducted in Binh Dien village, Huong tra district, Hue province involving 40 pigs (crossbred between Mong cai and Cornwall) and 20 farmers. The pig ration (DM base) consist of sugarcane juice 68%, fish meal 16%, vegetable 16% and salt. Data was collected from pigs raised by 7 families.

In the morning the pigs were fed the full ration of protein supplements (fish meal and groundnut cake) and half the sugar cane juice ration and some sweet potato leaves

The second feed at 17.00h, the pigs were fed the remainder of SCJ and some sweet potato leaves .Water was available ad-libitum.

The results are showed in Table 8.

Table 8. Daily gain of pigs fed sugar cane juice

Groups	No of pigs	Initial LW	Final LW	Gain,g/day
I (low init. LW)	8	18.3+-1.97	56.5+-3.7	318.5+-19
II (high init. LW)	8	43.5+-3.44	104.1+-5.96	505.3+-45.7

The results were satisfactory (a mean daily live weigh gain of 318 g/d and 503 g/d) so it is feasible to use sugar cane juice to replace cereals and their by-products in the diet of pigs.

The data show that the weight gain of pig fed sugar cane juice was good. It is possible to replace entirely concentrates with sugarcane juice in pig rations. The ADG was affected by farmer management.

Conclusions

- The typical diet fed to fattening pigs is based on the following ingredients in order of importance: cooked rice, rice bran, cassava meal, fresh cassava root and sweet potato leaves. Calculation of the probable nutrient supply showed that protein was the main limiting nutrient with the amount supplied being less than 100 g per pig per day in most cases.
- Limited supplementation of the traditional diet with the equivalent of 100 g protein/pig/day increased live weight gain by 83% and improved economic benefits to the farmers.
- Ensiling ground cassava roots appeared to be as effective as sun-drying in reducing cyanide levels to non-toxic proportions. Ensiling increases the palatability of the roots for pigs. The technique is simple, cheap and suited to the conditions of farmers in Central Vietnam.
- Inclusion of low levels of "A" molasses appears to improve slightly the utilization of cassava root meal and ensiled cassava root. Feeding cassava meal or ensiled cassava root with 15 or 20% replaced by "A" molasses and maintaining the protein allowance at a level of 200 g/pig/day throughout the growing-finishing period gave reasonably high growth rates and good economic returns (20% lower feed costs

per unit gain).

- The technical of feeding sugar cane juice with 200 grams CP supplement derived from fish meal and ground cake in farm households in two villages were good.

References

Association of Official Analytical Chemists (AOAC), 1985. Official methods of analysis. 12th ed. Washington, DC.

Balagopalan, C., Padmaja, G., Nanda, S.K. and Moorthy, S.N. 1988. Cassava in food, feed and industry. CRC Press, Florida, USA. 205pp.

CIAT (Centro Internacional de Agricultura Tropical), 1978. Informe anual, programa de Yuca. 1978. Cali, Colombia.

CIAT, 1981., Informe anual, programa de Yuca. 1981. Cali, Colombia.

Dolberg F., 1993 Transfer of sustainable technologies in Vietnam. Development of sustainable livestock technologies for ecologically fragile zones in the tropics. Swedish International Development Agency (SIDA) Stockholm Sweden. Internal Report

Easley.J.F, J.T. McCall, G.K. Davis and R.L. Shirley., 1970. Nutrition laboratory of department of Animal Science University of Florida,1970

Gomez, G., 1977. Lifecycle swine feeding systems with cassava. In: Nestel, B.; Graham, M. (Eds.) World Animal Review .

Gomez, G., Valdivieso, M., De la Cuesta, D. And Salcedo, T.S. 1984. Effect of variety and plant age on the cyanide content of whole root cassava chips and its reduction by sundrying.Animal feed Science and technology 11: 57-65

Gomez, G., 1979. Cassava as swine feed. World Animal Review 29: 13-20.

Ikediobi, C.O.; Onyila, G.O.C.; Eluwah, C.E., 1980. A rapid and in expensive enzymatic assay for total cyanide in cassava and cassava products, Agric. Biol. Chem. 44 (12): 2803-2809.

Lepper *et al*., 1982. Methods how to determine volatile fatty acids in silage. Handbook for feed analyses. Moscow Kolos. Ministery of Agriculture, Soviet Union-Cooporation Chemistry Agriculture.

Nguyen Van Thuong, 1992. The hand book of nutrient composition of animal feed in Vietnam. Agricultural Publishing House, Hanoi, 1992. 237-238 pp

Nguyen sinh Cuc, 1995. Agriculture of Vietnam 1945-1995.Stat. Publishing House, Hanoi, 1995. 225-231 pp.

Nguyen Kim Duong and Le Duc Ngoan, 1993. A molasses in diets for pigs, broilers and ducks. Proceeding of the Regional Workshop: Increasing Livestock Production by Making Better Use of local Feed Resources. Hanoi/Ho Chi Minh City. Vietnam. Nov. 25-29, 1991. FAO-SAREC. FAO Regional Office for Asia and the Pacific (RAPA) publications. Bangkok, Thailand. 80 pp.

Nguyen Thi Loc, Ogle, R.B. and Preston, T.R. 1997. Village pig production in central Vietnam: results of a participatory rural appraisal survey and on-farm feeding trials with protein supplementation of traditional diets. Livestock Research for Rural Develoment. In Press.

Ospina Liliana, Preston, T.R and Ogle, R. B., 1995. Effect of protein supply in cassava root meal based diets on the performance of growing - finishing pigs. Livestock Research for Rural Develoment. Volume 7, number 2, October 1995, pp 30-39. Serres. H.y

Ostergarrd V., 1994. Livestock systems research-appropriate methods of the future. Integrated livestock / crop production systems in the small scale and communal farming sector. Symposia at the Department of Animal Science, University of Zimbabwe, January 26- 28, 1994

Serres. H.y Tillon.J.P., 1972. L ensilage des racines de manioc. Rev. Elev. Med. Vet. Pays Trop. 25 (3): 455-456.

Tewe, O.O. and Iyayi, E.A. 1989. Cyanogenic glucosides. In Toxicants of plant origin, Vol II. Glycosides. Ed. Cheeke, P.R. CRS Press. pp. 43-60.

Vinas, RC; Cisneros, JC., 1990. Feeding growing pigs with sugarcane molasses to replace maize as an energy source. Revista-Argentina-de-Production-Animal.1990, 10:3, 193- 199

Integrated Animal Production in the Oil Palm Plantation

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Abstract
The oil palm industry offers a number of opportunities in terms of feed resources which can be utilised for animal production. These feed resources range from forages in the inter-rows to the by-products from the oil palm. Many of these by-products, e.g. palm kernel cake and oil palm fronds, are rich in nutrients and have been proven to be feeds of high quality. Integrating animals with oil palm plantations will ensure long-term profitability as well as sustainability of the agriculture industry in a very competitive environment.

KEY WORDS: African oil palm, by-products, forages

Introduction
Oil palm cultivation is rapidly expanding within the tropical zone and South-East Asia is the leading producer of palm oil, accounting for more than 80% of the world's output. Palm oil, with a 20% market share, has emerged as one of the dominant vegetable oils, second only to soya bean oil. During the past three decades, the production of palm oil grew at the fastest rate (8% per year) compared to rape seed oil (7.2%), soya bean oil (4.5%), and sunflower oil (3.7%). Palm oil production is expected to increase further with the expansion of oil palm cultivation and improved cultivation techniques. The oil palm industry, with diverse products and by-products, offers two opportunities for the promotion of animal production. Firstly, the products and by-products from the industry are valuable feed resources with the potential to be utilised for expanding

animal production. Secondly, the forages in the inter-rows can be consumed by ruminants. Integrating animal production with oil palm plantations should take into account all the available resources, i.e. the products and by-products of the industry as well as the forages grown in the inter-rows.

Palm Oil By-products

Palm oil is available in about 15 different grades, ranging from crude to semi-refined, refined, crude fractionated, refined fractionated oil and refinery by-products. Palm oil is currently the main fat source in feeds for monogastric animals, but it is not commonly fed to ruminants because it can result in rumen disorders, metabolic problems and reduced milk fat content (Palmquist, 1995). However, calcium soaps of palm oil origin, given to dairy cattle to increase energy intake, produced many positive effects of an energy supplement (Palmquist, 1995). This is attributed to the high level of unsaturated fatty acids (primarily oleic acid) which escape rumen degradation, leading to enhance digestibility. This makes calcium soaps of palm oil origin a good source of by-pass energy.

Oil Palm By-products

Palm press fibre

Palm press fibre (PPF) is a fibrous residue of oil palm fruits after oil extraction. The potential of using PPF for ruminant production is enormous but, due to its bulkiness and low feeding value, the amount consumed and digested is inadequate to support production at an economic level. Therefore, the use of PPF could be enhanced by improving its nutritive value by chemical treatment and by manipulating the ration to optimise rumen fermentation.

Treating PPF with chemicals such as sodium hydroxide, urea and ammonium hydroxide has shown varying degrees of improvement in feed intake and biodegradability. For example, DMD increased from 43.3% to 58.0% when PPF was treated with 8% sodium hydroxide (Jelan *et al.*, 1986). Buffalo could be induced to increase voluntary intake of PPF (360 g/head/day) which was sprayed with molasses and supplemented with fish meal. Animals fed urea-treated PPF had significantly higher voluntary feed intake when energy and protein were supplemented compared to those receiving only protein or energy. This is a clear indication that PPF is limiting in both energy and protein. A feeding system based on PPF needs to be carefully balanced with supplements in order to ensure optimum production.

Palm Kernel Cake

In Malaysia, more than 60,000 tonnes of palm kernel cake (PKC) are produced annually. The world production of PKC far exceeds the stated amount. PKC has a fairly high nutritive value and is being used extensively for fattening steers in feedlots. Crude protein content of PKC ranges from 7.7 to 18.7% depending on processing methods and the degree of impurities such as shell content. At 70% DMD, PKC is readily consumed. Hutagalung (1985) reported that cattle fed 6-8 kg PKC combined with small quantities of feed additive (e.g., minerals and vitamins) produced daily growth rates of 0.7-1.0 kg/animal. Similar results were obtained under farming conditions by Jelan *et al.* (1986).

There are two intrinsic problems in the utilisation of PKC, namely, the high oil residue and the copper content. The oil content in certain cases can be as high as 20%, which can cause rancidity and rejection by the animals. Palm oil is extracted by expeller or solvent. The former process is rather inefficient resulting in large quantities of oil residue in the PKC. The high copper content can cause toxicity in small ruminants, particularly sheep. To a certain extent, copper toxicity can be alleviated by the addition of zinc molybdate. The extent of copper toxicity in larger ruminants is somewhat unclear because feeding PKC over a long period to either cattle or buffalo has not resulted in retarded growth or mortality. Furthermore, steers fed high level of PKC were found to have normal concentrations of rumen metabolites, glucose, urea, alkaline phosphate and glutamate oxaloacetate transaminase. A more recent study by Hair-Bejo *et al.* (1995) showed that buffalo fed 100% PKC had twice as much copper and zinc in the liver and adrenal cortex compared to buffalo fed a normal diet. However, high mineral contents in these two organs did not cause any mortality.

Oil Palm Fronds

Oil palm trees require regular pruning to facilitate harvesting of mature fruit, thus yielding large quantities of fronds (leaves and petioles), which at present are not utilised for feeding animals. Oil palm fronds (OPF) with nearly 15% crude protein is a potential ruminant feed (Abu Hassan, 1995). However, it cannot be economically utilised unless processed into pellet form. Cattle fed OPF pellets measuring 9 mm in diameter and 3-5 cm in length with 33.3% total digestible nutrients gained 0.93 kg/day (Asada *et al.*, 1991).

Empty Fruit Bunch

Empty fruit bunch (EFB) can also be processed into ruminant feed as pellets. Very little work has been done to utilise EFB as ruminant feed but there should not be serious problems in developing appropriate technology to improve the feeding qualities of EFB.

Forage Cover Crops

The inter-row spaces found in all oil palm plantations promote the growth of at least 60 plant species - usually considered as weeds (Chen and Dahlan, 1995). In intensive oil palm plantations, chemicals are used regularly to control weed growth so that the competition for plant nutrients is minimal. The cost of weeding is quite substantial and can be easily eliminated if the forages in the inter-rows are utilised for animal production. In addition, soil and environmental pollution is minimised. Integrating animals in the plantation can also reduce fertilizer application since the nutrients returned to the soil from the animals are quite substantial. Reducing chemical fertilisers in the long-run will not only reduce production costs but, more importantly, will minimise further deterioration in soil fertility. It is a known fact that constant application of chemicals will alter the ecological profile of the soil. With reduced biodiversity in the soil, plant growth can be affected.

Cover crops such as *Centrosema pubescens*, *Desmodium audifolium*, *Pueraria phaseoloides*, *Calopogonium caeruleum*, etc., found in the inter-rows in most plantations, are legumes with a high nutrient content. As the palm matures, the canopy increases and limits light penetration, which in turn will reduce forage production in the inter-rows. It has been estimated that after the second year of planting, the light intensity declined by an average of 10 - 15%. Forage DM yield for the five years after planting ranges from 2000-3000 kg/ha to as high as 7000-8000 kg/ha DM depending on the extent of weeding done (Chen *et al.*, 1991). After five years, DM yields declined to between 500 and 1000 kg/ha.

The stocking density has to be adjusted to correspond with the forage yield. The carrying capacities and liveweight productions of cattle grazing under immature oil palm are comparable to those found in ranch operations in Malaysia, which is about 138-285 kg/ha/year (Chen and Dahlan, 1995). The carrying capacity under mature oil palm is only 0.3 head/ha which is low. The carrying capacity can be sustained at a higher level if all the available biomass (including the by-products) are utilised. However, a production system which fully integrates livestock utilising forage and other biomass has not been developed.

Grazing Systems

Forage production in the inter-rows can be substantially increased even under mature palms provided the planting density is reduced. Reducing planting density does not necessarily mean lower fruit bunch production. On the contrary, production of fruit bunch is maintained because the reduction in planting density is compensated by increased production from individual trees. Under reduced planting density there is greater light penetration resulting in increased forage production.

Chen and Dahlan (1995) suggested that a rotational grazing system at 6-8 weekly intervals is ideal since it allows routine work to be done. They also recommended that the interval of grazing be adjusted depending upon forage availability. The stocking rate for cattle varies from 0.3-3.0/ha and in the case of sheep, from 2.0-14.0/ha. The large variation is due to the inconsistency in forage availability. Animals should be relocated after 60% of the forage is grazed when it meets both objectives of weeding and forage regeneration.

Integrated animal farming can be further intensified if the system incorporates the utilisation of by-products. The by-products from the oil palm industry are easily available at competitive costs. There is no reason why a viable animal production system cannot be developed in conjunction with the oil palm plantation. In fact, the oil palm industry is the only basis for animal production in the tropics since conventional grazing alone is uneconomic.

Conclusion

The concept of integrating animals with oil palm plantations is a feasible and practical proposition as demonstrated by many studies conducted in Malaysia over the past two decades. The only impediment towards implementing the concept is the attitude of the plantation management which lacks the expertise in animal husbandry and is unable to see the benefits derived from such a farming system. Future plantation managers should be competent in both crop and animal production. At present, plantation management cannot ignore the need to optimise all available resources for two reasons. Firstly, with the rapid expansion of oil palm cultivation worldwide, ensuring profitability solely from extracting oil has become somewhat uncertain. Secondly, demand for animal products has exceeded supply because of improved standards of living and affluence. Finally, a paradigm shift is needed in the way the oil palm sector is managed. This is only possible through new policy directions and availability of training packages to advance the concept of animal/crop integrated farming system.

References

Abu Hassan, O. 1995. Utilisation of oil palm trunks and fronds. In Proc. 1st Int. Symp on Integration of Livestock to Oil Palm Prod. Kuala Lumpur, Malaysia. pp. 129-138.

Asada, T., Konno, T., and Saito, T. 1991. Study on the conversion of oil palm leaves and petioles into feeds for ruminants. In Proc. 3rd. Int. Symp. on the Nutrition of Herbivores. Penang, Malaysia. pp. 104.

Chen, C. P. and Dahlan, I. 1995. In Proc. 1st Int. Symp. on Integration of Livestock to Oil Palm Prod. FAO, Rome. pp. 35-49.

Chen, C. P. H. K. Wong and Dahlan, I. 1991. In Recent Advances on the Nutrition of Herbivores. Y. W. Ho et. al (Eds.) Malaysian Society and

Animal Production. pp. 233-246.

Hair-Bejo, M., Liang, J. B. and Alimon, A. R. 1995. Copper tolerance in buffalo: The potential toxic effect of copper in buffalo fed palm kernel cake. In Proc. 17th Malaysian Society of Animal Production Ann. Conf. Penang, Malaysia. pp. 246-247.

Hutagalung, R. I. 1985. Nutrient availability and utilisation of unconventional feedstuffs used in tropical regions. In Proc. Feeding Systems of Animals in Temperate Areas. Seoul, Korea. pp. 326-337.

Jelan, Z. A., Jalaludin, S., and Vijchulata, P. 1986. In Final RCM on isotope-aided studies on non-protein nitrogen and agro-industrial by-products utilisation by ruminants. International Atomic Energy Agency, Vienna, Austria. pp. 77.

Palmquist, D. L. 1995. By pass energy from palm oil for cattle. ln Proc. 1st Int. Symp. on Integration of Livestock to Oil Palm Prod. Kuala Lumpur, Malaysia. pp. 123-128.

Integration of Animal Production in Coconut Plantations

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Abstract

Worldwide there are between 10 and 11 million hectares of coconuts. With the marked fluctuations and long term decline in copra and coconut oil prices the integration of livestock and coconuts is economically increasingly attractive. Traditionally used for weed control in plantations so that coconuts could be located, cattle (and sheep and goats) are increasingly seen as important parts of the system. Although there are constraints particularly related to the level of shade under closely spaced coconuts, a number of grass and legume species have been identified which have varying degrees of shade tolerance. Where light transmission is greater than 50%, sustainable grazing of pastures is possible.

The paper reviews some of the main production systems and details animal production levels in grazing and cut-and-carry systems.

Key areas for future work are:

- the screening of new forage species for shade tolerance and persistence;
- the focus on systems of coconut spacing which emphasize wide inter-row areas for increased forage production under high light conditions;
- the development of coconut multicropping systems where various management options are modelled to maximize returns for the grower, and
- the increased use of by-products and alternative feed resources by smallholder farmers.

KEY WORDS: coconut, plantation, forage, feed, livestock

Introduction

The substantial potential for animal production from a number of agroforestry systems has been reviewed by Gutteridge and Shelton (1994). The plantation crop system with perhaps the greatest potential for further development is the integration of livestock, especially cattle (but also sheep and goats) with coconuts (Shelton, 1991). Worldwide there are probably between 10 and 11 million hectares of coconuts, with more than 90% located in the Asia and Pacific region.

Integration of cattle production with coconut plantations is based on the premise that cattle are beneficial to the management of coconuts and that the combined income of the two enterprises is greater. In the past, coconut was the main agricultural activity and cattle management was directed towards reducing plantation weeding costs and increasing copra production (largely from a higher recovery of fallen nuts). In recent years the marked fluctuation in copra prices, both monthly and from year to year, and the structural decline in copra prices since 1950, has encouraged farmers to diversify.

Cattle production is one avenue for diversification. It is increasingly economically attractive both through consistent price increases and price stability. In the Philippines retail prices for beef nearly tripled between 1985 and 1992. Although increases in actual farmgate prices may have been lower, cattle production compares favourably with other intercropping options. Similarly the demand for meat is increasing in Indonesia and this has lead to considerable price increases.

Benefits and Constraints

Any attempt to grow two or more crops together, and particularly to grow one (forages) beneath the shading canopy of another(coconuts), necessitates some understanding of the environmental factors involved and the degree of competition likely. Important factors affecting the growth of forage species under coconuts are the available soil moisture and nutrients, the amount of light and the degree of competition between the forage species and the coconuts. The yield of plantation crops may be positively or negatively affected by the pasture system, depending on the nature of the interference which develops and the net effect on the crop environment. The influence of the plantation tree canopy on the quantity and quality of light reaching the ground surface, on temperature and humidity and soil moisture levels has been reviewed by Wilson and Ludlow (1991).

On the positive side, cattle are important for weed control and this has been the traditional use of cattle in coconut plantations. Light transmission in the commonly used tall coconut varieties decreases from >90% in recently planted coconuts to a minimum of around 40% at an age of 5-15 years, and then increases again with time until the coconuts are due for replanting at age 50-60 years. Light transmission obviously varies depending on variety (with dwarf or hybrid varieties intercepting more light than the tall varieties), tree spacing and management. Much of the area of existing coconut plantations is of tall varieties and often more than 30 years old, therefore light levels are high enough to support an understorey vegetation. Unless it is controlled this understorey vegetation competes with the trees for water and nutrients.

Grazing can reduce competition from the understorey vegetation by recycling nutrients "locked up" in the standing biomass. A near doubling of coconut yield was reported by several researchers when previously ungrazed coconut plantations were grazed. This was probably only partly related to increased nutrient cycling; the main effect of grazing being related to a higher recovery rate of nuts in short grazed vegetation. Negative effects of any understorey vegetation on coconut yield must be expected if rainfall or soil fertility is marginal for coconut growth, although the latter can be ameliorated by sufficient fertilization. Competition for moisture is likely to occur where annual rainfall is below 1750 mm, particularly if rainfall is not evenly distributed.

As far as animal production is concerned the provision of shade and thus lower heat loads on animals is likely to have a positive effect on animal productivity. The nutritive quality of forages grown in partially shaded environments such as old coconuts is comparable to those grown in full sun (Norton *et al.* 1991). Incompatability of cattle and coconuts is likely to be caused by unacceptable damage to young trees or interference in the management of coconuts. Damage to fronds of young coconuts could be caused by grazing animals and it is usual practice to keep cattle away from young coconuts until fronds are out of reach of the grazing animals. The time required for coconuts to grow beyond the reach of cattle varies, but periods of 3-8 years have been mentioned in the literature. Small ruminants such as sheep have been successfully grazed in 2-year old coconuts (Simonnet, 1990). Damage to stems of coconuts is minimal although there are concerns over possible soil compaction and increased erosion that may occur when the understorey vegetation is overgrazed.

Forage Species

Some grasses and legumes are more shade tolerant than others (see Table 1). When light transmission values fall below 40 or 50% then both production values and the range of species are severely reduced. In general herbage production (and therefore carrying capacity) is inversely proportional to tree density (and light transmission values). Wong (1991) defined shade tolerance (agronomically) as "the relative growth performance of plants in shade compared to that in full sunlight as influenced by regular defoliation. It embodies the attributes of both dry matter productivity and persistence". The term persistence includes both the survival of individual plants and seedling replacement.

Indigenous species

Native vegetation under coconut varies according to the location and intensity of grazing. Unless there is control of the stocking pressure there may be changes in pasture composition over time with undesirable weed species gradually dominating the sward. Using cattle as "sweepers" or "weeders" without additional selective weed control measures may control the weeds in the short term but allow tough unpalatable species to become dominant. The more promising of the native species include: carpet or mat grass (*Axonopus compressus*), buffalo couch grass (*Stenotaphrum secundatum*), Pemba grass (*Stenotaphrum dimidiatum*), T-grass (*Paspalum conjugatum*), as well as various legumes such as alyce clover (*Alysicarpus vaginalis*), *Desmodium ovalifolium*, *Desmodium triflorum*, hetero (*Desmodium heterophyllum*) and sensitive plant (*Mimosa pudica*).

Table 1 Shade tolerance of some tropical forages (after Wong 1991, and Shelton *et al*. 1987)

Shade tolerance	Grasses	Legumes
High	*Axonopus compressus* *Brachiaria miliiformis* *Ischaemum aristatum* *Ottochloa nodosa* *Paspalum conjugatum* *Stenotaphrum secundatum*	*Desmodium heterophyllum* *Desmodium ovalifolium* *Flemingia congesta* *Mimosa pudica*
Medium	*Brachiaria brizantha* *Brachiaria decumbens* *Brachiaria humidicola* *Digitaria setivalva* *Panicum maximum* *Pennisetum purpureum* *Setaria sphacelata* *Urochloa mosambicensis*	*Arachis pintoi* *Calopogonium mucunoides* *Centrosema pubescens* *Desmodium triflorum* *Pueraria phaseoloides* *Desmodium intortum* *Leucaena leucocephala* *Desmodium canum* *Neonotonia wightii* *Vigna luteola*
Low	*Brachiaria mutica* *Cynodon plectostachyus* *Digitaria decumbens* *Digitaria pentzii*	*Stylosanthes hamata* *Stylosanthes guianensis* *Zornia diphylla* *Macroptilium atropurpureum*

Productivity may vary from low to moderate depending on the relative percentage of productive grass, legume species and weeds, particularly bush weeds. For example, in Western Samoa local pastures dominated by Mimosa pudica and hetero were considered to be particularly productive while in the Solomon Islands there was no significant difference in liveweight gains between improved pastures and naturalized pastures with a high legume content and consisting of *Axonopus compressus, Mimosa pudica, Centrosema pubescens* and *Calopogonium mucunoides.*

Exotic species

Where the aim is to do more than merely keep weeds under control, so that fallen nuts can be located, then various exotic grass and legume species are available. Grass species most suited to the reduced light conditions under coconut palms are sod forming stoloniferous grasses that form short to moderate height swards. They provide moderate carrying capacity, allow fallen nuts to be quickly located, are inexpensive and easy to establish from cuttings, compete well with aggressive weed species, maintain a reasonable balance with companion legumes under grazing and do not compete excessively with coconut production. Such grasses include Angleton grass or Alabang X (*Dichanthium aristatum*), Batiki (*I. aristatum*), Cori (*B. miliiformis*), Koronivia (*B. humidicola*), Palisade (*B. brizantha*) and Signal (*B. decumbens*). Although Para grass (*B. mutica*) is popular in the Philippines, elsewhere it has been shown to be not very shade tolerant and requires good management under the high light conditions (light transmission >75%) of old coconut plantations or where trees are widely spaced (9 x 9 or 10m). Buffalo couch (*S. secundatum*) and Pemba grass (*S. dimidiatum*) are well adapted to heavy shade conditions in Vanuatu and Zanzibar, respectively.

The legumes most suited to coconut plantations include centro *(C. pubescens*) and Siratro (*M. atropurpureum*), with puero (*P. phaseoloides*) and sometimes Calopo (*C. mucunoides*) used as pioneers (and as cover crops). However, in some humid tropical environments Siratro is subject to Rhizoctonia leaf blight. Legumes that combine particularly well with *B. brizantha* and *B. decumbens* include hetero *(D. heterophyllum*), *D. triflorum* and *A. vaginalis*. Sensitive plant (*M. pudica*) should be utilized where it is indigenous, but needs to be carefully controlled. In Zanzibar, *T. labialis* was found to combine well with Pemba grass. Leucaena (*L. leucocephala*), or (on acid soils) gliricidia (*G. sepium*), can be grown as a double-row hedge (rows 1m apart) between every two rows of coconuts.

Although there have been a number of studies on the shade tolerance of herbaceous legumes less information is available on tree legumes. Leucaena leucocephala has been shown to have limited shade tolerance. In a more recent study of the response of six fodder tree legumes to a range of light intensities (ranging from 100 to 20%) the relative order of shade tolerance was *Gliricidia sepium* > *Calliandra calothyrsus* > *Leucaena leucocephala* > *Sesbania grandiflora* > *Acacia villosa* > *Albizia chinensis*. With the psyllid insect causing serious damage to *Leucaena leucocephala* in Bali, Indonesia, psyllid-resistant tree legumes are required. A trial under coconuts (58% light transmission) to identify suitably adapted species concluded that *Calliandra calothyrsus*, *Codariocalyx gyroides, Desmodium rensonii* and *Gliricidia sepium* warranted further study as forage species for use in the coconut plantations in Bali. A similar study was carried out in North Sulawesi where *Gliricidia sepium* and *Erythrina* sp. are commonly used as fences and live stakes under coconuts. *Calliandra* sp. CPI 108458 produced by far the highest leaf yields and other potentially useful species included *Flemingia macrophylla, Calliandra calothyrsus* (local), *Gliricidia sepium* (local), *Desmodium rensonii* and *Codariocalyx gyroides*. In the drier environment of South Sulawesi, there was little difference between the leaf yield of *C. calothyrsus, L. leucocephala* and *G. sepium*. This was before the effect of the psyllid on *Leucaena*.

Production Systems

In Asia, smallholder farmers often have one or two cattle which are grazed on whatever feed resources are available in their area. This varies considerably, depending on the available resources and farming system. In many situations cattle are grazed on fallow cropping areas before and after rice or other food crops, and are shifted to plantation areas during the cropping period when there is little available land for cattle. Also smallholders have to maximize use of their limited land resources, and coconuts are usually intercropped with food and other perennial crops such as banana, cloves, pepper and vanilla, particularly in areas with high population density. Despite this intensive land use there are often small areas under coconuts available for grazing or the growing of forage crops. Cattle are generally tethered in such intensive farming systems and shortfalls in feed are overcome by cutting naturally occurring grasses from communal areas such as roadsides. In these circumstances tree legumes can play a significant role in increasing protein content of the feed material, and thereby animal production. The use of tree legumes grown along field boundaries is particularly widely used in Bali.

In the Pacific, a large proportion of cattle are grazed under coconuts. In Fiji, Papua New Guinea (PNG), Western Samoa and Vanuatu cattle have been used traditionally to control weeds and thus reduce upkeep costs, and to provide an additional income from extra copra and meat. In PNG a 70% reduction in upkeep costs has been mentioned and substantially reduced labour costs on plantations in the Solomon Islands have also been indicated.

Cut-and-carry systems extract a considerable amount of nutrients from the forage production area and this is moved to where the animals are fed; particular care is required to return nutrients to the forage area. Neglect to do so may result in loss of coconut yield and cause a sharp decline in forage yield.

Grazing systems are generally found in more extensive coconut production areas such as in North Sulawesi, Indonesia, parts of the Philippines and also in many South Pacific countries. Some tethering is used to control animals but the majority of cattle are herded or animals are allowed to graze freely. A key factor hampering the development of more commercially oriented cattle production systems under coconuts is the lack of marketing facilities in the more remote coconut plantation areas. The importance of market access for the successful development of a viable cattle industry in the South Pacific was clearly demonstrated by Shelton (1991).

Animal Production

Grazing Systems

The level of animal production reported in grazing trials varies greatly (Table 2). Average daily gains (ADG) vary from 0.12 kg/hd/day to 0.51

kg/hd/day and liveweight gains per hectare varied from 44 kg/ha/year to 744 kg/ha/year. Stocking rates (SR) also varied widely from 1 to 4 cattle/ha (varying sizes) and stocking rate was related negatively to ADG.

The variation in animal production was clearly related to the feed resource available. Liveweight gains were lower on natural vegetation than on improved pastures except in the Solomon Islands where the natural pasture consisted of a very high proportion of legumes. In other cases substantial improvement in LWG was obtained by planting improved pasture. The importance of legumes was clearly indicated in many experiments. Other factors affecting forage growth and therefore animal production were soil fertility and/or fertilizer strategy, and light transmission. In general terms, as indicated above, yield of forages is linearly related to the amount of light available, provided that other factors affecting growth are not limiting. Thus in a coconut plantation with 50% light transmission, the yield of a highly productive grass like *Panicum maximum* will be approximately 50% of the yield achieved in full sunlight. Animal production is likely to be affected similarly by light transmission.

Cut-and-Carry Systems

Small backyard dairy and beef units are common in Bali, Indonesia, Philippines and Thailand, with the grasses Panicum maximum and Pennisetum purpureum being supplemented with leucaena, gliricidia and various by-products. These are widely used in the tropics because of the small size of holdings and the limited grazing area, the fragmentation of land holdings, a lack of fencing in cropping areas and the low cost of labour. These grasses are particularly suitable for plantation crops when the trees are young and vulnerable to damage from grazing animals. Animal production in smallholder cut-and-carry systems is difficult to assess. Rika *et al.* (1981) compared the growth rates of 12 Bali cattle leased individually to local farmers and fed natural vegetation, banana stem and coconut leaf (a local feeding system) with the growth rates of cattle grazing improved pasture in Bali. Average daily gain of cattle in the local feeding system was similar to that at the highest stocking rate in the grazing trial but considerably lower than those obtained at lower stocking rates where animals were able to choose their own diets.

However, a comparison of a cut-and-carry feedlot system, a semi-feedlot system, and free grazing for beef cattle in Johore, Malaysia revealed higher daily gains for stall-fed animals (Sukri and Dahlan, 1986). Trials were carried out with smallholders in West Johore, where coffee was grown as an intercrop under coconuts. Feed rations consisted of coffee by-products (30%), palm kernal cake (37%), urea (2%) and mineral-vitamin premix (1%) and various native forage species (*Paspalum, Axonopus, Ottochloa, Ischaemum* and *Brachiaria*) for grazing. The animals under the feedlot system were confined and fed the feed ration ad lib.; the semi-feedlot treatment involved tethering and grazing on the native grasses for 5 hours daily before the animals received the same feed ration ad lib.; the free-grazing animals were tethered to graze the native grasses. Average daily gains of the animals in the feedlot, semi-feedlot and free-grazing systems were 0.48, 0.37 and 0.15 kg respectively (over period of 178 days). The feedlot and semi-feedlot groups were extended for a further 116 days (trial 2) with average daily gains of 0.60 and 0.38 kg/animal respectively An economic evaluation demonstrated that gross profit was higher for the feedlot animals than the semi-feedlot or grazing groups. It was concluded that feedlot and semi-feedlot systems had great potential for increasing beef production among smallholder farmers and should avoid the major problem of low feed availability (and quality) in dry spells.

Table 2 Cattle production from grazing experiments under coconut

Country	Pasture	Light transmiss -ion(%)	LWG (kg/ ha/yr)	Stocking rate (b/ha)	ADG (kg/ha/d)
Solomon	natural	60	235-345	1.5-3.5	0.27-0.40
Islands	improved	60	227-348	1.5-3.5	0.27-0.40
(2900 mm)	natural	60	219-332	1.5-3.5	0.26-0.40
	improved	62	206-309	1.5-3.5	0.23-0.35
Western	natural	50	148	1.8	0.22
Samoa	improved	50	225-305	1.8-2.2	0.33-0.47
(2900 mm)	natural	50	127	2.5	0.14
	improved	70-84	273-396	2.5	0.30-0.43
	natural	70-84	401-466	4.0	0.27-0.32
	improved	70-84	421-744	4.0	0.29-0.51
Indonesia (1700mm)	improved	79	288-505	2.7-6.3	0.22-0.29
Philipp-	improved	n.a.	169-315	1.0-2.0	0.43-0.47
ines	improved	n.a.	130-155	1.0-3.0	0.14-0.36
(>2000mm)	improved	n.a.	137-306	1.0-3.0	0.20-0.37
	natural	n.a.	51	1.0	0.14
	improved	n.a.	91-146	1.0-2.0	
Thailand	natural	n.a.	44	1.0	0.12
(1600mm)	improved	n.a.	94-142	1.0-2.5	0.16-0.26
Vanuatu	improved	n.a.	175	1.5	0.32
(>1500mm)	natural	n.a.	250-285	2.6-3.0	0.26
	improved	n.a.	550	3.0	0.50

Annual rainfall in brackets
n.a. - not available.
Source: Adapted from Shelton (1991)

In Timor, tethered bulls fatten at an excellent rate of over 1 kg/day on an *ad lib.* diet of *Leucaena* leaves plus a metre of banana stem for moisture each day. The arrival of psyllids has reduced *Leucaena* growth in this system and *Leucaena* has been replaced by other tree legumes such as *Sesbania grandiflora, Acacia villosa* and *Gliricidia sepium*. However, in all cut-and-carry systems animal performance depends on the skill and experience of the farmer in ensuring that forages and feeds are provided according to the animal requirements.

Future Developments

The present emphasis in coconut areas is on planting high-yielding hybrids (mainly in large commercial plantations) and/or on coconut based farming systems where complementary enterprises such as livestock are integrated with coconuts to increase productivity per unit area, increase employment opportunities and to provide a buffer against low and fluctuating copra prices. Increasingly, new management techniques have been adopted, improved grasses and legumes have been planted to increase the animal carrying capacity and in smallholder systems increased use is being made of by-products and forage production is being integrated with food crops.

What is likely to happen in the future and can we learn from the experience of livestock integration with other tree crops?

i) For the immediate future the large majority of coconut areas will remain planted at traditional spacings, so there is a continuing need to identify grass and legume species for reduced light situations (and especially < 50% light transmission).

ii) Where high yielding hybrids are planted at even closer spacings than those traditionally used it remains to be seen if intergrazing is feasible and catch cropping prior to canopy closure may be the main intercropping activity. With the positive results from grazing sheep under coconuts in Vanuatu the integration of sheep at low stocking rates may be feasible, with the same need for low light species as in (i).

iii) As long as high prices were obtained for rubber, palm oil and copra and coconut oil then any use of ruminants was as an aid to the management of the key enterprise, the plantation crop. With the fall in prices for rubber, palm oil, copra and coconut oil in recent years there has been more interest in integrating tree crops and livestock and in developing systems where the combined income from the two enterprises is significantly greater than that obtained from the plantation crop alone.

iv) In many areas seasonality of forage production is a problem. There are large quantities of alternative feed sources which can be used as supplements including banana, cassava, cocoa pod husk, copra cake, oil palm products, rice by-products, sugar cane residues and by-products etc.

Conclusions

Coconut plantations offer an excellent opportunity for the integration of cattle and a tree crop, particularly in the less populated areas where the land under coconuts is not fully utilized and is weed covered.

Given the appropriate tree spacing there are few major constraints and provided that adapted forages are planted to ensure a high quality sustainable feed resource, cattle production under coconuts can be a profitable and sustainable form of land use.

Unfortunately in many areas tree spacing is such that reduced light availability restricts the range of forage species and their productivity. Also, there has been little work on developing farming systems which allow farmers to choose from various management options. While research work is ongoing to identify alternative feed sources there is need to develop and apply low input systems in many coconut areas where poor farmers are faced with feed shortages especially in the dry season.

Areas where future work needs to be focussed include:

i) The identification of forage species better adapted to the low light environment of coconut plantations (<50%) which are capable of persisting under heavy grazing pressure.

ii) The adoption of coconut planting (rectangular) configurations with wide between-row spacing which allow for maximum light penetration, encourage cultivation, improve forage yields and to which to a large extent forage species already available would be well adapted.

iii) More detailed and systematic studies of the pasture-livestock-crop-coconut system and to develop management options for the farmer.
iv) Better utilization of existing by-products and alternative feed resources for livestock in the smallholder coconut based farming systems.
v) Continued efforts to identify alternative tree legumes to supplement *Leucaena* where infestation of the *Leucaena* psyllid has devastated production and severely affected smallholder cattle feeding systems.

References

Gutteridge, R.C. and Shelton, H.M. (1994). Animal Production Potential of Agroforestry Systems. In Copland, J.W., Djajanegra, A. and Sabrani, M. (ed) Agroforestry and Animal Production for Human Welfare. ACIAR Proceedings No. 55, 7-16.

Norton, B.W., Wilson, J.R., Shelton, H.M. and Hill, K.D. (1991). The effect of shade on forage quality. In: Proc. of Workshop Forages for Plantation Crops, Shelton, H.M. and Stur, W.W. (ed.). Sanur Beach, Bali, Indonesia 27-29 June 1990. ACIAR Proc. No. 32, 83-88.

Rika, I.K., Nitis, I.M. and Humphreys, L.R. (1981). Effects of stocking rate on cattle growth, pasture production and coconut yield in Bali. Trop. Grasslands 15 (3), 149-157.

Shelton, H.M. (1991). Productivity of cattle under coconuts. In: Proc. of workshop Forages for Plantation Crops, Shelton, H.M. and Stur, W.W. (ed.). Sanur Beach, Bali, Indonesia 27-29 June 1990. ACIAR Proc. No. 32, 92-96.

Shelton, H.M., Humphreys, L.R. and Batello, C. (1987). Pastures in the plantations of Asia and the Pacific: performance and prospect. Tropical Grasslands 21(4), 159-168.

Simonnet, P. (1990). Sheep flock management in a tropical environment under coconut. Oléagineux, 45(10), 451-455.

Sukri, M.I. and Dahlan, I. (1986). Feedlot and semi-feedlot systems for beef cattle fattening among smallholders. In: Proc. 8th Ann. Conf. MSAP (ed. Hutagalung, R.I. *et al.*) held at Genting Highlands 13-14 March 1984. 74-78.

Wilson, J.R. and Ludlow, M.M. (1991). The environment and potential growth of herbage under plantations. In: Forages for Plantation Crops (ed. Shelton, H.M. and Stur, W.W.) ACIAR Proceedings No. 32, 10-24.

Wong, C.C. (1991). Shade tolerance of tropical forages: a review. In: Proceedings of workshop Forages for Plantation Crops, Shelton, H.M. and Stur, W.W. (ed.). Sanur Beach, Bali, Indonesia 27-29 June 1990. ACIAR Proceedings No. 32, 64-69.

NOTE: More detailed information on the pasture-cattle-coconut system can be found in the following, copies of which will be sent on request (provided full name and address are forwarded):

Reynolds, S.G.(1995) Pasture-Cattle-Coconut Systems. FAO RAPA Publication 1995/7, 668p.

Stur, W.W., Reynolds, S.G. and Macfarlane, D.C. (1994) Cattle Production under Coconuts. In Copland, J.W., Djajanegra, A. and Sabrani, M. (ed) Agroforestry and Animal Production for Human Welfare. ACIAR Proceedings No. 55, 106-114.

Reynolds, S.G. (1993) Pastures and livestock under tree crops: present situation and possible future developments. In Evans, T.R., Macfarlane, D.C. and Mullen, B.F. (ed) Sustainable beef production from smallholder and plantation farming systems in the South Pacific: proceedings of a workshop. AIDAB, 77-117.

The Potential of Tapping Palm Trees for Animal Production

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Abstract
Palm trees have proved to be efficient converters of solar energy into biomass in most agro-ecological zones of the tropical world. Most tapped palm trees gives a sap very rich in sugar (10 to 20%). For several millennia, many species of palm trees (including coconut) have been used for sugar production. Highly sophisticated techniques of tapping were developed through the centuries in Asia, Africa and America. High yields of sugar were obtained from palms that could continue for up to a hundred years of production. One of the main constraints on production in recent times has been the increasing lack of fuel needed for processing palm sap into sugar and the price thereof. Nevertheless, since trials of feeding pigs with fresh sugar palm sap were successfully initiated in an FAO project in Cambodia, there has been renewed interest in tapping palm trees for sap to be used as feed. A thorough review of the literature has shown that intensive pig rearing based on palm sap has already been practised by the Indonesians for centuries and was found to be a very efficient system for intensifying agriculture in some highly populated islands. In today's economy, developing animal production using palm sap as the main source of energy in the diet looks very promising: the land could sustain higher population densities through the intensification of crop and animal production within sustainable integrated systems for small farmers.

KEY WORDS: sugar palm, tapping, sap, livestock, feed

Introduction

For centuries, many palm species have been tapped throughout the tropical world in order to produce fresh juice (sweet toddy), fermented drinks (toddy, wine, arak), syrup ("honey"), brown sugar (jaggery) or refined sugar. Most tapped palm trees do not only produce sap but are multipurpose (edible fruits, building materials, fibres, wax, etc.) and their socio-economic importance can be critical for the rural poor. Palm trees are also often associated with crops and pastures.

Rationale

Theoretically, the advantages of taking the sugars from the sap before it goes to the fruits are obvious. These sugars are intercepted before being used in the production of the non-edible parts such as husk in coconut, which represents 35% of the fruit (Rangaswami, 1977), and in the production of edible material through chemical reactions which imply a loss, mainly a conversion of sugar into oil as for coconut and oil palm. It is therefore more profitable from the point of view of edible energy production to tap a palm for the sap rather than allowing the palm to produce fruits. Similarly, it was demonstrated that, in the context of harvestable energy from the coconut palm, the amount of energy harvested in the sap (through production of ethanol) could be 5 to 7 times higher than from the oil of the nuts (Banzon, 1984).

Physiology

It is possible to obtain a sugary solution by the excision of the meristem in nearly all palms (Tuley, 1965). Basically, starch reserves from the trunk are converted to sugar and are transported upwards to the stem apex (Fox, 1977). Although this is true in the case of Corypha, other explanations are needed for palms such as coconut which does not accumulate starch in its trunk (Reijne, 1948, cited by Van Die, 1974). Pethiyagoda (1978) describes the upward stream as a watery liquid containing dissolved salts absorbed from the soil, and the downward stream as a comparatively rich mixture of food (principally sugars) manufactured in the leaves. The sap flow is intercepted by injuring fibro-vascular tissues of the apex or of the inflorescence. Nevertheless, this author recognizes that the large volume of exudate produced during tapping and the high sugar concentration clearly indicate that the material is drawn from stored resources and is in excess of currently synthesised sugars. The origin of the large flow of sap that occurs in a tapped tree is not yet clearly demonstrated. This is also the case for Borassus flabellifer where water from root absorption appears quite insufficient (Kovoor, 1983). Pethiyagoda (1978) suggests that there is a steep rise in respiration which occurs whenever there is a rapid solubilisation and movement of materials from sites of storage to the points at which they are needed such as during seed germination, flower opening and fruit ripening. This phenomenon can be fostered, heightened and sustained by manipulative processes, the use of generally young growing sites (merismatic tissues) and the act of freshening the wound. Preliminary studies (not published) cited by Pethiyagoda (1978) show a considerably increased respiration by fragments of coconut inflorescence drawn from stimulated spadices.

Location, Products and Tapped Parts of Palms

Table 1 lists nearly 30 different palm species that are traditionally tapped in parts of the tropical world. The major part of the information was found on palms that are tapped in the Old World, with more or less as many different tapped species in Asia and in Africa. It has been possible to identify only three tapped palm species in the New World (Carnauba cerifera, Jubaea spectabilis and Mauritia flexuosa) and very little literature seems to be available on tapping these trees. In America and Africa, it seems that tapping palms has been practised exclusively or mainly for wine production, whereas in Asia the sap is used either as fresh juice or processed into a large array of products (wine, arak, sugar, vinegar, etc.). Table 1 also shows that there are tapped palm species adapted to almost all agro-ecological zones of the tropical world from tidal areas and swamps to deserts and mountains.

Table 1: Location and management of tapped palm species

Latin name	Regions and management
Areca catechu	Tropical rain forest S & SE Asia; Improved cultivated palm [1]
Arenga pinnata or *saccharifera* *Arenga undulatifolia*	Tropical rain forest into dry forest SE Asia; Unimproved cultivated or managed palm [1]
Beccariophoenix madagascariensis	Central Madagascar (1,000m)
Borassus aethiopium	Tropical savanna Africa; Semi-wild or wild palms [1]
Borassus flabellifer *Borassus sundaicus*	Tropical forest into savanna Asia; unimproved cultivated or managed palm [1]
Borassus madagascariensis	Along rivers Madagascar [2]
Carnauba cerifera	Brazil
Caryota urens	Tropical rain forest Asia & S Pacific; Unimproved cultivated or managed palm [1]
Cocos nucifera	Coastal tropical rain forest E Africa, Asia & Pacific; Improved cultivated palm [1]
Corypha elata	SE Asia Unimproved cultivated or managed palm [1]
Corypha umbraculifera	Tropical rain forest S & SE Asia;

Table 1: (Continued)

Elaeis guineensis	W Africa, Madagascar [2], Indonesia [4]; Improved cultivated palm [1]
Hyphaene coriacea	SE Africa
Hyphaene thebaica	Semi-deserts & deserts of E Africa; Unimproved cultivated or managed palm [1]
Hyphaene shatan	Madagascar
Jubaea spectabilis	Chile
Mauritia flexuosa	Tropical rain forest Peru; Semi-wild or wild palms [1]
Nypa fruticans	Tidal areas Asia; Unimproved cultivated or managed palm [1]
Phloga polystachya	Madagascar [2]
Phoenix dactylifera	Semi-desert N. Africa; Improved cultivated palm [1]
Phoenix reclinata	Coast W & SE Africa [5][3][4][6]
Phoenix sylvestris	Trop. rain forest to 1,500m [1]; India, Bangladesh, Ivory Coast; Unimproved cultivated or managed palm [1]; Bangladesh: plantations [7]
Raphia hookeri, R. vinifera, R. sudanica, R. ruffia	Tropical rain forest W Africa, Madagascar [2]; Semi-wild or wild palms [1]

References: [1] Johnson, 1987; [2] Decary, 1964; [3] Giffard, 1967; [4] Blanc-Pamard, 1980; [5]Cunningham, 1990; [6] Adand , 1954; [7] Annett, 1913.

Methods of Palm Tapping

The techniques for tapping palms are numerous and can vary drastically from one continent to another, as demonstrated by the case of *Borassus aethiopium* in Africa and *Borassus flabellifer* in Asia. Refined techniques of tapping the inflorescence of the latter are compatible with production in the long term. Destructive techniques are usually practised on the terminal bud of *B. aethiopium* and are often responsible for the death of the tree within a few months. The African oil palm is used in Africa for producing wine mainly through two different techniques: one is destructive (incision of stem apex of felled palm) and is preferred in Ghana; the other is not destructive (excision of male inflorescence) and has been developed where economic considerations have forced the people to preserve their palms, e.g. in eastern Nigeria (Hartley, 1977). The excision of the terminal bud of standing trees is quite harmful since tapped palms never resume vigorous growth. If the terminal bud is only perforated, then the trees will show malformation in subsequent leaves, flowers and trunk growth (Kovoor, 1983). Nevertheless, it has been observed that multi-stemmed trees such as *Hyphaene coriacea* and *Phoenix reclinata* in south-eastern Africa generally recoppice after tapping, although tapped stems die unless tapping is stopped before the apical meristem is totally destroyed (Cunningham, 1990). The very low yields of sap from these trees are interpreted as a result of over exploitation. Cunningham (1990) suggests that if palm size classes shifted to the extent that there was again a high proportion of mature fruit-bearing palms in the population, then inflorescence tapping could be practised.

The most advanced method of tapping is that applied to the inflorescence spadix which guarantees a high yield for long periods without affecting the well-being of the tree. It only entails a sacrifice of a bunch of fruit in the case of tapping female inflorescences. Tapping the inflorescence is practised throughout S.E. Asia on all species of tapped palm trees (Kovoor, 1983). Two features are common in tapping: manipulative treatment or preparation (application of chemicals and substances of plant origin, twisting, distortion, kneading, pounding, bruising, beating or tapping) necessary as a prelude to copious and sustained sap flow, and renewing the exuding wound by shaving off a thin slice of tissue once or twice a day (Pethiyagoda, 1978). Tapping is an art: sap yields depend on the skills of the tapper (Khieu, 1996; Coconut Research Institute, 1967).

Except for *Nypa fruticans*, which is trunkless and develops its inflorescence at a height of about 1m (Hamilton and Murphy, 1988), other palm trees have to be climbed for tapping as their inflorescences are located at the summit of their trunk which is often over 10m high. Various methods are used to climb the tree (six recorded by Kovoor, 1983), using ankle-loops, aerial ropeways between trees, hoop-belt, rivetted bamboo, mobile 4-9m long ladders and fixed ones on the upper part of the trunks, notches in the trunk, etc.

Management of Tapped Palm Trees

The management of palm trees for sap production varies very much according to species. *Nypa fruticans, Phoenix sylvestris, Elaeis guineensis, Raphia hookeri* and *Cocos nucifera* can be tapped at a rather early age, respectively when the trees are 4, 5, 6, 7 and 7 years old (Crevost and Lemari , 1913; Abedin *et al.*, 1987; Essiamah, 1992; Profizi, 1988; Levang, 1988). On the other hand, many years are needed before tapping *Caryota urens* (10 to 15), *Borassus flabellifer* (15 to 30) or *Corypha elata* (20 to 100) (Redhead, 1989, Fox, 1977).

The number of years a palm tree can be tapped is also very different depending on the species. *Corypha elata* and *Raphia hookeri* flower just once. They will produce sap only for a few months before dying (Fox, 1977; Profizi, 1988). *Arenga pinnata* and *Caryota urens* will produce sap for several years, with large interruptions in the case of *Caryota urens* as it flowers only every two or three years (Redhead, 1989; Dissanayake, 1977). Other palm trees will produce sap for much longer periods: 10 to 15 years for *Elaeis guineensis*, more than 20 years for *Cocos nucifera*, 50 years for *Nypa fruticans* and *Phoenix sylvestris* and 30 to 100 years for *Borassus flabellifer* (Adand , 1954; Levang, 1988; Magalon, 1930; Abedin *et al.*, 1987; Lubeigt, 1977).

Some species are able to produce sap all year round: *Arenga pinnata, Cocos nucifera, Elaeis guineensis* and *Nypa fruticans* (Mogea *et al.*, 1991; Rangaswami, 1977; Tuley, 1965; Kiew, 1989). *Borassus flabellifer* and *Phoenix sylvestris* produce only seasonally (Crevost and Lemari , 1913; Annett, 1913).

Yields of Sugar

Most tapped palm trees gives a sap very rich in sugar (10 to 20% according to species and individual variation). The yields are highly variable according to the species and their management. Under proper management, the main tapped palm species (*Arenga pinnata, Borassus flabellifer, Cocos nucifera* and *Nypa fruticans*) can reach yields of about 20 tonnes of sugar per hectare (Van Die, 1974; Watson cited by Kiew, 1989). Compared to sugarcane production (5-15 tonnes of sugar/ha/year), the *Borassus flabellifer* tree can reach 18 tons/ha/year under rain-fed conditions (Khieu, 1996) and the coconut tree 19 tons/ha/year (Jeganathan, 1974). According to estimates, *Elaeis guineensis* produces much less sugar (1.2 tonne per hectare, Udom, 1987) but, as it has never been exploited for sugar production but only for wine production, there are good prospects for obtaining much higher yields in a production system oriented towards sugar production.

Multipurpose Uses and Role in Sustainable Integrated Production Systems

Most palm trees have multipurpose uses. Nevertheless, they are not always compatible. Sap production is at its maximum just before or during fruit formation. Tapping the tree competes with the production of the ripening fruit (Redhead, 1989). Tapping can also stimulate fruit production: a young coconut palm tapped during 6-12 months for sugar production will then produce more nuts (Magalon, 1930; M.F., 1925). A technique called sequential coconut toddy and nut production has been developed in the Philippines at the Davao Research Centre. The first half of the spathe is tapped and the second half is left for fruit production as female flowers that develop to mature nuts are situated in this lower portion. Nut and copra yields are about 50% lower than non-tapped palms; however, this technique has been demonstrated to be very feasible and highly profitable for small producers (Maravilla and Magat, 1993).

Arenga pinnata can be tapped when they are between 12-15 and more than 30 years old; then they can be cut for sago production (Sumadi, 1988). Nevertheless, in West Java, where sago is obtained from trees 10-12 years old, no tapping will be done previously, farmers arguing that it would reduce the quantity of starch in the trunk (Mogea *et al.*, 1991). In Eastern Nigeria, oil palms that have been abandoned as uneconomic bunch producers usually give good economic returns for wine production before old plantings are cleared and replanted (Tuley, 1965).

There are various types of palm-crop associations in Bangladesh. *Phoenix sylvestris* and *Borassus flabellifer* can both be associated with several of the following crops: rice, wheat, chickpea, mustard, jute, lentil, potato, linseed, winter vegetables and sugarcane (Abedin *et al.*, 1987).

Palm trees often have advantages compared with other crops as far as sustainability is concerned: in parts of west Java where *Arenga pinnata* is still tended in groves, soils appear much more stable and productive of other crops than where cassava is cultivated (Dransfield, 1977). Furthermore the advantages of this tree are its great ecological tolerance, its ability to grow and stabilize unproductive erosion-prone sites such as steep dryland slopes (e.g., coffee orchards in North Sulawesi, Mogea *et al.*, 1991), its potential to grow on almost any type of soil, to increase soil fertility and water conservation, its great tolerance of accidental burning (the only surviving tree in the Minahassa, Sulawesi after volcanic activity), the relatively fast growth rate, the fact that it needs almost no maintenance and usually does not suffer from any serious pests or disease, and the wide range of secondary or alternate products obtainable (Mogea *et al.*, 1991).

Borassus flabellifer is often planted on paddy fields boundaries in Cambodia and India. The effect of shading on understorey crops are likely to be negligible due to the small-sized crowns and to the large space (10-15m) between trees (Jambulingam and Fernandes, 1986). Like *Arenga pinnata*, this tree thrives in reputedly the poorest, infertile and arid regions. It also suffers remarkably little from prolonged flooding. It is extraordinarily pest and disease-resistant, requiring limited means of cultivation if any. As it grows in sandy plains, it is used for blocking erosion and fixing dunes, thanks to its deep root system (Kovoor, 1983).

It is also, like *Corypha elata*, a fire resistant palm that is a pioneer species on regularly burnt land such as those exploited by the slash-and-burn technique (Ormeling (1956), cited by Fox, 1977). It is used in Burma as a wind-break in areas cropped with groundnut (Lubeigt, 1977). It plays a major role in Savu and Roti islands (Indonesia) where the soil fertility is a crucial constraint. Traditional slash-and-burn system which is currently practised in neighbouring islands (Timor and Sumba for example) has been replaced by semi-permanent gardening through the use of large amounts of old *Borassus* leaves that are burnt in the fields. This permits fertile gardens to be kept in the vicinity of the houses (Fox, 1977). Borassus forests possess a potentially unique pattern of nutrient cycling, which enables them to support relatively productive and stable forms of agriculture as well as to contribute to recovery of disturbed sites (Anderson, 1987).

In the Peruvian Amazonia, *Mauritia flexuosa* constitutes dense populations in seasonal swamp forests on waterlogged or sandy soils, which are generally considered as unfit for agriculture (Kahn, 1988). Unlike sugarcane, *Nypa fruticans* does not compete with other crops for agricultural land except where total reclamation is undertaken on mangrove land (Hamilton and Murphy, 1988).

Origin of the Decline in Palm Tree Tapping Activity

One of the main reasons for the decline of sugar production from palm trees is the increasing lack of fuelwood and its increasing price. In the case of wine-producing palm trees, the decline often occurred under religious or colonial pressure. In Africa, some destructive techniques of tapping were responsible for the disappearance of the trees in entire areas. The important moves of population in the fifties (settlers setting up coffee, cocoa, rubber trees and oil palm plantations) were also responsible for loss of traditional codes of managing the trees and less long term concerns. Thus the traditional technique of tapping only male trees and keeping females for regeneration was abandoned (Port res, 1964; Blanc-Pamard, 1980). In Sri Lanka, widespread cultivation of coconut as an exported-oriented crop drastically changed the local economy and imported sugar became cheaper (Dissanayake, 1977). In

Peninsular Malaysia, the swamp areas were drained for coconut plantations where *Nypa fruticans* was before predominant (Kiew, 1989). Fishponds developers also found great profits in various fishpond operations made possible by converting mangrove swamps, including *Nypa fruticans* areas, for fish production (Encendencia, 1985).

Tapping sugar palms is very labour intensive. It must be done daily otherwise the sap flow rapidly diminishes as tissue healing occurs and restarting the sap flow requires long and hard work. Whenever easier and better paid jobs were available, tapping was given up. During the colonial period in India, *Borassus* tappers were recruited in the British plantations abroad, particularly on the rubber and oil palm estates where their skills could be easily adapted to those required for these trees (Fox, 1977).

In many countries, in comparison to other crops or commodities, there is a general lack of interest shown by the decision makers about the socio-economic potential of tapping palms. None or little research, selection of higher yielding varieties or training and extension services are funded and the tappers are seldom exposed to technological innovations if they do not generate them by themselves.

Origin of the New Interest for Palm Tree Tapping Activity

In today's economy, the profitability of tapping palms for sugar has improved: this is the case for coconut and *Caryota urens* in Sri Lanka. In the mid-seventies, with continuing foreign exchange crises, a reduction in the import of sugar occurred and was immediately followed by a sudden rise in its price and palm sugar again became a low-cost source of sugar (Dissanayake, 1977). In parts of South Sumatra (Sriwangi), tapping coconut for sugar production is 8 to 10 times more profitable than selling nuts (Levang, 1988). In the Philippines, a sequential coconut toddy and nut production system can provide the small scale coconut farmers with incomes nearly 10 times higher per hectare and per year (Maravilla and Magat, 1993). In Nigeria, an oil palm estate is likely to be better off devoting all its resources to the production of 9,770 litres/ha/year of oil palm wine than producing 10 tonnes of fresh fruit bunch per hectare per annum. Furthermore, as oil palm wine production is more labour-intensive than fresh fruit bunch production, tapping oil palm trees for wine is likely to create more jobs than harvesting fruit bunches (Udom, 1987).

Producing sugar from palm trees that can be tapped all year round (like coconut and *Nypa fruticans*) is an advantage compared to the seasonal production of sugar from sugarcane. Palm trees that produce sugar seasonally, like *Phoenix sylvestris* from November to March (cold weather) and *Borassus flabellifer* from April to September (hot weather) would grow very well side by side, as suggested by Annett (1913) in Bangladesh, and would ensure continuous sugar production all year round.

Prospects for Increasing Sugar Yields

Indigenous knowledge is available in countries that have had a long experience in tapping palm trees. The tapper generally makes a selection before starting tapping: he chooses the trees that, according to his experience, should fulfill the following objectives: high sap yield, reduced time between commencement of working an inflorescence and the first flow of sap, maximum volume of sap sustained for as long as possible; health and well-being of the tree maintained during tapping (Pethiyagoda, 1978).

Different management techniques permit increased sugar production from palm trees. *Nypa fruticans* produces more inflorescences (and potentially more sap) when the stands are kept thinned of old leaves. Sap production can be improved by wider spacing between trees than in wild almost pure stands of Nypa fruticans: from 2,500/ha down to 500 or less (Hamilton and Murphy, 1988). In the Philippines, Quimbo (1991) developed a new, highly profitable method of tapping that increases the sap yield from less than 60,000 litres/ha to more than 100,000. Daily *Borassus flabellifer* sap yields average between 6 and 10 litres per tree but can be as low as 1 litre or as high as 20 litres per tree (Paulas (1983); Tjitrosoepomo and Pudjoarinto (1983) cited by Kovoor, 1983). This can be explained by genetic and environmental factors. More sap per tree can be obtained if each inflorescence produces more, over a longer period (skill of the operator), if there are more inflorescences in a given time, if flowering starts on younger trees and lasts longer (genetic factors) and if the response to tapping is higher (genetic factors) (Kovoor, 1983). Tall varieties of coconut trees yield twice as much sap as dwarf palms and are also more resistant to pests and to droughts and winds because their root system is more developed (Jeganathan, 1974). The impact of manuring trees on sap yields is reported to be great for coconuts but scientific results are scarce. In Sri Lanka, through hybridization work to identify the most promising species with regard to nut production, an hybrid between a tall variety (Typica) and a dwarf one (Pumila) was found to be the best. Selection and breeding of the African oil palm for high sap yields and high concentration of sugar have not yet started. It is likely that yield improvement research will produce varieties that will yield more than 100 litres of sap per palm and more than 14,800 litres per hectare per annum (Udom, 1987). It is absolutely essential for most tapped palm species in Asia to have a sophisticated preparatory phase, sometimes continued throughout the tapping period, in order to ensure high yields of sap. Such a preparatory phase has not been reported in Africa for the African oil palm and it is likely that south-south transfer of technology could permit a major increase in sap production from this tree.

Prospects for Facilitating Sap Collection

For most non-destructive tapping techniques, a high degree of traditional expertise is needed and where this technique is not traditionally practised, great difficulties might be encountered in training people. In the case of the high sugar producing palms, reduced height would be a much appreciated quality decreasing labour time, effort and risks. Unlike the coconut, dwarf mutants and races have not been reported to occur in the case of Borassus flabellifer (Kovoor, 1983). This may be attributed to the lack of systematic research. An alternative would be to select the most precocious trees (that starts flowering at a very low height) as precocity is a genetic trait (Kovoor, 1983). Devices for safer and more efficient ways of climbing palm trees have been invented: one by Davis (1984), cited by Davis and Johnson (1987); another was developed by the Palmyra Development Board of Sri Lanka and using it, the tapper would be able to tap about 100 trees a day, more than twice the present average

(Dissanayake, 1986). Hybridization of the African oil palm with the American species, *Elaeis oleifera*, which has a creeping trunk and better resistance to disease (Kahn, 1988) could produce a productive variety, easy to tap because of low and stable height.

Prospects for Animal Production

Storage of sap at local level is not possible as fermentations rapidly occur even if delayed by some chemical agents. Fermented sap is not suitable for the production of good quality sugar and this usually limits the expansion of palm sugar making at village level. Processing sap into good quality jaggery is also a difficult and time-consuming task: up to 16 hours per day in Cambodia (Khieu, 1996). It also requires an experienced and skilled worker, often a woman (stirring, removing of froth and maintaining the appropriate temperature). This is also a major bottle-neck which limits sap processing (Dissanayake, 1986). Furthermore, in many countries, production and sale of toddy is prohibited by regulations and some raw material is wasted (Dissanayake, 1986).

On the other hand, meat demand is increasing in many developing countries as population grows and living standards improve: in the case of Cambodia, the pig population is increasing at a rate of 16.6% per year (Devendra (1993) cited by Khieu, 1996). Instead of preparing sugar from the sap of sugar producing palm trees, the sap can be directly fed to the animals and provide most of the energy needed in the diet. This has been done for centuries in two Indonesian islands, Roti and Savu (Fox, 1977). They have a complex diverse economy that has *Borassus* as the centre and which includes a small-scale semi-intensive or intensive pig-rearing component (7-8 pigs per household). In a *Borassus* economy, pigs are a prime means of converting palm products to protein. Pigs are fed fresh sap throughout most of the tapping season and therefore fatten during the dry season while other livestock lose weight. In addition, pigs always receive the residue and spill from the syrup-cooking process. During the rainy season they are frequently fed syrup mixed with water. Fox concludes in these words: "*Borassus* syrup and fruit constitute the primary food for pigs; pigs in turn are a principal means by which Savu's palm economy is able to support its dense population; pigs and palms go together and one can view pigs as a reasonable indicator of palm utilization". This is further demonstrated by the strong correlations (much higher than for other livestock species) between pig and human populations in the different areas of these two islands. The areas where the population densities are highest, are the areas of most intensive pig rearing; pigs also representing the highest proportions of the total livestock (Fox, 1977). Captain James Cook, sailing west from New Guinea stopped at the Savu island from 17 to 21 September 1770, at the high point of the tapping season. He reported in his book "Voyages" detailed information on the use of Borassus. In this particular year, the crops were reported to have failed. Therefore the maximum harvest of sap was taking place in order to secure 6 to 8 months food supply. Despite this threatened food security situation, Cook witnessed that syrup was given to pigs and used even for other animal production: "I have already observed, that it is given with the husks of rice to the hogs, and that they grow enormously fat without taking any other food: we were told also, that this syrup is used to fatten their dogs and their fowls..." (Cook, cited by Fox, 1977).

Trials on feeding pigs with palm juice have been initiated recently in Cambodia by T.R. Preston, FAO consultant, within the framework of an FAO Technical Cooperation Project (FAO, 1995). Pigs were reared from 20 to 80 kg, with ADG of 356g using the following daily diet: approximately 8 kg of palm juice, 156g CP (soya bean), lime, salt and 500g of fresh water spinach per day. Twelve farms were studied. Taking into account the price of fuelwood, the profit per tree per day was nearly 14 times higher when the juice was used for feeding pigs instead of making sugar syrup (Khieu, 1996). Using fresh sap for feeding animals will avoid burning large quantities of fuel. Nevertheless, as part of this fuel generally comes from the palm tree itself, it might be possible to make syrup or sugar that will be easy to preserve and that will be later fed to the animals when the sugar production season is over. If this is not possible, sap production can be entirely used as fresh juice for feeding fattening animals and the fattening cycle can coincide with the sometimes rather short tapping season. This can easily be done with pigs and ducks. Sap, syrup or sugar could also be used as emergency feeds, replacing other feeds whose production has been compromized by droughts or other calamities, whenever necessary. There is a huge potential for capitalising on under-exploited sugar palm trees which are not used because of the lack of fuelwood for making sugar or the limited marketing possibilities (Mogea *et al.*, 1991). In Sri Lanka, only about 2% of the total area suitable for tapping is reported to be actually tapped (Sivilingam (1983) cited by Dissanayake, 1986). Therefore, there is a niche for diversification. In these cases, the sap could be used for animal production. Present labour constraints can be overcome through the use of climbing devices that enable the tapper to tap twice as many palm trees (Dissanayake, 1986).

To balance monogastric diets based on sugar palm juice or syrup, a good source of protein is required. As soya bean is hardly available at a reasonable price in many tropical areas, some alternative sources of protein are needed: cassava leaves, sweet potatoes leaves, fodder tree leaves, aquatic plants (duckweed, Azolla, etc.), whole soya plant at milky grain stage, fish wastes, etc. Proper use and management of these different alternative sources of protein can contribute to reducing pollution, increasing carbon sinks and decreasing erosion. Animal feeding systems based on palm juice/syrup favours keeping the animals in confinement instead of grazing or scavenging systems. This protects the environment, limits the dissemination of contagious diseases and also optimizes the integration of livestock within an intensive farming system. Manure can be processed through a biodigester, producing the energy for family cooking needs, and the effluent can be used as a fertilizer either for crops or for fish ponds. The potential of feeding goats and cows with palm sap as the main source of energy for milk production should be investigated as well as the source of nitrogen (non-protein nitrogen and by-pass proteins), minerals and fibre to complete the diet. Incidentally, tapping palm trees will also always offer an easy source of sugar for bees which will tend to spontaneously harvest all wasted sugar. Honey production is therefore increased in areas where palm trees are tapped (Fox, 1977).

Conclusion

Borassus palms are the most numerous palms in the world after the coconut palm (Fox, 1977). Despite this, they are among the least studied of all the palm species in the world. This lack of interest can be explained during colonial history by the fact that, from the colonizer's point of view, it was much easier to set up, manage and control large sugarcane plantations to produce sugar than to use existing scattered palm trees that had been managed for centuries by the local people, often within a subsistence economy. Beside this, these trees are often associated with the poor. The fact that their juice quickly ferments and makes alcohol made tapping activities undesirable to governments, and also for the Hindouist, Buddhists and Muslims orthodoxes (Fox, 1977).

Nevertheless, there are many good arguments for revitalizing knowledge and research on sugar producing palm trees. Considering their multipurpose uses, they can contribute in many ways to the sustainability of integrated farming systems. As these trees are often the main subsistence resource for the poorest people (*Borassus flabellifer*), improving the way these trees are used will contribute to the alleviation of poverty. Palm tapping, especially as far as wild and semi-wild species are concerned, is an activity that does not require capital to start. In highly populated rural areas, it can be a major source of self-employment for the poorest people and avoid major drifts from the land. In the case of coconut (in Sri Lanka for example) or African oil palm (in Colombia and Nigeria for example), with the low and unpredictable world prices of copra and palm oil, it has become increasingly difficult for small farmers to depend on their production. This encourages attempts to find other ways of using these trees, including diversification for better sustainability of the system. Sugar production and animal production are alternatives to consider if markets can be developed for these products.

Future research on using palm tree sap for animal production should consider the following issues:

- Assessment of existing stands of wild palms (*Nypa fruticans*, *Borassus* sp., etc.) and the economic prospects for tapping these trees.
- Assessment of the economic potential of palm trees selected over centuries for sap production to be used in other regions.
- Identification of criteria for proper selection of individuals to be

tapped and for recognizing the proper plant stage for initiating successful tapping operations.

- Physiology of the production of sap flow and precise significance of the various acts that constitute the art of tapping in order to develop improved technologies for increasing sugar yields (techniques of tapping, frequency, fertilization, tree spacing) and to optimize the use of labour.
- Improved technologies for safely tapping trees.
- Techniques to preserve the juice and avoid fermentation.
- Identification of production systems with palm trees, crops and animals: according to the present economic and environmental changes
- Assessment of the relevance of tapping sugar palm trees for animal production in comparison with energy production (ethanol) or other products (copra from coconut or oil from oil palm).

What is needed is a thorough field survey reviewing in detail all indigenous knowledge related to tapping palm trees for sugar and animal production. This would permit a major breakthrough for assessing all the future potential of these trees and for sharing techniques and experiences between regions and countries. Once the potential of tapping palm trees for sugar and animal production has received the full attention it deserves from decision makers through funding research, selection, technology improvement, training and extension and small credit for farmers, many rural areas are likely to benefit from a new source of self-employment and sustainable income.

References

Abedin, Z., Aktar, S., Haque, F. and Alam S. 1987. Uses of Multipurpose Trees on the Small Farms of the Low-Rainfall Ganges Floodplain Soils of Bangladesh. In: Proceedings of an international workshop held in Pataya, Thailand, 2-5 November 1987, pp. 31-47.

Adand , A. 1954. Le vin de palme chez les Diola de la Casamance - Notes Africaines 61:4-7.

Anderson, A.B. 1987. Management of native palm forests: a comparison of case studies in Indonesia and Brazil. In: Agroforestry: realities, possibilities and potentials [edited by Gholz, H.L] Dordrecht, Netherlands. 155-167.

Annett, H.E. 1913. The date sugar industry in Bengal - An investigation into its chemistry and agriculture. Agriculture Research Institute, Pusa, India, Chemical Series II(6): 281-389.

Banzon, J.A. 1984. Harvestable energy from the coconut palm. Energy in Agriculture, 3: 337-344.

Bellouard, P. 1950. Le Renier en A.O.F. Bois et For ts des Tropiques. 14: 117-126.

Blanc-Pamard, C. 1980. De l'utilisation de trois esp ces de palmiers dans le sud du "V Baoul "(C"te d'Ivoire). Cahiers ORSTOM, s rie Sciences Humaines. (3-4): 247-255.

Chevalier, A. 1930. Le *Borassus aethiopum* de l'Afrique Occidentale et son utilisation. Revue de Botanique Appliqu e. pp. 649-655.

Coconut Research Institute. 1967. Toddy tapping. Ceylon. Leaflet No. 48. pp. 13pp.

Crevost, C. and Lemari , C. 1913. Catalogue des produits de l'Indochine. I Produits Alimentaires. Gouvernement G n ral de l'Indochine, pp. 347-352.

Cunningham, A.B. 1990. Income, sap yield and effects of sap tapping on palms in south-eastern Africa. S. Afr. J. Bot. 56(2): 137-144.

Davis, T.A. and Johnson, D.V. 1987. Current Utilization and Further Development of the Palmyra Palm (*Borassus flabellifer* L., Arecaceae) in Tamil Nadu State, India. Economic Botany, 41(2): 247-266.

Decary, R. 1964. Les utilisations des palmiers Madagascar. Journal d'Agriculture Tropicale et de Botanique Appliqu e. XI (8-9): 259-266. Dissanayake, B.W. 1977. Use of *Caryota urens* in Sri Lanka. In: First International Sago Symposium. The Equatorial Swamp as a Natural Resource. Ed. Tan K. Sarawak, East Malaysia, Kuching, 1976. Kuala Lumpur. pp. 84-90.

Dissanayake, B.W. 1986. Techno-economic aspects of production and utilization of two related palms kitul (*Caryota urens*) and palmyra. Proceedings of the Third International Sago Symposium, Tokyo, Japan. pp. 75-85.

Dransfield, J. 1977. Dryland Sago Palms. In: First International Sago Symposium. The Equatorial Swamp as a Natural Resource. Ed. Tan K. Sarawak, East Malaysia, Kuching, 1976. Kuala Lumpur. pp. 76-83.

Encendencia, E.M. 1985. Versatile Nipa: Potential Resource for Various Economic Needs. NSTA Technology Journal/July-Sept. pp. 4-12.

Essiamah, S.K. 1992. Sapping of Oil Palm (*Elaeis guineensis*, Jacq.) in the Rain Forest Region of West Africa. Tropenlandwirt (Germany). 93(2): 123-135.

FAO. 1995. Plan d'urgence pour la sauvegarde du b tail au Cambodge. Compte rendu final de projet. TCP/CMB/2254. FAO, Rome. pp. 14.

Fox, J.F. 1977. Harvest of the Palm, Ecological Change in Eastern Indonesia. Harvard University Press, Cambridge, Massachusets, and London, England. pp. 290.

Giffard, P.L. 1967. Le Palmier R"nier *Borassus aethiopum* MART. Bois et For ts des Tropiques. 116: 3-13.

Hamilton, L.S. and Murphy D.H. 1988. Use and Management of Nipa Palm (*Nypa fruticans*, Arecaceae): a Review - Economic Botany. 42(2): 206-213.

Hartley, C.W.S. 1977. The Oil Palm (*Elaeis guineensis* Jacq.). 2nd ed. Longmans and Green London. pp. 600-603.

Jambulingam, R. and Fernandes, E.C.M. 1986. Multipurpose trees and shrubs on farmlands in Tamil Nadu State (India). Agroforestry Systems 4: 17-32.

Jeganathan, M. 1974. Toddy yields from hybrid coconut palms. Ceylon Cocon. Q. 25: 139-148.

Johnson, D. 1987. Palms as Multipurpose Cash and Subsistance Tree Crops. In: Proceedings of an international workshop held in Pataya, Thailand, 2-5 November 1987, pp. 222-236.

Kahn, F. 1988. Ecology of Economically Important Palms in Peruvian Amazonia. Advances in Economic Botany 6: 42-49.

Khieu, B. 1996. A study on the use of the sugar palm tree (*Borassus flabellifer*) for different purposes in Cambodia. M.Sc. Thesis Swedish University of Agricultural Sciences, Uppsala. pp. 67.

Kiew, R. 1989. Utilization of Palms in Peninsular Malaysia. Malayan Naturalist 43 (1&2): 43-67.

Kovoor, A. 1983. The palmyrah palm: potential and perspectives. FAO Plant Production and Protection Paper No 52. FAO, Rome. pp. 77.

Levang, P. 1988. Le cocotier est aussi une plante sucri re. Ol agineux, 43(4): 159-164.

Lubeigt, G. 1977. Le palmier sucre, *Borassus flabellifer* L., ses diff rents produits et la technologie associ e en Birmanie. Journal d'Agriculture Tropicale et de Botanique Appliqu e. XXIV (4): 311-340.

M.F. 1925. Quelques Palmiers exploit s pour la production de Sucre. Revue de Botanique Appliqu e & d'Agriculture Coloniale. 45: 382-387.

Magalon, M. 1930. Contribution l' tude des palmiers de l'Indochine fran aise. Paris, pp.185-191.

Maravilla, J.N. and Magat, S.S. 1993. Sequential coconut toddy (sap) and nut production in Laguna tall variety and hybrid coconuts Philippine Journal of Coconut Studies XVIII(2): 7-15.

Mogea, J., Seibert, B. and Smits W. 1991. Multipurpose palms: the sugar palm. Agroforestry Systems 13: 111-129.

Pethiyagoda, U. 1978. Coconut inflorescence sap. Perak Planters' Association Journal. Malaysia. pp. 86-91.

Port res, R. 1964. Le Palmier Ronier (*Borassus aethiopum* Mart.) dans la province du Baoul (Cote d'Ivoire). Journal d'Agriculture Tropicale et de Botanique Appliqu e. XI (12):499-515.

Profizi, J.P. 1988. Swampy Area Transformations by Exploitation of *Raphia hookeri* (Arecaceae) in Southern Benin (West Africa). Human Ecology, 16(1): 87-94.

Quimbo, L.L. 1991. Increasing Nipa Sap Yield Through Improved Mechanical Tapping. Technology! PCARRD. The Philippines. XIII (4): pp.16.

Rangaswami, G. 1977. Palm tree crops in India. Outlook-on- Agriculture (UK). 9(4): 167-173.

Redhead, J. 1989. Utilization of tropical foods: trees. In: FAO Food and Nutrition Paper No 47: 3. FAO, Rome, pp. 52.

Sumadi, G. 1988. *Arenga pinnata*: A Palm for Agroforestry. In: Proceedings of an international workshop held in Pataya, Thailand, 2-5 November 1987, pp. 149-150.

Tuley, P. 1965. Studies on the production of wine from the oil palm. J. Nigerian Inst. Oil Palm Res. 4: 284-289.

Udom, D.S. 1987. Economics of oil palm wine tapping. Nigerian Journal of Palms and Oil Seeds. VIII(1): 56-77.

Van Die, J. 1974. The developing fruits of *Cocos nucifera* and *Phoenix dactylifera* as physiological sinks importing and assimilating the mobile aqueous phase of the sieve tube system. Acta Bot. Neerl. 23(4): 521-540.

The Sugar Palm Tree As the Basis of Integrated Farming Systems in Cambodia

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Abstract

The sugar palm tree (*Borassus flabellifer*) plays an important role in the small integrated farming systems in Cambodia. The sugar palm is considered to be a multi-purpose tree and provides different products such as juice, sugar, leaves, timber, fruits, underground seedlings and roots. The juice from the sugar palm is rich in highly digestible carbohydrate (sugars) which is an alternative energy source for animal feeding in the rural areas. The impact of the sugar palm on the farming system is increased when the excreta from the animals is recycled through biodigesters to provide gas for household cooking and effluent to fertilize the pond which can produce fish or water plants, the former for the household and the latter for the livestock.

When sugar palm juice is used for pig feeding, rather than the making of sugar, it is better from both the economic and environmental points of view, because sugar production requires large amounts of firewood that makes the cost of production very high. It is even less profitable and extremely harmful to the environment when palm trees are used as fuel in order to produce the sugar.

KEY WORDS: *Borassus flabellifer,* palm juice, palm sugar, fuel, environment, biodigester, sustainable production

Introduction

In Cambodia, 85 per cent of the total population is dependent on agricultural activities. Most of their annual income comes from agriculture. The farming system comprises rice cultivation, sugar palm production, livestock farming, and vegetable growing. Livestock make many contributions to the farming activities, such as draught power, meat, milk, eggs, organic fertilizer, fuel, social status, etc. In order to maintain these important contributions, livestock have to be adequately fed, well managed, and properly cared for. However, there must be a clear division between what is human food and what is animal feed. As Preston and Sansoucy (1987) have suggested, one way to achieve a sustainable animal production system is to match livestock with the available local resources. In this case, there are resources which can be used for animal feed such as multipurpose trees, aquatic plants, agricultural products and by-products.

The sugar palm tree, which is called "Thnot" in Khmer, is a source of income in different seasons of the year. In addition, it provides good materials for house construction such as leaves, leaf branches and trunk, when juice production is not carried out. The palm tree commences to produce inflorescences (maturity) in 15-20 years depending on soil fertility. There is no relevant literature which describes the productive life of the tree, although there are examples of trees today which have been used to produce juice for more than 70 years. Borin Khieu *et al.* (1996a) reported that the juice can be collected for 3 months of the year from the male tree and 5-6 months from the female tree. The average yield was 5 kg of juice per day per tree with an average brix value of 13.5% (sugar content). In 1995, the sugar palm population was estimated at 8 million trees in different provinces in Cambodia. The trees are found mostly on sandy soils with a pH of 5.5. The sugar palm trees are capable of producing 160,000 tonnes of juice or 21,600 tonnes of sugar (sucrose) per year per hectare. This is a great potential feed resource that can be used as an alternative to cereal grains for feeding monogastric animals. The preferred animal species are pigs and ducks which adapt readily to "unconventional" high moisture feed resources. However, it may also be used as a supplement for draught animals.

The system is based on the sugar palm which provides the carbohydrate feed (juice). The other multipurpose trees and water plants supply protein in addition to the important role that the trees play as a sink for carbon dioxide, in nitrogen fixation, in controlling erosion and as a source of biodiversity. Sugar palm trees are integrated into the farming activities.

The Role of Sugar Palm Trees

The sugar palm tree is considered a multipurpose tree since it demonstrates great potential by providing different products for humans, as well as for animal feeding. The role of sugar palm trees in the mixed farming system is as follow:

- To provide sugar, fruits, germinated seeds and juice for human consumption and animal feeding.
- To use as the green fence around the household, as well as on the bunds of rice fields.
- As the sugar palm tree has a deep root system (up to 15 m), it can be used also to control erosion.
- The leaves of the sugar palm tree can be used as a nest for bats which provide manure as a good source of fertilizer. The bats can provide 0.5 to 1 kg of manure per day which could be sold to the city for flower gardens.

The Production of Sugar Palm Tree

The sugar palm tree does not require any management for biomass production. But the leaves should not be harvested when trees are kept for juice collection. Farmers believe harvesting the leaves has a great influence on the yield of juice. The juice from the sugar palm tree is normally collected once a day. However, there are high production trees (20-25 kg of juice per day) which should be collected from twice daily. The yield and the brix value (sugar content) vary from tree to tree, farmer to farmer and time of production. Some skillful farmers can manage to get juice with high brix value that is good for sugar syrup production because it requires less firewood for boiling the juice. Potentially, trees (especially females) can produce juice throughout the whole year.

The composition of the syrup samples (Table 1) showed considerable variation among farmers and between harvest periods. Seasonal variation in composition is shown in Table 2. Sucrose as per cent of total solids in the juice ranged from 66 to 94% in the samples taken in January and from 51 to 88% in April. In contrast, glucose and fructose levels in juice increased. The levels of glucose ranged from 2.1 to 9.6% in samples taken in January and from 3.5 to 18.2% in April. The fructose levels ranged from 2.6 to 11% in samples taken in January and from 4.6 to 24.5% in April.

The constraint on sugar palm production is the fuel consumption. The estimate of firewood consumption is 460 kg per tree per year which is equivalent to 3.68 millions tonnes of firewood required for sugar production annually in the country. However, rice husk can be used as an alternative fuel to boil juice but it is still a problem to get sufficient quantity for this purpose. The other way to achieve better utilization of the sugar palm tree is by diverting juice from sugar production to animal feeding.

The Use of Sugar Palm and By-products in Animal Feeding

There is no relevant literature which describes the real amount of sugar palm and its by-products given to domestic animals in the country. But it has certainly been used as a livestock feed supplement in the rural areas.

Ruminant Feeding

The main feed for cattle and buffaloes during the dry season is rice straw. In this period, most of the animals become very thin because of the poor quality feed supply. However, some of the animals which get a supplement from sugar palm products and by-products have good performance or at least maintain weight. The juice from the sugar palm is sprayed over the rice straw and kept for some minutes and then fed mainly to draught animals. This also makes rice straw more palatable.

Table 1. Chemical composition of sugar palm syrup

			- - - - - -As % of dry matter- - - -			
	DM	Ash	Sucrose	Glucose	Fructose	Total CHOs
16 Jan.1995						
Hay Yang	84.8	1.4	65.8	9.6	10.6	86.7
Huy Kiel	86.5	1.3	85.7	5.8	6.6	98.0
Pring Huy	84.3	1.7	74.1	9.4	11.0	94.8
Map Chreb	82.7	1.2	88.2	4.8	5.5	98.6
Sim Hen	87.8	1.0	93.1	2.1	2.6	97.9
Pauv Pauv	84.1	1.4	81.7	5.7	7.5	95.5
Tha Khorn	88.1	1.5	94.3	2.1	3.3	99.7
Thorn Punn	89.9	1.8	74.3	6.8	8.3	91.1
Yem Khnol	84.2	1.8	72.9	9.1	10.6	93.6
Chan Mak	88.4	1.0	93.1	2.5	2.9	98.5
Thorn Chreb	78.6	1.7	85.7	4.8	2.9	96.9
15 Apr. 1995						
Hay Yang	85.8	1.7	69.8	7.3	12.5	89.6
Huy Kiel	88.9	1.5	68.5	11.2	13.4	93.5
Pring Huy	82.9	1.6	51.0	18.2	24.5	91.2
Map Chreb	82.3	1.5	57.4	15.7	18.1	92.7
Sim Hen	85.0	1.3	74.9	8.7	9.9	96.2
Pauv Pauv	79.7	1.6	68.0	10.6	12.2	92.2
Tha Khorn	82.2	1.1	87.6	5.5	5.9	99.0
Thol Onn	86.9	1.2	73.5	8.0	11.0	92.6
Thorn Punn	87.4	1.5	87.1	3.5	4.6	96.1
Yem Khnol	92.0	1.5	62.6	9.4	15.8	90.0
Thorn Chreb	75.6	1.6	76.4	9.8	9.5	95.7

Table 2. T test analysis of changes in sucrose, glucose & fructose (reduced sugar)and ash in sugar palm juice with advance of harvesting season.

	16 Jan 1995	15 Apr 1995	Mean diff	t value	Prob.
Sucrose	81.6	70.4	11.2	2.79	0.021
Glucose	6	10	-4.0	-2.78	0.021
Fructose	7.2	12.3	-5.1	-3.56	0.006
Ash	1.4	1.4	-0.02	-0.19	0.86

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Sugar palm syrup can also be used as an ingredient to make multi-nutritional blocks. Experience from FAO Project TCP/CMB/ 2254 "Emergency Plan for Livestock Security" has shown that multi-nutritional blocks are a good potential supplement for draught animals in the dry season. The formula used for a hundred kg of mixture was: rice bran 40 kg, sugar palm syrup (80% DM) 15 kg, urea 7.5 kg, salt 7.5, lime 5, cement 5, clay 20 kg. The animals have good performance, a bright coat and stop licking urine from others animals.

The fruits from sugar palm are chopped and given to animals after having taken the soft part and kernel for human consumption. The mature fruits are soaked in water and the wiry fibers sucked out. The solution of yellow pulp is given to the draught animals or lactating cows. During the dry season, it has been observed that the leaves from the young palm trees are eaten by cattle.

Monogastric Animal Feeding

The common monogastric animals kept in the rural areas are pigs, chicken and ducks. The population of monogastric animals is growing very fast because of the quick turnover of capital and the available market. A scavenging system is the common practice. The animals are sometimes supplemented with kitchen waste or cereal grains. Another important feed is the solution which is obtained after cleaning the pan from making palm sugar. The solution is mixed with rice bran and fed to pigs. Pigs show good performance compared to the ones which are fed rice alone.

Starting in 1993 with the introduction of TCP/CMB/2254 and later on with SAREC, research has demonstrated that the sugar palm juice can be used as a source of energy supply for pigs. The trials were adapted and tested in different villages in Cambodia. When the monogastric animals are fed a basal diet derived from tropical feed resources such as sugar cane, cassava, bananas, sweet potatoes or palm oil, the supplementary nutrients needed are protein, lipids, minerals and vitamins (Preston, 1992).

The first idea was to use the scum from making sugar palm syrup to feed pigs. But the reaction from the farmers was to use fresh juice for pig feeding instead of the scum. In 1995, there was a trial involving 72 pigs divided between 12 families in Kandoeung Commune, Takeo Province, Cambodia. The objective of the research was to evaluate the juice of the sugar palm tree as a sole energy feed for pigs. The result was reasonably good compared to sugar palm syrup production. The average live weight gain was 356 g per day per pig with only 156 g CP supplement. In fact, the most important feature is the economic impact of feeding juice to pigs. Elliott and Kloren (1987) reported that the use of fibre-free energy sources such as raw sugar or sugar cane juice permits greater use of cheaper vegetable and aquatic protein sources which are not usually included to a great extent in conventional diets because of their high fibre content. Therefore, the use of sugar palm juice in monogastric feeding, especially for pigs, will provide opportunities to farmers for better utilization of their own locally available feed resources as protein supplements and the cost of production will be reduced.

Economic Aspects of Sugar Palm Tree

Sugar palm production has been one of the main sources of income for rural families. The number of trees ranged from 10 to 30 per family which results in 1 to 3 tonnes of sugar palm syrup (approximately 80% DM) in the 6 month production period. However there are farmers who can collect juice from the female trees for the whole year. The price of the syrup varies from 400 - 600 Riels during the production period (dry season) to 1,000 - 1,200 Riels afterwards (rainy season). Sugar production still continues to be a source of income for the people who have access to free firewood.

It was shown during the study (Borin Khieu *et al.*, 1996b) that when firewood was purchased for condensing sugar palm juice, some farmers lost an average of 20 Riels per tree per day. There is another alternative source of fuel, rice husks, which can replace firewood. This system requires a new kind of stove that was adapted by a French organization, the GRET. The income from sugar production using rice husk is comparatively better than with firewood. However, there is still insufficient fuel for cooking because the yield of husk from a hectare of rice is approximately 240 kg which provides only 4.5% of the total fuel consumption for condensing the juice of 20 trees. If opportunity cost of labour is taken into consideration, it greatly increases the cost of production because one to two persons are permanently assigned to take care of boiling juice.

Using palm juice for pig feeding has proved to be an effective and sustainable method of production. Several trials showed that, from the economic point of view, the profit from using palm juice for pig feeding was much higher than for sugar production. The net profit was 140 Riels per tree per day, compared to only 10 Riels from sugar production (Borin Khieu *et al.*, 1996b).

The sugar palm tree may produce 8-15 bunches of fruits with a total of about 80 fruits per year from female trees which are not exploited for juice. The price is 3,000 to 3,500 Riels per 40 kernels which are extracted from 15-20 fruits. Therefore, each tree provides approximately 12,000-14,000 Riels annually. In addition, the leaves also contribute other income or at least they can be used to thatch the houses. Finally when palm trees are over 10 m (70-100 years old), it is difficult to use them for juice collection. They are cut and sawn for house construction.

Constraints on Sugar Production

At present, the densest population of sugar palms is found in highly populated areas. This is leading to the disappearance of the trees because of the high demand for land for cultivation to satisfy the needs of the people. Another important reason could be that there is a need for timber for construction materials and a need for fuel for household cooking and for boiling juice. Many sugar palm tree are used every year as fuel to condense sugar palm juice. As an example, in 1995, it was estimated that 10-15 sugar palm trees were cut to supply part of the firewood requirement by the sugar producers in Tumnop Thom Commune, Punhea Leu District, Kandal province.

It should be noted that by using juice for pigs, 3.68 million tonnes of firewood will be saved each year. Therefore this system will contribute to the reforestation programme which is taking place at present in Cambodia.

Alternative Integrated Farming Systems

It has been calculated that the sugar palm trees in the country may produce enough juice to feed 3-4 million pigs or 14 million ducks. This shows great potential for replacement of cereals for animal feeding which is very important for a country like Cambodia which has not produced enough cereal grain to feed its population since 1979. As the population grows rapidly, there will be a demand, not only for cereal, but also for meat. Pigs and ducks are the first choice as they grow fast and are in high demand by the people.

When low protein basal diets such as sugar cane and sugar palm products and by-products are fed to monogastric animals, the total protein needed is reduced considerably. This is because the ratio of essential amino acids is close to the optimum when the animal is supplemented with tree foliage and water plants such as Nacedero (*Trichantera gigantea*), duckweed (*Lemna* ssp.), water spinach (*Ipomea aquatica*) and azolla (*Azolla anabaena*) (Preston, 1995 and Leng *et al.*, 1995). All these sources of protein are available in the ponds or around the households which are fertilized with the effluent from the plastic biodigester.

This integrated farming system provides an environmentally friendly solution, where the biodigester is playing an intermediate role in the system. Biodigestion enables the farmers to recycle waste and excreta from animals as well as humans. The number of biodigesters is growing very fast in Cambodia; up to now, there have been 450 digesters installed in different provinces of Cambodia. The popularity of the biodigester is connected to that of the human latrine and the need to solve the firewood problem. In addition, when pigs are raised in confinement, they produce waste and manure as a substrate for the digester which has not been the case in the past when they were mostly kept in a scavenging system. The biodigester does not produce only gas (methane) for household cooking but also provides fertilizer for rice fields and vegetable gardens which is better than the fresh manure. Farmers participating in the FAO GCP/RAS/143/JPN and Lutheran World Service (LWS) projects demonstrated that the biodigester provided great value by cutting down the expenditure on chemical fertilizer. The slurry from the digester is safe and it can be used as feed in the fish pond. It is also very important that the housekeepers (wives) are happy to participate in the system because it provides a clean environment in the kitchen, as well as the whole house, and it gives her more time to perform other work or participate in social activities.

Strategy for Animal Production Based on Sugar Palm

The development of livestock production in Cambodia will be based on small-scale farmers and the utilization of local resources. The free range system is the common practice for all kinds of animals. But now there is a need to utilize available land for crop production in order to satisfy the demands of the growing population. The sustainable way to keep the system working and to solve these problems is to raise animals (especially cattle, buffaloes and poultry) in a semi-scavenging system. For instance, sugar palm products and by-products can be used as the energy basal diet with the protein supplement from the leaves of multipurpose trees like *Gliricidia, Acacia, Leucaena, Trichanthera*, etc. and water plants such as duckweed, *Azolla*, water spinach and so on. This should be the alternative way for livestock production in Cambodia. In the same strategy, pigs are proposed to be confined because of their propensity to destroy crops like sweet potato and vegetable gardens. By keeping pigs in a pen, they will also provide additional income as mentioned above.

Perspectives

In order to further develop this integrated system, more involvement from farmers is vitally important. A credit programme is needed for the poorer farmers who do not have money to start. It is crucial that both women and men participate in the discussion, in planning as well as implementing. The role of women in these activities is very important because the woman is the one who feeds the animals and spends most of her time looking after the farming system. However, the man does the rest of the activities such as climbing the sugar palm tree, ploughing the land, digging the pond, etc.

The majority of farmers are interested in raising fattening pigs but very few keep sows which makes the system unbalanced. Therefore the price of the piglets (15-20 kg) is 100,000 Riels, relatively high compared to the finishing pigs (90-100 kg) which cost about 330,000 Riels. The strategy for long term and sustainable development is to establish the reproduction system which can provide piglets in the villages so that they are more adapted to the native environment and local conditions. In this case, the indigenous pigs such as Chrouk Domrey, Chrouk Hainam, Chrouk Kandor, etc., are likely to be the best for prolificacy and efficient use of poor quality feed.

In the tropics there are many plant species that can be utilized better for animal feeding from the economic and environmental points of view than imported concentrate feeds. They are excellent components of the integrated farming system and part of the local ecological context. The plants which produce energy-rich feed are sugar cane, sugar palm trees and all palms yielding juice (*Coco nucifera, Arenga pinnata, Borassus species, Caryota urens, Nypa fruticans*, etc), palm oil, cassava, etc. However, in all livestock feeding, the most expensive ingredient is protein. In fact, on the small farm in remote areas, the availability of protein is restricted to what can be grown on the farm and the by-products available in the areas. In these cases, it is crucial to introduce multipurpose plant species that could be used as animal feed and which have a better amino acid balance.

Conclusions

In Cambodia, it is important to diversify the use of sugar palm trees for animal production in order to maintain these trees as part of the farming system because sugar production will not survive any longer in the provinces due to the firewood problem.

The multipurpose sugar palm trees have played an important role in an integrated system. They are very efficient utilizers of solar energy and may not require any fertilizer inputs. They provide high energy feeds, low in fibre but with very low protein contents. This allows the optimum use of on-farm products and by-products as protein sources for monogastric nutrition. These include leaves of Nacedero (*Trichantera gigantea*), sweet potato leaves, water spinach, silage of cassava leaves, duckweed, azolla, etc.

References

Borin Khieu, Preston, T. R. and Lindberg,J. E. 1996a. Juice Production from the sugar palm tree (*Borassus flabellifer*) in Cambodia and the performance of growing pigs fed sugar palm juice. (MSC thesis in Sustainable Tropical Animal System, Swedish University of Agricultural Sciences, Uppsala). pp 1-11.

Borin Khieu, Lindberg, J. E. and Preston, T. R. 1996b. A study on the multipurpose tree (*Borassus flabellifer*) and its products for animal feeding in Cambodia. (MSc thesis in Sustainable Tropical Animal System, Swedish University of Agricultural Sciences, Uppsala). pp 1-10.

Elliott, R. and Kloren, W. R. L. 1987. The use of sugar in diet for monogastric. Recent Advances in Anim. Nutri. in Australia. pp 164-169.

Leng, R. A., Stambolie, J. H. and Bell R. 1995. Duckweed - A potential high-protein feed resource for domestic animals and fish. Livestock Research for Rural Development. Volume 7, number 1, October 1995. (16kb).

Preston, T. R. 1995. Tropical Animal Feeding: A manual for research workers, FAO Animal Production and Health Paper, No. 126. Chapter 3: Nutrition of non-ruminants. pp 35-49.

Preston, T. R. 1992. The role of multi-purpose trees in integrated farming systems for the wet tropics. In: Legume trees and other fodder trees as protein sources for livestock (Proceedings of the FAO Expert Consultation help at the Malaysia Agricultural Research and Development Institute (MARDI). FAO Animal Production and Health Paper No. 102. pp 193-208.

Preston, T. R. and Sansoucy, R. 1987. Matching livestock system with available feed resources. In: Proceeding of FAO Expert Consultation on the substitution of the imported concentrate feed in animal production system in developing countries. FAO Animal Production and Health Paper No. 63. pp 32-41.

The African Oil Palm in Integrated Farming Systems in Colombia: New Developments

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Abstract
Recent work supports and extends the idea of using the African oil palm as a strategic resource within integrated tropical production systems.

The use of high-energy multi-nutritional blocks containing palm oil for beef cattle has been evaluated. Results show a significant increase in animal production especially in grazing systems based on the natural savannahs.

Pig production work has continued with the aim of refining the use of crude palm oil in the diet and increasing the use of protein rich forages like the leaves of *Manihot esculenta*, *Trichanthera gigantea* or *Azolla filliculoides* as replacements for soyabean meal. Also, a feeding and management system for grazing pigs has been designed with satisfactory results. This system, based on an integral approach, aims to improve the soil conditions of land which is destined for crop production.

The utilization of crude palm oil in the diet of broilers kept in a semi-confined system has resulted in similar performance to that of a confined system based on cereals, as well as permitting the inclusion of significant levels of protein-rich forages.

High-energy blocks have also been used with good results in African hair sheep production.

These systems offer new alternatives for small and medium-sized farmers to increase profitability, make better use of local resources, reduce dependence on external inputs and exploit the biodiversity of the natural ecosystem.

KEY WORDS: African oil palm, livestock, integration, *Elaeis guineensis*

Tropical Beef Production

The nutritive value of grasses is a major limitation to beef production in the tropics (Escobar, 1991). They are low in energy (especially in non-structural carbohydrates and lipids), protein and minerals. They are high in fibre which limits intake. The presence of secondary compounds in forages, particularly legumes, has very variable effects on the animal. The quality of forages themselves is very variable, both locally and seasonally, as a result of agro-ecological factors such as climate, soil, nutrient availability, topography, etc. These factors determine to a large part the productivity of tropical beef production, which is generally low when no action is taken to correct these limitations. This does not mean that the production potential is low. On the contrary, by understanding the limitations, it has been possible to design different strategies to significantly improve animal performance, including the provision of non-protein nitrogen, mineral supplementation, the use of pasture legumes and particularly legume trees, and health management.

Recently, Huertas (1996) conducted an analysis of feed efficiency in Colombian cattle production (Table 1), showing evidence of the same low levels of productivity as measured by the feed conversion ratio in extensive or semi-intensive systems based on grass pastures.

In terms of efficiency, there has not been any improvement from the practice of replacing natural pastures with introduced species, known as 'improved pastures'. But on the contrary, the introduction of legumes has succeeded, giving an important improvement in efficiency.

The cultivation of African Palm has the potential to offer various production alternatives, different products and by-products that can be utilized in the energy supplementation of cattle, improving efficiency and productivity.

Energy Strategy Using Multinutritional Blocks

The advantages of the use of multi-nutritional blocks, in diets based on crop by-products or pastures of typical low quality, are well known in terms of providing adequate non-protein nitrogen in the rumen, improving both function and efficiency, which is reflected in higher voluntary intake by the animal and better digestibility of fibre.

Table 1. Feed efficiency of cattle in Colombia

Ecosystem	Live weight kg	Ratio kg forage/1 per kg live weight gain	
		Grass	Grass +legume
Natural conditions	120	10:1	
Eastern Llanos	200	22:1	
	300	25:1	
Valle del Sinu	250-280	20:1	15:1
	300-350	22:1	18:1
Magdalena Medio	250-280	20:1	-
	300-350	22:1	-
Ladera Antioquena	230-260	22:1	18:1
	300-460	24:1	18:1
Piedemonte Llanero	220-260	22:1	18:1
	300-450	25:1	18:1

1/calculated on the basis of dry forage
Source: Adapted from Huertas (1996).

Work is in progress with blocks not just to supply nitrogen but as a way of offering additional energy using fat from palm oil and solubilized fatty acids.

The block being used contains 10% urea, 10% rice polishings, 40% molasses, 15% quick lime, 10% rice husks, 5% mineral salt and 10% crude palm oil or solubilized fatty acids. The content of crude palm oil can be raised to 15%, reducing the amount of rice husks to 5%.

In recent work, Ocampo *et al.* (1996) have supplemented cull cows with multi-nutritional blocks using two levels of crude palm oil, 10 and 15%, following the formula described above. The 30 cows with an average weight of 290 kg were on short pasture of Brachiaria decumbens, at an average stocking rate of 1 animal/hectare and three treatments: two with blocks and one control. The results are summarized in the following table.

Table 2. Average performance of female cattle following treatments (90 days experiment).

Variable	Control Block	Block 10% oil	Block 15% oil
Initial LW kg	300.6	288.6	290.5
Final LW kg	349.5	345.7	353.3
LWG g/day	544	634.4	697.7
Block intake g/d	0	111.1	123.3
Additional LWG from block g/day		90.4	153.7
Cost of block consumed USD		0.023	0.027
Value of extra LWG in USD		0.106	0.117

The animals that received blocks gave the best results, in both economic and biological terms. It is very important to emphasize the low intake of blocks, the response to which was significant to the animals, resulting mainly from the additional supply of energy.

Note how the difference between 0.023 USD and 0.027 USD daily represented an additional gain in production of meat that ranged from 0.106 USD to 0.117 USD, making it very worthwhile. It is not usual to encounter gains at pasture of 543 g/day, as shown in the control group, which was an indication of the good condition of the pasture.

Nevertheless, the response to the effect of blocks was good. This shows that the use of energy blocks works not only in the dry season but that it is worth using throughout the whole year, improving the return per unit area of the smallholding or farm.

Very interesting results were obtained in the analysis of rumen degradability of the block, being approximately 50% at 6 hours for both blocks, 65% at 24 hours and 76% at 72 hours. The nitrogen content of the blocks had a degradability of 40% at 6 hours, 63% at 24 hours and 79% at 72 hours. Similar results were found with the NDF content. It can be concluded that supplementation with energy blocks improved overall animal performance, demonstrating that the effect of additional fat as a source of energy is viable.

Further work carried out in the Puerto Gaitan area, Departamento del Meta, Colombia evaluated the response to energy blocks by fattening cattle, with 45 steers per treatment lasting 67 days, and an initial average live weight of 250 kg. There were 4 treatments: one on Brachiaria decumbens without block, another on natural savannah without block and two on natural savannah (*Axonopus purpussi*) with blocks containing 10% crude palm oil or solubilized fatty acids (SFA).

The results which are reported in the above table show once more the validity of the energy strategy using multi-nutritional blocks.

It leads to an interesting discussion of the production achieved on natural savannah of Axonopus purpussi compared to that on Brachiaria decumbens. The daily LWG is practically the same and the only difference is in carrying capacity which resulted in greater annual meat production per hectare from the improved pastures'. However, the latter depends on converting the local ecosystem by removing the natural pasture, adapted over many years and with a high capacity for persistence. In addition, the costs of establishment and maintenance of the introduced pasture implies a very great cost in order to achieve the levels of production reported.

The increase in production achieved on the natural savannah is highly significant, with minimal inputs and a high rate of return. To increase production to 90 kg/ha/year solely by introducing the block system is a very interesting finding and raises the issue of the politics of substitution of the natural ecosystem with introduced pasture, which is currently considered as the only way of increasing productivity.

Table 3. Multi-nutritional blocks with palm oil or solubilized fatty acids for fattening cattle on natural savannah (*Axonopus purpussi*).

Variable	Savannah without block	Block 10% oil	Block 10% SFA	*B. decumbens* without block
Initial LW kg	218	241.9	238.0	
Final LW kg	227.8	270.0	267.7	
LWG g/d	146.2	420.0	443.2	450.0
Additional LWG cp. savannah		237.8	297.0	
Block intake g		215	218	
Cost of block USD		0.045	0.047	
Additional gain USD		0.284	0.356	
Stocking rate/ha	0.22	0.6	0.4	0.8
Meat production kg/ha/month	0.965	7.6	5.3	10.6
Meat production kg/ha/year	11.6	91.2	63.6	129.6

The Savannah System of Pig Production

This work was carried out in the Municipality of Puerto Gaitan, Departmento del Meta, Colombia in the ecological zones of savannah plains and the banks of the river Meta, an area of tropical rainforest with an average annual temperature of 28 deg C, annual rainfall of 1800-2300 mm/year and an altitude of 200 m a.s.l.

Three trials were carried out; each trial corresponded to one phase or cycle of the pigs (Penuela *et al.*, 1996).

Each phase was carried out in an area of 1 hectare, surrounded by a wooden fence with wire netting, divided into 4 equal parts (0.25 ha each) with feeder and water pipe in each corral. Each corral was provided with 16 sq m of shade. The number of animals in each trial varied from 40 to 60 depending on the stocking rate to be evaluated. The treatments (diets) were designed with 2 replicates and 10 animals per replicate.

The treatments applied were (g/animal/day):

	T1	T2
Fortified soya cake[1]	500	500
Rice polishings[2]	200-300	200-300
Crude palm oil[3]	300-500	500-600
Sugar cane (crushed)	ad lib.	-------

[1] 945 g of soya cake + 50 kg tricalcium phosphate + 3 kg salt + 2 kg vit/min premix

[2] 200 g from 20-60 kg LW and 300 g from60 kg until they reached 90 kg

[3] 300 g from 20-60 kg LW and 500 or 600 g from 60 kg until they reached 90 kg

For phase 1 and 2, an adjustment was made to the diets by adding 100g/pig/day of rice polishings and 100g/pig/day of crude palm oil for each treatment respectively.

In the study area (1 ha), the botanical composition and existing soil fauna were examined before the entry of the pigs and once following the completed cycle, as well as monitoring the physical and chemical characteristics of the soil and the performance of the pigs.

The results obtained reflected the biological and economic performance of the pigs at pasture, their behaviour and the changes in soil and botanical characteristics of the study area.

Biological Performance of the Pigs

The results obtained during the three phases of the investigation are summarized in the following table:

Table 4. Average results for fattening pigs

	T1	T2
No. of animals	27	27
Number of days on trial	117	117
Live weight kg		
Initial	36.0	33.3
Final	87.6	85.8
LWG (g/day)	440	448
Intake (kg/day)		
Soya bean meal	0.500	0.500
Palm oil	0.420	0.620
Rice polishings	0.326	0.587
Sugar cane	2.3	0.0
Total DM intake (kg/day)	1.74	1.23
Feed conversion (DM)	3.6	2.7

Source: Penuela *et al.*, 1996.

The average biological results are positive and acquire additional value when it is realized that they were obtained under an open field system (pasture). It could be said that it is difficult to find positive results for fattening pigs in these conditions. The main reason for these good results is due to the use of fatty acids contained in the palm oil, responsible for a high percentage of the energy provided in the diet. It would be difficult to achieve this with cereals as the source of energy.

It is interesting to compare the production of meat from pigs and cattle per unit area under savannah conditions, still with reference to a cattle system based on *Brachiaria decumbens* pastures.

From the experimental results, the production of pig meat per hectare in one cycle is 1,958 kg. If a minimum of two cycles are considered per year, the meat produced rises to 3,916 kg/ha/year. In similar savannah conditions, using improved pastures (*Brachiaria*), cattle produce around 130 kg meat per year.

These results show that there is a much greater range of potential for the use of savannahs, without having to transform all the characteristic conditions of the ecosystem.

Ethology

The following account of the behaviour of the animals was observed:

- At the introduction of the pigs to the experimental area, they began to explore the ground by moving around the whole area.
- The pigs stayed in a group, defined their social organization, established their rank: those which fed first and the lower rank ones which fed second.
- The pigs selected certain places for rooting and used the same place daily so as to convert it into a mud patch.
- Under these conditions, the body condition and health of the pigs was good. It should be noted that no form of medication was used throughout the trials.
- The consumption of water varied over time. On sunny days it was 12 litres/animal/day and 6 litres per day on dull days.
- The pigs consumed various plant species that were available in the experimental field, including mainly: *Salvia palaefolia, Anturium* spp. and *Pueraria phaseloides*.

Monitoring of Physical and Chemical Conditions of the Soil

The physical and chemical conditions of the soil were monitored over a period of 16 months, the time which carried it to the end of three phases of the trial.

Soil analysis showed that the texture was maintained in the range of less than 20% clay and more than 60% sand. The increase in soil organic matter (although small) is significant, considering the short monitoring time and the soil conditions in the region. The tendency is to increase organic matter, a condition which would favour water retention and reduce the impact of the dry season on the soil and production.

With respect to minor nutrients, there were deficiencies of copper and zinc, although the tendency is to increase with time; manganese was within the acceptable range and iron was normal for this type of soil (oxisol). The pH tends to reduce, possibly due to the increase in organic matter.

In general, it can be said that the changes recorded in the experimental area are favourable, however small because of the short timescale, and tending to improve with time.

Biological Activity of the Soil

In order to monitor biological activity of the soil, samples of the invertebrate population were taken periodically throughout the same 16 month period.

Very interesting results were observed in the changes in the invertebrates (Table 5), showing notable differences in the number and diversity of species present in the experimental site, monitored before and after the presence of the pigs, and also according to the season (summer/winter).

More than 9 different species of invertebrates associated with the soil in the experimental area are reported.

To show comparative effects, a control site was established outside the experiment. After a series of samples were taken at the same time as in the experimental area, no associated invertebrates were found.

In general terms, the presence of the pigs increased the biological activity in the study area, in response to the physical disturbance of the soil by the rooting of the animals and a greater supply of organic matter.

Table 5. Invertebrate populations (per sq m)

	1/95	6/95	9/95	12/95	3/96
Earthworms	0	7	99	37+e	102+e
Scarabid larvae	41	20	53		
Adult Scarabids	0	0	0	0	4
Centipedes	0	1	10	6	62
Ants	+	+	++	+++	+++
Termites	0	0	++	+++	+++
Coleoptera	0	0	14	6	91
Hemiptera	0	0	5	0	12
Carabid larvae	0	0	6	4	71
Adult carabids	0	0	0	0	3
Lepidoptera larvae	0	0	7	1	9
Elaterid larvae	0	0	0	0	6
Adult cicindellidae	0	0	0	0	3
Asilid larvae	0	0	0	0	2

+e = earthworm eggs

The results are variable depending on the time of year. In the first sample (January-Summer), no biological activity was found in either the experimental zone or the control site. Different results were found in December, also in summer, when biological activity was shown in the experimental site but not in the control area. The difference appears to depend on the presence of the pigs in the experimental area and the growing biological changes that this initiates in the soil. The greatest biological activity was found in the rainy season (July-September and May) which favoured soil moisture and living organisms in the soil.

Economic Analysis

The profitability per pig in phases 1 (USD 19.3-24.6) and 2 (USD 20.0-26.2) was good. In phase 3 (USD 4.7-8.3), the results were not so favourable as a result of the low level of prices in Colombia which failed to meet the costs of production, possibly due to the market crisis caused by imports of pigmeat from other countries, a problem which was critical to all pig producers at the time.

The biological and economic results are highly relevant, because it is difficult to find such results with out-door pigs. There is an urgent need to confirm the recommendations for this system.

It must be noted that, although the reported profitability is good with respect to pigs alone, it also provides an alternative method of pasture management that does not require high initial capital for installations. Furthermore it does not indicate the other economic and environmental advantages conferred by the presence of pigs. These include the improvement of soil conditions, increase in biological activity, the encouragement of desirable species and the effect on subsequent production.

Pig production based on the system described also plays an important role in furthering the processes of regeneration of pasture and greater capacity for seed development of the species present in the area: the pigs exert a scarifying effect on the seed, increasing its viability. The direction in which this leads suggests a dynamic increase in productivity starting with pigs production, through the greater organic activity which it stimulates to achieve additional benefits in pigmeat production, as well as greater vegetation cover.

Currently, work is in progress to collect the data on agricultural production in areas previously exploited by pigs, and to construct a model for the integral use of natural savannah soils. This will involve crops that are exclusively managed within the concept of organic farming, with a view to implementing a sustainable system with integrated use of resources. The proposed rotations are: pigs-maize-cowpea; african palm-cowpea; and pigs-cowpea-maize-palm. During the establishment of the african palms and throughout their productive life, cowpea and soya are produced in the alleys; the design for this involves the planting of 100 palms per hectare. It is also possible to consider other perennial crops besides palms, with the criterion that they produce biomass which may be included in the pigs' diet.

New Advances in Pig Production

With the help of FAO, two experiments have recently been carried out on the feeding of fattening pigs, incorporating forage sources in the diet as partial substitutes for the protein normally provided by soyabean meal. The diets used have crude african palm oil as the principal source of energy.

The first experiment evaluated the partial replacement (20%) of the protein (200 g/day) by *Azolla filiculoides* and leaves of *Trichanthera gigantea*, as well as offering crude palm oil either ad lib or restricted. Sixteen animals per treatment were used over the complete fattening cycle (126 days).

Table 6. Average results for pigs fed diets with *Azolla filiculoides*, *Manihot esculenta* (cassava) and *Trichanthera gigantea*.

	T1	T2	T3	T4
Live weight kg				
Initial	23.6	24.5	24.2	24.4
Final	86.6	87.5	83.4	87.4
LWG g/day	0.500	0.500	0.470	0.500
Intake kg/day				
Soya bean cake	0.500	0.350	0.350	0.350
T. Gigantea	0.0	1.2	0.0	0.0
Azolla	0.0	0.0	3.0	0.0
Manihot esculenta	0.0	0.0	0.0	1.5
Palm oil	0.450	0.450	0.450	0.450
Rice polishings	0.175	0.175	0.175	0.175
TOTAL	1.125	2.18	3.98	2.48
DM	1.04	1.2	1.05	1.14
FCR (DM)	2.08	2.4	2.23	2.28

Animal performance was slightly better when they were offered leaves of *Trichanthera gigantea* as a substitute for the protein provided by soyabean meal, a very interesting result in relation to the design of integrated production systems in which the tree component plays an important role.

This experiment showed that supplying a higher level of energy from african palm oil (T1 and T4) did not lead to a large response by the animal, but it significantly raised the costs, reduced the quality of the carcass by producing a large amount of fat and affected the feed conversion efficiency. It appears that pigs respond better to an adequate balance of the sources of energy (fatty acids and carbohydrates) that is well provided by the medium treatments (T2 and T3) and the relation between the content and quality of the protein in the diet.

Another experiment, evaluating three forage protein sources as substitutes for 25% of the soya protein (200 g/day) by means of giving Azolla filiculoides (DM 5%, CP 25%), Trichanthera gigantea (DM 25%, CP 18%) or cassava leaves (DM 16%, CP 22%) in a diet based on crude palm oil and a strategic input of rice polishings, demonstrated the viability of introducing forages in diets where the source of energy was principally provided by crude palm oil.

Table 7. Average results for pigs fed diets containing *Azolla filiculoides* and *Trichanthera gigantea*.

	T1	T2	T3	T4
Live weight kg				
Initial	23.9	23.1	23.5	26.2
Final	89.1	80.1	82.8	93.1
LWG g/day	0.517	0.453	0.470	0.530
Intake kg/day				
Soya bean cake	0.400	0.400	0.400	0.400
Azolla	1.6	1.9	0	0
T. gigantea	0	0	1.0	1.0
Palm oil	1.3	0.450	0.450	1.3
Rice polishings	0.200	0.200	0.200	0.200
TOTAL	3.3	2.95	2.05	2.9
DM	1.85	1.06	1.21	2.02
FCR (DM)	3.5	2.33	2.57	3.82

Animal performance was not affected by substituting 25% of the traditional protein. It is particularly attractive to use the leaves of cassava which can be done as an integral use of this resource during the growing stage of the crop.

In all cases, excluding feed conversion efficiency, the results were as good as those given by the standard recommendations for pigs based on cereals and traditional sources of protein, with total inputs far higher than those reported here. In this sense, the concentrated input of energy in the form of fatty acids (african palm oil) performs a strategic role in the feeding system that is proposed.

These alternatives permit the pig producer to achieve a good level of integration of production and, at the same time, a greater independence from external factors and inputs to the system, which allows greater economic sustainability and productivity. This tendency can be even better when the production of the oil palm is included as the central energy component of the production unit, achieving a higher level of autonomy in the production cycle and allowing a growing level of integration.

Finally, it is important to point out the simplicity of the proposed feeding system, which can be implemented by any producer without the need for special equipment or machinery. Also, when offering this kind of diet, it is possible to carry out the management operations on the pigs in the morning only.

Advances in Fattening Broilers

Having in mind the design of a feeding system for fattening broilers in semi-confinement associated with established perennial crops, a system has been evaluated which uses crude palm oil as the basic energy source together with fortified soyabean meal (soyabean meal 97.5%, tricalcium phosphate 2%, mineral/vitamin mix 0.3% and sodium hydroxide 0.2%) as the protein source (Ocampo *et al.*, 1995; Ocampo *et al.*, 1996).

The birds were managed in the traditional commercial way up to the third week, when they received a commercial concentrate, and were housed in confinement with heating. From the fourth week, they were offered the experimental diet and the birds went out to pasture between the trees.

Two types of diet were evaluated initially: diet A which consisted of a 1:1 mixture of crude palm oil and soyabean meal fortified with minerals and vitamins, with a maximum intake equivalent to 70% of the expected consumption on commercial diets (determined from 3 initial experiments) and diet B which included a 1:1 mixture, of which one part consisted of 80% palm oil and 20% rice polishings and the other part of fortified soya with minerals and vitamins, offered *ad libitum*.

Following a total period of 49 days, the results were as follows: Diet A - mean final weight 1,939 g, cumulative FCR 1.68, killing-out percentage 78.55, with average daily intake of 539 g; Diet B - mean final weight 2,016 g, FCR 1.64, KO% 75.4 and daily intake 604 g.

After that, *Azolla filiculoides* was included in the diet to appetite with the birds allowed to adjust their protein intake on a free-choice basis. Azolla was offered fresh after a period of draining for 3 hours after harvesting.

The diets A and B remained in the design and only the addition of Azolla was different. The results were as follows: Diet A - final weight 1,804 g, FCR 1.79, KO% 75, intake of supplement 500 g and intake of Azolla increasing from 40 to 163 g/bird/week; Diet B - final weight 1,963 g, FCR 1.77, KO% 76, intake of supplement 698 g and intake of Azolla from 39 to 176 g/bird/week.

The results with fattening broilers have been good, it being important to note that the birds were at pasture from the start of the fourth week, which is interesting from the point of view of integrated systems. As a result of the management given, the welfare of the animal was evident; the birds not only performed well in biological and economic terms but it was possible to achieve this with a happy chicken!

Results with Hair Sheep

Finally, it is interesting to relate the results of an investigation with hair sheep as the focus of the basic production system (Ocampo A, Monje S and Pineda C, 1996).

In order to understand the results, the components of the system are presented: the inputs, by-products and outputs from the system.

Components: total area 4,828 sq m (3,264 sq m under shade and 1,564 open), duration of study 405 days, 54 trees of the species *Erythrina poeppigiana*, *Brachiaria decumbens* pasture, 10 ewes and 1 ram, a building and standard sheep management.

Inputs: 860 kg high energy blocks (with 10% palm oil similar to those described for cattle), labour, 8900 litres of drinking water, and 3,240 kg rice husk bedding.

By-products: 4,131 kg organic compost from the floor of the building, which had a contribution of organic matter of 1,367 kg, sheep manure 233.8 kg, plant material not consumed by the sheep 503.5 kg, biomass production from *Erythrina* leaves 629 kg (equivalent to 31.6 kg protein) and 2,230 kg of *B. decumbens*.

Output: 286 kg sheep meat and their skins.

If the meat producing capacity per unit area from the proposed system and the farm is analysed, the benefits are obvious: hair sheep system 42.3 kg/ha/month and 507 kg/ha/year; beef system 13.75 kg/ha/month and 165 kg/ha/year. The production is significantly higher with the hair sheep. This demonstrates the possibility that small and medium sized producers could really achieve high levels of profit from hair sheep and that it is made possible as a result of integration of the different components within the production unit.

Conclusions

There are good opportunities to achieve high levels of production in tropical countries based on the growing of oil palm, which particularly favours a high degree of integration within the production unit and with diversification as a basic factor.

This line of research is likely to lead to the incorporation of trees and perennial crops, and to the better utilization of biomass due to improved energetic efficiency and the exploitation of biodiversity and integration, allowing tropical countries to capitalize on their comparative advantage and evolve more efficient production systems.

References

Alvarez E 1990. Utilizacion de los lodos en el engorde de bovinos. Hacienda Guaicaramo, Meta. Unpublished.

Alvarez Manuel 1990. Los Solubilizados grasos en la produccion de carne durante la Epoca seca. En: Actividad Ganadera. Vol 1 No.1. Fondo Ganadero del Meta. Villavicencio, Colombia.

Borda I and Ramirez P 1991. Uso del bloque multinutricional en la alimentacion de terneras doble proposito. Tesis para optar el titulo de Medico Veterinario y Zootecnia, Universidad de los Llanos, Villavicencio, Colombia.

Dieter B. Suproductos de la palma africana en plantas de beneficio primario y su utilizacion. Memorias del encuentro nacional de palma africana. Bogota, Colombia. 1988.

Escobar Aquiles. Avances en la nutricion de los rumiantes. Ponencia IV seminario nacional y I internacional Alternativas de produccion animal con recursos tropicales. Unillanos, Villavicencio, Colombia, 1991.

FEDEPALMA 1993. Informe de labores 1992 - 1993.

Huertas H. B. 1996. Eficiencia alimenticia en la ganaderia de carne en Colombia. Instituo Colombiano Agropecuario, Villavicencio. Sin publicar.

Ocampo A, Castro C and Alfonso L 1990b. Determinacion del nivel optimo de proteina al utilizar cachaza de palma africana como fuente de energia en raciones para cerdos de engorde. Livestock Research for Rural Development. Volume 2, Number 2:67-76

Ocampo A, Lozano E and Reyes E 1990a. Utilizacion de la cachaza de palma africana como fuente de energia en el levante, desarrollo y ceba de cerdos. Livestock Research for Rural Development. Volume 2, Number 1: 43-50

Ocampo A 1992. Oil-rich fibrous residue from african oil palm as basal diet of pigs; effects of supplementation with methionine. Livestock Research for Rural Development, Volume 4, Number, 2:55-59

Ocampo A 1994a. Utilizacion del fruto de palma africana como fuente de energia con niveles rentringidos de proteina en la alimentacion de cerdos de engorde. Livestock Research for Rural Development. Volume 4, Number 1

Ocampo A 1994b. Raw palm oil as the energy source in pig fattening diets and *Azolla filiculoides* as a substitute for soya bean meal. Livestock Research for Rural Development. Volume 6, Number 1

Ocampo A 1994c. Efecto del nivel de pulidura de arroz en una dieta basada en el fruto entero de palma africana para el engorde de cerdos. Livestock Research for Rural Development Volume 6, Number 2.

Ocampo A, Penuela L y Mejia M 1995. Desarrollo de Sistemas Sostenibles de produccion para los Llanos Orientales de Colombia. Proyecto Fundacion Horizonte Verde - Fundacion Yamato - Corporacion Ecofondo. Puerto Gaitan, Meta.

Ocampo A 1995. La Palma Africana (Elaeis guinnensis Jack), Recurso Estrategico en Sistemas Integrados de Produccion Tropical. Tesis Magister en Desarrollo Sostenible de Sistemas Agrarios. Universidad Javeriana, convenio con la Fundacion Cipav y el Instituto Mayor Campesino. Santafe de Bogota.

Ocampo A, Camacho M y Torres J 1996. Suplementacion de vacas de descarte con bloque nutricional utilizando dos niveles de aceite de palma. Escuela de Medicina Veterinaria y Zootecnia, Villavicenio.

Ocampo A, Monje S y Pineda C 1996. Sistema de produccion de ovinos de pelo una alternativa para el mediano y pequeno productor. Universdiad de los Llanos. Villavicencio.

Integration of Livestock in the Sugarcane Industry in Cuba

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Abstract

The Cuban sugarcane industry comprises a total of 1.8 million hectares dedicated to sugarcane for sucrose, produced in 156 sugarmills on the island. An additional 188 thousand hectares, is used to produce agricultural produce, milk, meat, poultry and eggs in order to help feed part of the half-million size workforce. For this, 94 thousand hectares are dedicated to food crops and animal feeds, while a similar amount of land is used for pastures and forests. The economic recession of the early nineties has stimulated the development of sustainable agricultural policies for producing livestock in the sugarcane-sector.

All of the sugarcane ground in the mills is produced in two types of cooperatives: 1) 1300 Basic Units of Cooperative Production (BUCP), newly-formed in 1993 from the previous state-run and sugarmill-administered cane plantations, and 2) 400 Agricultural Production Cooperatives (APC), originally formed by private landowners into a cooperative organisation 20 years ago. Presently, 80% of all sugarcane entering the mills is produced by the 1300 BUCPs and 20% by the APCs and other private owners. In addition to the production of livestock in the 1300 newly-formed cane cooperatives, approximately 200 state-run farms, administered directly by the sugarmills and other sugarcane service industries, such as transport, construction and maintenance, also maintain livestock. Presently, in both areas, the cane coops and state farms, new emphasis is being placed on the use of sugarcane and its derivatives, soybeans, forage trees and multinutritional blocks for feeding livestock.

In December 1995, there were 72 thousand pigs, 188 thousand sheep, 4 thousand goats, 16 thousand rabbits, 6 thousand ducks, 21 thousand horses and 122 thousand head of cattle, including oxen. That same year a total of 8.7 thousand tons liveweight was produced, in addition to 1.6 thousand tons of fish and 20 thousand tons of milk.

KEY WORDS: Livestock, sugarcane, integration, Cuba

Introduction

The Cuban sugar industry, until the economic recession of the early 1990's, produced during 6 months of each year, from December to May, approximately 10% of the world annual production of crude sugar. For this, 70 million tons of sugarcane, harvested from 1.8 million hectares, were processed in 156 sugar mills into approximately 8 million tons of crude sugar and 2 to 2.5 million tons of final molasses. The basic division of all agriculture on the island is "cane" and "non-cane" and, in 1983, the government encouraged the "cane" sector, which employs 450 thousand workers or 12% of the entire active workforce, to set up crop and animal production systems to help feed the workers, and eventually their families. Ever since the introduction of this crop in the island, food for cane workers was mostly imported. By 1985, reproductive and productive livestock herds had been organized in all 156 sugar mills and other major service industries, to include: swine, rabbits, poultry, sheep, goats and cows (Table 1).

Until 1990, in addition to 450 sugarmill farms that produced crops and livestock, the sugar industry produced for the "non-cane" sector a total of 4.5 million tons of animal feeds, in 11 different products and when mostly needed, during the 6-month-long dry season. These included: 500.000 MT of 3% molasses-urea; 200.000 MT molasses-urea-bagasse; 325.000 MT hydrolysed bagasse pith; 400.000 MT each of B molasses and protein molasses, mostly for pigs, and 80.000 MT of Torula yeast. However, by 1995, due to a drastic nation-wide economic cutback, reflected in the lack of urea and caustic soda for hydrolysing and processing bagasse, and problems in transporting such highly fibrous feedstuffs to the feedlots, the production of most animal feeds was curtailed.

Table 1. Integration of livestock in the Cuban sugar industry

	1985		1990		1995	
	reprod.	total	reprod.	total	reprod.	total
Swine	9365	63646	12387	108231	10994	72244
Sheep	38731	87015	105050	228294	86058	187562
Goats	1593	3552	1702	3879	1507	3667
Rabbits	-	-	10167	41628	4046	16473
Ducks	-	-	-	2961	3028	5900
Horses	4017	34587	3817	30332	5547	20713
Cattle	2059	23069	14990	56655	30533	122641*

* includes a total of 79 thousand oxen: 29,267 working pairs; 5879 pairs in full training and 6399 pairs beginning training (requirement: 33 thousand pairs)

Land Tenure, Livestock and Food Production

Land Tenure

Due also to the economic recession, land tenure was drastically affected and most of the previously state-run agricultural enterprises, including the sugarcane plantations, were reorganized into cooperatives, called Basic Production Cooperatives (BPC). Formerly, 82% of all land in agriculture, including sugarcane, had been managed by the state, however, after the readjustment, this figure had dropped to 33 percent. Moreover, while the average size of the state-run sugarcane plantations had been between 12 and 13 thousand hectares, the 1300 newly-formed coops were assigned, each, slightly more than one thousand hectares (ONE 1994). Presently, 80% of all sugarcane entering the mills is produced by the BPCs and 20% by Agricultural Production Cooperatives (APCs) and other private owners. Livestock production is now in the in the hands of the newly-formed cane coops and in approximately 200 remaining farms which are managed directly by the sugar mills and other service industries, such as transport, construction, maintenance and the research institutes (Tables 2 & 3).

Table 2. Food program* of the Cuban sugar industry

Crops	Amount g/d	kg/yr	Animal products	Amount g/d	kg/yr
Rice**	115	36	Meat (w bone)	145	30
Beans **	58	18	Fish (cleaned)	150	8
Tubercles ***	500	156	Eggs	2/wk	104/yr
Fresh vegetables	170	35	Fat	20	6
Fresh fruits	230	48	Milk	1/4 l.	78

* breakfast and/or lunch while at work; ** uncooked; *** unpeeled

Livestock and Food Production

Two factors, which occurred almost simultaneously, caused a revamping of conventional agricultural livestock policies, towards the promotion of alternative or sustainable agricultural policies in the sugar industry. The first was: in order to develop livestock in the newly-formed cane coops, the government decided that most of the animals belonging to the former state cane plantations should be handed over to the coops. The new coops had little other than cane, consequently, they were receptive to new ideas related to using cane for feeding their livestock.

The second factor was that, when the sugarcane plantations were broken up, besides the sugarmill farms losing all of their cane and most of their animals to the coops, they no longer had sufficient sugarcane for their remaining livestock, and had to replant. And that is what they are presently doing, planting sugarcane. These farms might have relied more on molasses to feed their animals, but the economic recession meant less fertilizer and insecticides, therefore much less cane, resulting finally in the need to restrict molasses for use mostly in multi-nutrient blocks.

Table 3. Food production in the Cuban sugar industry (1990-95)*

	1990	1991	1992	1993	1994	1995
Crops, 000 MT	129	145	156	119	142	166
Livestock, MT	6671	6421	6173	5697	5803	6518
Fish, MT	-	268	457	849	1127	1600
Milk, MT	9830	12394	14846	15054	17704	19494

* in addition, 450-500 t/yr. of cheese

At present, in order to reduce basic food importation and feed better the workers, the coops need to produce more livestock. For that, they must use more cane for their animals, more efficiently. They need additional cane grinders and choppers. The remaining 200 sugarmill farms, that have more access to machinery, are re-planting sugarcane specifically as animal feed. A reconsideration of conventional agricultural policies towards alternative or sustainable agriculture is definitely the order of the day (Perez and Rabago 1996) and new emphasis is being placed on the use of sugarcane, soybean forage, protein trees and multinutritional blocks for feeding livestock in a technological package arrangement referred to as a "sugarcane village" for 300 workers (Table 4).

Table 4. Livestock objectives in a "sugarcane village" for 300 workers

Concept	Amount per capita	Reproductive herd	No.animals/day
Milk	1/4 litre/d	20 cows & progeny	30
Eggs	2/week	300 laying hens	300
Poultry	1 per 3 mo.	start 350 every 3 mo.	350
Rabbits	1 per 3 mo.	50 does and 6 bucks	125-150
Mutton	1/4 carcass/yr.	150 ewes and 6 rams	375-400
Pork	1/3 carcass/yr.	20 sows and 2 boars	200
Fish	2 kg per 3 mo.	5000 fingerlings/ha-yr.	-

Towards a Sustainable Agriculture Policy for Livestock in the Sugar Industry

Since the current economic cutback, the number one problem related to livestock production in the sugar industry has been to provide animals a sufficient daily amount of energy and protein. Prior to the recession, the country imported annually, 1.9 million tons of cereals and protein supplements, and naturally some of these feeds eventually trickled down to livestock in the sugar industry. However, all that disappeared, feedstuff importations remain 30% of the pre-recessional period, and justly prioritized for livestock production in the "non-cane" sector of the country. Therefore, the new emphasis for feeding livestock in the sugar industry is with sugarcane, a crop that although it requires 16 months from planting to reach maturity, is a perennial crop that this country definitely knows, and, if "fractionated", could provide up to 80% of the daily energy needs of most livestock. As protein sources, the emphasis is now on soybean forage, sunflowers (mainly for oil) and protein trees. Multi-nutrient blocks (MNBs) are finally being promoted as a source of non-protein nitrogen for ruminants. The following is a brief description of the state of this program as it relates to a new chapter in the history of the Cuban sugar industry: livestock for half a million workers!

Sugarcane

The proposed "fractionation" of sugar cane for feed and fuel, first proposed in 1986 during an FAO Expert Consultation in the Dominican Republic (Preston 1988), has since then been promoted almost exclusively for animal production, where it has been shown that free-choice sugarcane juice and a restricted amount of a protein supplement can be used for pigs (Sarria *et al.*, 1990) and ducks (Men and Su 1992). However, in order for sugarcane to constitute an economically viable livestock production system, the cane tops, 15%, and the pressed cane stalks, 40% of air-dry weight, need also to be used for animal production. For that, the "sugarcane fractionation system" requires little other than protein forage and free-choice MNBs. In support of the "cane fractionation system", is the following recent and fascinating farm study done in Colombia (Molina *et al.*, 1995).

The farm study used as an example, an average amount of 28 kg of whole sugarcane, which was chopped and used solely as ruminant feed, or pressed to extract the juice for pigs before the stalks and tops were fed to a group of heifers. The pigs received a daily average of 0.5 kg of soybean meal and 10 kg of fresh cane juice. The heifers on the "leftover fibre diet", received a daily average of 12 kg of pressed stalks, 6 kg of cane tops, 9 kg of protein tree forage (*Gliricidia sepium*), 0.6 kg rice bran and 0.4 kg of poultry litter. They also consumed 0.7 kg of MNBs. The control (whole cane) diet, also fed to heifers, consisted of 28 kg of chopped, whole sugarcane, in addition to the same ingredients fed to the heifers on the experimental ration.

The same 28 kg of whole cane, "fractionated", produced a total of 1100 g liveweight gain, 500 g with cattle and 600 g with pigs, almost double the 765 g liveweight gain produced on the whole cane heifer ration. This general concept, or strategy, is gaining momentum within the livestock program of the Cuban sugar industry. What has added a certain momentum, or strength, to the overall program, is the fact that farmers can now produce their own "protein", in the form of soybean forage.

Soya Bean Forage

In 1989-90, the Cuban sugar industry initiated a program to plant soybeans in rotation with cane, 5 thousand hectares for seed. It was a failure, due to many reasons: an incorrect planting schedule, lack of inoculants, herbicides and insecticides, and insufficient combines for harvesting, but perhaps more importantly, a lack of basic, farmer-friendly, grass-roots soybean technology. Several months later, and perhaps in part because the soybean program had failed, in a sugarmill in the eastern part of the island, pigs fed diluted B molasses, were offered as a source of protein, fresh soybean plants (PEREZ 1995). They began to grow faster and it was decided to plant soybeans periodically adjacent to the pig barn for this purpose. The idea quickly took hold amongst the other sugar mills of the province and freshly-harvested soybean forage is now being used in more than 150 sugarmill farms and cane coops throughout the entire island for pigs, ducks, rabbits and chickens, and to a limited extent for ruminants, particularly for milk production, until the protein trees are in production.

The technique consists in planting a 7-row plot of soybeans, weekly (Perez and Ochoa 1996). The length of the rows in the plots corresponds to the number of animals to be fed. The distance between rows is 35 cm, half the distance recommended for the production of soybeans for seed. The seeds should be inoculated and each plot requires weekly irrigation. After 8 or 9 plots have been sown, the first plot is ready for harvest. Harvesting must be carried out while the forage is still in the early milk-stage, otherwise, the anti-trypsin factor present in the formed seed, described as a defence mechanism against insects and birds, could affect non-ruminant performance. A recently-performed, in vitro, digestibility trial of nitrogen in the whole soybean plant was 67% (IIP 1995), which compares favourably to that of soybean meal of 75%, and to forages in general of between 35 and 40 percent. Perhaps, this is a clue to one of the reasons for its success.

Protein Trees

At last, trees are beginning to be recognized as "protein trees" and farmers in both the cane coops and the sugar mills are beginning to refer to them as protein banks. Until recently, these trees, mostly *Erythrina* and *Gliricidia*, were used only for fencing and cut back once yearly, in the early spring. As earlier stated, traditionally, cane farmers were never livestock farmers. Having to produce one's basic needs was, and still is, an entirely new concept, since up until 10 years ago, most food for the cane sector was imported. And because "protein" for animals has been something one normally had to "plant" in the soil, the idea that tree leaves can contain up to 25% protein and be used for cattle is new and difficult to grasp (Perez 1996).

The "non-cane" sector continues to promote the use of *Leucaena* in the form of a swath at 5-metre intervals in pastures, while the "cane" sector, in addition to *Trichantera gigantea*, is promoting *Gliricidia* planted in a double-row arrangement, 0.5 x 0.5m, with a one metre wide band between double rows to facilitate hand cutting (Molina 1993). At present, in more than 70 different sites, this is occurring. Finally, the information that a Vietnamese student, studying in Colombia, fed oxen, in addition to their daily diet of bagasse, *Gliricidia* and MNBs, and got them to move more quickly (Thu *et al*., 1993), was widely disseminated here in a recent island-wide meeting on oxen in the sugar plantation. This information has begun to have wide-sweeping consequences on the use and propagation of protein trees and on the local manufacture of MNBs, and more importantly perhaps, for use in up to 80 thousand oxen in the coming 1996-97 cane harvest.

Multinutritional Blocks

Surely, because the cattle industry in Cuba used so much molasses/urea and other animal feeds, prepared in the sugar mills, MNBs were, for a long period, not promoted. The recession changed all that; in 1995, the production of cane-based, animal feeds was approximately 10% of that of previous years. One outstanding incident changed the outlook on MNBs. In January of 1993, in the middle of the dry season, and a drastic 70% cutback on the importation of animal feeds, a 200-head dairy reported 101 animals in anestrus. The diet had been reduced to dry-season pasture, supplemented by sugarcane, nothing else. Multi-nutrient blocks were provided. Three months later, still in the dry season, only 8 cows remained in anestrus and the manager of the dairy reported that the animals were consuming more cane.

At present, in about 60 cane coops and sugarmill farms, MNBs are being made by hand, while in the "non-cane" sector, the interest is to perfect machinery for their centralized preparation and distribution. Although the most common formula refers to the use of molasses, one interesting development, particularly in the sugar mills, has been to use limited molasses, up to 50 or 60% fresh filter-press mud, 10% each of urea, minerals and calcium oxide or hydroxide, and no additional fibre.

Perhaps, one of the more eloquent examples of, firstly, the effect of MNBs, and secondly, the effect of MNBs, together with more locally-available feedstuffs, is the information presented in Table 5, obtained over a period of 16 months from a small sugarmill-owned dairy herd of approximately 15 milking cows. At the end of June, 1995, the herd was first exposed to MNBs and, in November, 1995, besides the MNBs, to a mixture of pressed cane stalks, chopped cassava stems, king grass and soybean forage. Milk production has practically doubled, and milking cows, expressed as a percentage of the total herd, has already increased from 57 to 70 percent.

Table 5. Average daily milk production during 16 months (litres/ day)

	J	F	M	A	M	J	J	A	S	O	N	D
1995	-	-	-	4.8	4.6	4.8	6.4	6.2	6.6	6.6	6.5	7.5
1996	7.5	7.9	8.1	8.3	8.1	8.4	8.9	-	-	-	-	-

Guideline to Livestock Feeding Systems

It is impossible to monitor 1300 cane coops and 200 sugarmill farms, all with crops and livestock, and accurately report the results of the recent introduction of alternative and/or more sustainable forms of agriculture. It will be a long process; perhaps, more precise information will be ready for FAO's Third Electronic Conference on Tropical Feeds! Meanwhile, the following is a brief guideline of the different production systems and diets being promoted according to the general livestock objectives set out in Table 4.

Pigs

The reproductive herd is managed at the coop or farm level. Each family receives two weaner pigs/year, one every 6 months, to be fattened mostly on table scraps and other local resources. The cane co-op, or the sugarmill farm, produces the weaners for the families and the pork, and lard, consumed in the collective dining area (Table 2). Energy sources can vary from fresh cassava, sweet potatoes, ripe bananas, cane juice or just plain ground cane, depending upon the time of year and/or available machinery. Protein sources are generally fish or fish silage, torula yeast, some saccharomyces yeast in cream form from the distilleries, but increasingly, whole plant soybean forage, about one metre freshly-cut forage per pig, per day.

Ducks

Surprisingly, ducks will eat the whole soybean plant and only leave the thicker part of the stem which then can be gathered and fed to pigs or sheep. Ducklings are started on one kilogram of dry feed, then switched over to soybean forage, one metre for every 5 ducks, the same amount for rabbits, approximately. As energy, the ducks are fed diluted molasses, cane juice or boiled tubercles.

Rabbits

They are kept in cages. Previously, macro-pellets (a type of MNB, without urea), made preferably with B molasses and a protein supplement, were widely used. However, the soybean forage feeding system is now overtaking the molasses blocks. In one farm, a trial was set up to compare: sweet potato vines, a mixture of sweet potato vines and soybean forage, or only soybean forage. It was impossible to obtain precise information for this report, however, the farm manager reported best results with soybean forage.

Chickens

Fresh cassava roots and soybean plants, ground finely together in a ratio of 50:50 are beginning to give promising results.

Sheep

The sheep are left to graze mostly in the cane fields to mid-morning, and return in the cool of the afternoon. At night, they are kept in paddocks near the other animals. The farmers are beginning to use MNBs, and as soon as conditions permit, meaning the acquisition of more and simple machinery to chop and crush the cane, and the production of sufficient protein tree forage, hope to keep the productive herd inside in the dry season and feed them a mixture of 80% cane or tops with 20% protein forage, and MNBs. Inbreeding has now been largely controlled by binding tightly the testicles with a piece of rubber tubing at 5 days of age, within several days, they drop off.

Cows

With the creation of the cane coops, and a general movement of workers and their families from a sugarmill-oriented to a coop-style life pattern, there has been an increasing need to produce milk locally. Most of the larger dairies have been broken up into mini-dairies of up to 20-30 cows; at the same time, the government has promoted the sale of both heifers and cows to the newly-formed cane coops. Wire fencing is imported, therefore mostly unavailable to the cane sector; this has meant that the traditional pasture system has been increasingly pressured to use a dry-lot system, particularly in the dry season. Moreover, the interesting work carried out in one sugarmill dairy (Table 5), the fact that cows can produce 9 l/day of milk without imported concentrates and with only locally-available feed resources, is now being replicated in other sugarmill dairies in the remaining 13 provinces. All this has stimulated new interest in MNBs, and in protein trees. In fact, one immediate problem in need of solution is: can *Gliricidia*, which basically does not produce viable seed in Cuba, be started by stake, year round?

Conclusion: Concerns and Problems

In Cuba, because food for the entire sugar industry was mostly always imported, cane farmers for 400 years have only been cane farmers, not cane and livestock farmers. The overall problems that affect a better integration of livestock in the sugar industry in the context of the current Cuban situation, recently affected by a drastic economic recession, are:

1. The fact that, as most Caribbean nations, Cuba imported "temperate belt animal genetics" and did not develop a national feed resource base consistent with the nutritional demands of this type of livestock;
2. The fact that, the entire university agricultural training program must be revamped: a) to produce graduates in sustainable farming systems, and b) to learn to effectively extend positive experimental results to grass-roots level; 3. the fact that, neither the island, nor the sugarcane industry on the island, produces the required quantity nor quality of seeds, nor inoculant, nor sufficient fingerings required to optimize and/or accelerate this unusual and interesting activity. For this, the cane sector must necessarily develop specialized farms at either the

provincial or sugarmill level for producing seeds and inoculant, and centres for producing fingerlings (cane sector has 4 000 ha of water); and 4. the fact that, there is insufficient simple machinery, such as, cane grinders and choppers, planters and harvesters, to face the immediate challenge of effectively and rapidly integrating livestock production in the 1300 newly-formed cane coops.

Finally, so as not to end on a pessimistic note, cane farmers, in 1995, received for the first time, a new Cuban sugar-industry-promoted magazine, "Canaveral", devoted to technical information for cane producers, including the production of livestock!

References

IIP (Instituto de Investigaciones Porcinas) 1995 Internal Report

Men B X and Su V V 1992 Sugar Cane Products in Diets of Ducks. Livest Rev Rur Dev 4(3):10-14

Molina C 1993 Granja "El Hatico". En Memorias Seminario Internacional: Estrategia de alimentacion en verano para ganaderias tropicales. Medellin Colombia Junio 2-4 1993

Molina C, CH, Molina D, CH, MolinaD, EJ and Molina D, JP 1995 Produccion de carne bovina y porcina con base en la utilizacion de la cana de azucar. Informe interna CIPAV Cali, Colombia

ONE (Oficina Nacional de Estadistica) 1994 Characteristicas de las UBPC (Informe interno) Ministerio Economia & Planificacion

Perez R 1995 La cana de azucar como base de un sistema alimenticio pecuario. Proceedings: II Encuentro Nacional de Agriculltura Organica 17-19 de mayo de 1995 La Habana Cuba p 77-84

Perez R 1996 Ventajas del pinon florido. Canaveral 2(2):38-41

Perez R and Rabago R 1996 El camino hacia una agricultura sostenible en las cooperativas caneras. Canaveral 2(1):40-46

Preston T R 1988 Fractionation of Sugarcane for Feed and Fuel. In: Sugarcane as feed. FAO Animal Production and Health Paper No 72 FAO Rome p 310-319

Sarria P, Solano A Y Preston TR 1990 Utilizacion de jugo de cana y cachaza panelera en la alimentacion de cerdos. Livest Rev Rur Dev 2(2):92-100

Thu N, Dong N, Hon N, Quac V 1993. Effect of molasses-urea cake on performance of growing and working local buffaloes and cattle. Livestock Research for Rural Development 5 (1):23-27

Sugarcane for Beef and Pork Production

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Abstract
Tropical countries have a great comparative advantage due to the intensity and regular availability of solar energy which may be exploited through plant photosynthesis. Sugarcane is a C4 plant which has a greater capacity to utilize high light intensities with reduced water requirement and hence produce as much as 3.8 times more biomass per hectare than cereals. Total biomass yields of 255-480 T/ha are reported.

Sugarcane has been used as the basis for meat production systems in the tropics, with the aim of maximizing output per hectare. Fractionation of cane, using traditional artisanal mills (50% extraction) yields juice for fattening pigs, and pressed cane stalk and tops for feeding cattle. Trials were carried out on the farm.

In this study, sugarcane juice, with or without palm oil, and 500 g protein supplement was fed to pigs from 20-80 kg and achieved average daily gains (ADG) of 633 and 666 g/day respectively. A second trial (30-80 kg) showed gains of 565 g/day, with or without palm oil.

Bull calves fed on pressed cane stalk and tops, with *Gliricidia sepium*, multinutritional blocks (20% urea), rice bran and poultry manure grew at 526 g per day, compared to cattle on a similar diet but with integral sugar cane replacing the pressed cane stalk and tops which had an average daily gain of 767 g per day.

Comparison of beef production alone with an integrated pig and beef system favoured the integrated system. Direct production from cane was

3,458 kg beef per hectare compared to 5,870 kg per hectare from pigs and bull-calves together.

These figures compare to a maximum potential production of 1500-2000 kg meat per hectare from one hectare of star grass (*Cynodon nlemfluensis*) with fertilizer and irrigation, under the same climatic conditions. The integrated systems also provided more employment.

KEY WORDS: Livestock, sugarcane, integration, meat production

Introduction

Farming production systems in tropical countries must take as much advantage as possible of the use of the soil, the water, the air and the solar energy. The integration between different animal and vegetal species must ensure production on the long term that warrants the improvement of the soil, the water and the air purity as well as protecting biodiversity that prevails in tropical areas.

From all the energy sources, the most renewable and under-used is the solar one. This is a great comparative advantage for the tropics (Preston, 1992) where it is widely available. Its most logical use is by plants through photosynthesis (Preston and Murgueitio, 1993). The biodiversity and high productivity of tropical ecosystems is due to the major and more regular flow of energy throughout the year (Preston and Murgueitio, 1993). Classical data show that in the tropics, net productivity of energy is twice the one obtained in temperate areas in all ecosystems.

But it is necessary to select the comparative advantages of the same genetic potential taking into account that some plants have an exceptional capacity to use the solar energy when luminosity and temperature are high (Preston and Murgueitio, 1993). These are the C4 plants which can produce more biomass with minor water requirements. Sugarcane is a C4 plant and for this reason, it produces several times more biomass than other grasses as pangola (*Digitaria decumbens*) even without irrigation or added nitrogen (Rodriguez and Ruiz, 1983).

The yields of various varieties of sugarcane are shown in Table 1.

Table 1: Production of biomass from 6 sugarcane varieties (first harvest at 15 months)

Variety	Tops Ton/ha	Canes Ton/ha	Total biomass Ton/ha
MZC-74275	70	235	305
V-7151	45	210	255
RD-7511	90	310	400
Co-421	130	350	480
POJ-2878	60	245	305
CC-8475	90	310	400
Average	81	277	358

Sugarcane yields per year and per hectare are much higher than those of any other traditional crop. From sugarcane juice or A molasses, 3.8 times more energy is obtained than with a secondary cereal (Figueroa and Ly, 1990).

The farming systems should include the production of food, fuel and organic fertilizers, integrating different animal and crop species. They should be more efficient through the optimized use of the components of the tropical wealth: the people, the earth, the water and the solar energy (Preston, 1988).

This paper intends to demonstrate the advantages obtained from meat production systems based on sugarcane, using different animal species and aiming at an increased meat production per hectare in tropical regions without depending on cereals. To reach this objective, it was chosen to feed pigs with the liquid component (sugarcane juice) and cattle with the fibrous component (bagasse and tops) of the sugarcane as the basis of their diet.

The study was conducted in the farm "El Hatico", located in the municipality of El Cerrito in the department of Valle del Cauca in Colombia. The climate and soil conditions are:

Average temperature: 24 C
Relative humidity: 75%
Annual rainfall: 750 mm
Altitude above sea level: 1000 m

Soil:
pH: 6.5 to 7.5
Texture: largely clayey
Organic matter content: 2.5 to 3 %
Phosphorus content: 30 p.p.b.

Since 1988, this farm has been conducting research on the integral use of sugarcane (chopped canes and tops) for feeding cattle while increasing the carrying capacity of the land (Molina *et al.*, 1992). The results have been satisfactory from the biological point of view, with Average Daily Gains (ADG) reaching 800 g. Nevertheless, the analysis of the profitability shows that the cost of supplementation is rather high, as sources of by-pass proteins and energy and non protein nitrogen are needed (Molina, 1994).

Therefore, research was re-oriented in the farm in order to integrate cattle and pig production with the aim of optimizing the sugarcane for meat production per hectare.

Background

It is necessary to take advantage of the specific physico-chemical characteristics of sugarcane in a proper way in order to optimize its use for animal feeding. This plant has been genetically selected and industrially processed for many decades with the only aim of producing sugar. Sugarcane is basically composed of two fractions, one of soluble simple sugars, essentially sucrose, and other insoluble fractions made of structural components as cellulosis, hemicellulosis and lignin. The protein content is very low. Furthermore, lignification, crystallization index of cellulosis and its level of polymerization are responsible for the cane rigidity. Taking into account these physical and chemical factors, it is necessary to process sugarcane in order to optimize its use for different animal species (Figueroa, 1990).

The soluble fraction of sugarcane is easy to extract through crushing which permits to reach extraction rates as high as 97% in the sugarcane industry and about the half through the traditional artisanal sugarcane mills. This fraction, the sugarcane juice (16-20% DM) is composed of sucrose and reduced sugars. It is a liquid feed which is rich in energy but difficult to preserve because of its tendency to rapidly ferment (Figueroa and Ly, 1990).

Mena (1981) started research in this field in Mexico on station and on farm. Fermín (1983) and Fernández (1984), in the Dominican Republic, carried out several experiments with the use of sugarcane juice and obtained similar results to those of this work and other works done in Colombia (Table 2) published by Sarria (1994).

Table 2: Results from fattening pigs with a diet based on sugarcane juice and soya cake in different locations in Colombia

Weight (kg)	Nx6,25 (g)	ADG (g/day)	Con-version	Reference
25-91	200	640	3.8	Quiroga and Preston, 1987
20-77	200*	580	3.1	Solano, 1989
21-90	200	730	3.2	Solano, 1989
19-92	300	755	3.2	Solano, 1989
27-98	200	625	3.0	Sarria *et al.*, 1992
27-78	200**	590	3.7	Sarria and Preston, 1992
28-81	200	631	4.0	Sarria *et al.*, 1992a
23-80	200**	455	3.7	Sarria *et al.*, 1992b
24-91	200	681	3.3	Ngoan, 1994
25-90	200	482	4.7	Becerra *et al.*, 1990
	200	720		Fernández CIPAV, 1990
13-90	200	790		Muñoz, 1989

Materials And Methods

Pigs

Two independent experiments were carried out in order to assess the potential of sugarcane juice, in association with small quantities of palm oil (from African oil palm, *Elaeis guineensis*) as the source of energy in the diets of pigs growing from 20 to 80 kg.

The aim was to study the alternative energy sources in order to increase the flexibility of the use of sugarcane juice. Nevertheless, the results are not sufficiently comprehensive to reach any conclusions with reference to the oil in the diet.

So far, it was considered very hard to reach the same levels or higher level of production in the tropics such as those in temperate countries where diets are based on cereals. The experiments carried out by Ocampo (1992) proved that it was not only possible to reach these levels, but even to exceed them with palm oil as source of energy.

The quantities of palm oil used were:

Pigs (kg)	Palm oil (g)
20 to 40	90
41 to 60	120
61 to 90	180

The oil was given twice a day in association with the source of protein.

The sugarcane used for the extraction of the juice was from the variety Mayaguez Colombia 74275, 12 months old, yielding 180 tonnes per hectare (135 tonnes of canes and 45 of tops) and producing a juice of 20 degrees Brix.

The trials were conducted in 4 barns (11 pigs in each) with a cement ground (15 m2) and fences of bamboo.

The results showed in Table 3 concern pigs 'berracos' originated from paternal lineage (Pietrain, Hampshire, Duroc) whereas the results showed in Table 4 concern pigs originated from boars from maternal lineage (Large white, Landrace, Yorkshire). This is important in order to interpret the differences in ADG between the two groups.

The initial weight of the animals were between 17 and 22 kg and they were weighed every 30 days before feeding them. Every treatment was repeated twice with 11 pigs in each.

Protein supplementation consisted in 500 g of a mixture of soya cake, vitamins and minerals (40% protein) per pig per day, given in two meals.

Cattle

Cattle was included in the trial in order to assess its capacity to use the fibrous residue left after crushing the sugarcane to get the juice. A trial was also conducted on bull-calves in order to compare the use of the integral sugarcane (chopped canes and tops) with the use of bagasse and tops.

Two corals were used: each included 200 m^2 of earth with 3 trees for shadow and 20 m^2 of cement grounds near a trough 4 m long (0.8 m per animal). In order to ease the management of the animals, and to keep the natural immunity given to them by grazing on the pastures, they were released during the week ends in pastures of star grass (*Cynodon nlemfuensis*).

The two groups (integral sugarcane; bagasse and tops) were identically supplemented:

- *Gliricidia sepium* (3% of the live weight on fresh matter basis) as the source of protein (Preston and Leng, 1987).
- Multinutrient blocks given *ad libitum* and including 20% urea as a source of non protein nitrogen, 15% cotton husks, 40 % molasses C, 10% rice bran, 5% salt and 10% lime.
- Rice bran as a source of by-pass energy, rich in long chain fatty acids: 500 g per animal per day.
- Poultry manure as a source of non protein nitrogen, minerals and protein: 500 g per animal per day.

The bagasse was obtained from the sugarcane crushed to get the juice for the pigs through an artisanal mill powered with animal draught and with an extraction capacity of 50% of the cane weight as juice. Therefore this bagasse is still rather rich in sugars. It was daily chopped with a Brazilian chopper (Nogueira 12 A) powered by a tractor Fordson Mayor of 65 HP (capacity of chopping 1 ton per hour). The thoroughly chopped bagasse (fragments 1 to 2 cm long) were transported to the trough on carts draught by mules.

The cane tops, which represents 25% of the biomass of the sugarcane, were chopped on the spot with the same equipment and were also transported by mules.

The diet of the control group of Table 5 consisted in integral sugarcane (chopped canes and tops) processed and transported as the tops above mentioned.

The animals used for these trials were from the Lucerna breed (Colombian breed) originating from a triple crossbreeding between the European breeds Holstein, Dairy Shorthorn and the Colombian creole breed Harton del Valle which has inhabited the region for more than four centuries.

Results

Pigs

In the first trial with pigs (Table 3), ADG are 33 g higher with the treatment including African oil palm and sugarcane juice (666 vs 633); taking into account the lower juice consumption (0.7 litres per pig per day), and the intake of 117 g of oil per pig per day, the difference amounts to 1,000 pesos (US$ 1.17) per pig after fattening is completed.

Table 3: Fattening pigs with sugarcane juice and African oil palm

Parameter	Unit	Juice and oil	Juice
Groups	-	2	2
Pigs/group	-	11	11
Duration	days	90	90
Initial weight	kg	21	21
Final weight	kg	81	78
ADG	g	666	633
Standard deviation		0.104	0.112
Intake			
Sugarcane juice	litres	7.7	8.4
African oil palm	g	117	0
Protein Supplement	g	0.500	0.500

In the second trial with pigs (Table 4), there was no difference in ADG between the group fed with sugarcane juice and oil and the group fed with only juice (565 vs 565). It was also observed that in this assessment, the difference between juice intake was maintained: 0.7 litres less per pig per day for the animals receiving an average of 134 g of palm oil per day per pig. In this case, the pigs that received juice and oil had an additional cost of 4,256 pesos (US$ 5) to complete fattening with comparison to the pigs that received only sugarcane juice.

Table 4: Fattening pigs with sugarcane juice and African oil palm

Parameter	Unit	Juice and oil	Juice
Groups	-	2	2
Pigs/group	-	11	11
Duration	days	92	92
Initial weight	kg	30	30
Final weight	kg	82	82
ADG	g	565	565
Standard deviation		0.170	0.118
Intake			
Sugarcane juice	litres	6.8	7.5
African oil palm	g	134	0
Protein Supplement	g	0.500	0.500

The minor ADG found in Table 4 with reference to Table 3, are due to the genetical difference between the animals. The average intake of sugarcane juice for the assessments of Table 3 and 4 are between 7.5 and 8.4 litres per pig per day.

Cattle

As shown in Table 5, the bull-calves used had an average initial weight of 276 kg. The trial lasted for 133 days. The ADG of the group receiving integral sugarcane, Gliricidia sepium, supplemented with multinutrient blocks (20% urea), rice bran and poultry manure were 250 g higher than those of the group receiving bagasse, tops and the same supplementation. The ADG were 767 g and 526 g respectively.

Table 5: Rairing/fattening Lucerna bull-calves with bagasse/sugar-cane tops vs integral sugarcane

Parameter	Unit	Bagasse and tops	Integral sugarcane
Animals	-	5	5
Duration	days	133	133
Initial weight	kg	276	277
Final weight	kg	346	379
ADG	g	526	767
Standard deviation		0.071	0.057
Intake			
Integral sugarcane	kg	0	23
Bagasse	kg	10	0
Tops	kg	6	0
Blocks 20% urea	kg	0.682	1.080
Gliricidia sepium	%LW	3	0
Rice bran & poultry manure	kg	1	1

Multinutrient block intake was 400 g higher for the animals receiving integral sugarcane compared to the animals receiving bagasse: 1080 and 682 g respectively. This might be interpreted by the higher requirements for ammonia concentration in the rumen for the animals receiving more fermentable sugars in their diet (Preston, personal communication, 1994).

Indeed, the low nitrogen content of the sugarcane and its by-products clearly indicates the need to provide supplements in order to increase the levels of ammonia in the rumen. This is done by the urea but this might also be achieved through other sources of fermentable ammonia as poultry manure or fodders with high contents of soluble protein. The requirements are between 20 and 30 g of nitrogen per kg of fermentable carbohydrate in the diet.

Because of the rapid degradation of a high proportion of the fermentable carbohydrates, it is necessary to thoroughly mix the urea with them in order to ensure the proper availability of ammonia from urea while the sugars are fermenting. In diets rich in fibers and sugars, the strategic use of the urea consists in maintaining high levels of ammonia in the rumen, when the fermentation of sugars ends, and the degradation of fibre starts (Leng, 1988).

It was also shown in Table 5 that the standard deviation for the two treatments was very low, 0.071 and 0.057 for the treatment with bagasse and the treatment with integral sugarcane respectively. This shows the confidence in the results that are expected with these two diets.

Conclusions

As shown in Tables 3 and 4, pigs that are fed sugarcane juice *ad libitum* during rairing-fattening and supplemented with 200 g of net protein per pig per day have an ADG of 600 g.

The potential of integral sugarcane (chopped canes and tops), in the fattening of bull-calves supplemented with *Gliricidia sepium* (3% of liveweight on fresh matter basis), multinutrient blocks (20% urea), 0.5 kg of rice bran and 0.5 kg of poultry manure is to produce ADG of 750 to 800 g per animal per day.

The integration of the cattle to take benefit of the crushed sugarcane (bagasse) from which only 50% of the sugar has been obtained, permits to reach ADG of 500 g with a supplementation including protein, non protein nitrogen and a source of by-pass energy (large chain fatty acids).

The present work shows the advantage of the integration of the pigs and cattle for using more efficiently the sugarcane in order to increase meat production per hectare. In Table 6, there is a comparison between the exclusive use of sugarcane for cattle (chopped canes and tops) and the integration between the pigs fed with the juice and the cattle fed with the bagasse and tops.

Table 6: Two alternatives for using sugarcane

Parameter	28 kg integral sugarcane Bull-calf	28 kg fractionated sugarcane Bull-calf	Pig
Integral sugarcane	28 kg		
Bagasse		10 kg	
Tops		8 kg	
Juice			10 l
Gliricidia	9 kg	9 kg	
Multinutrient block	1.1 kg	0.7 kg	
Rice bran & Poultry man.	1 kg	1 kg	
Prot. suppl.			0.5 kg
ADG	765 g	500 g	600 g

To analyze this trial, it is considered that the voluntary intake of sugarcane for a bull-calf of 350 kg in total confinement, amounts to 80 g of fresh sugarcane (canes and tops) per kg of liveweight, which means an offer of 28 kg per animal per day. The fractionation of these 28 kg gives 7 kgs of tops and 21 kg of canes. The crushing of these 21 kg of canes in an artisanal mill extracting 50% of juice, will give 10.5 kg of sugarcane juice and 10.5 kg of bagasse.

Taking into account what was mentioned previously, it is concluded that with the quantity of integral sugarcane needed to feed a bull-calf of 350 kg and to obtain ADG of nearly 800 g, it is possible to feed the same bull-calf with only the bagasse and the tops with ADG of 500 g and with their respective protein supplementation.

In Table 7, the economical analysis shows that the alternative of feeding only the cattle avoids a loss of 281 pesos (US$ 0.33) of lost per animal per day, whereas the association with pig production produces a benefit of 366 pesos (US$ 0.44) per day.

Table 7: Economic analysis of the two alternatives for using sugarcane

System	Integral sugarcane for fattening bull-calves		Fractionated sugarcane (Juice and bagasse)			
Species	Cattle		Cattle		Pig	
ADG (g)	765		500		600	
Value/kg	Pesos	US$	Pesos	US$	Pesos	US$
live weight	900	1.12	900	1.12	1700	2.0
Gross income	689	0.73	450	0.53	1020	1.2
Gross income/ system	689	0.73	1470 Pesos 1.73 US$			
Costs	970	1.14	649	0.76	455	0.5
Net income	-281	-0.33	-199	-0.23	565	0.7
Net income/ system	-281	-0.33	366 Pesos 0.43 US$			

The benefits from the production of organic fertilizer from the pig and cattle excreta should be added to these figures. In the case of the cattle, it is estimated that 17 bull-calves of 350 kg of liveweight (carrying capacity per hectare) can produce 21 tonnes of fresh matter of manure per year, which represents an additional income of about 100,000 pesos (US$ 118) per hectare. In the case of the production system using fractionated sugarcane, pig manure is obtained with its specific properties in relation with the production of energy (methane production) and as a fertilizer.

The potential of production of meat per hectare of sugarcane (yielding 180 tonnes of biomass per hectare) is 4,940 kg in the case of the use of integral sugarcane for bull- calves. When pig and cattle production are associated, it is possible to obtain 2,900 kg of beef and 4,800 kg of pork, which means a total of 7,700 kg of meat per hectare. This meat production is not entirely related to the effect of the sugarcane, as the animals receive a supplementation. Considering the percentage of sugarcane on dry matter basis in the diet, the productions would be:

Bull-calves fed with integral sugarcane:		3,458 kg
Integrated production system:	Bull-calves:	2,030 kg
	Pigs:	3,840 kg
	Total:	5,870 kg

The previous figures are more striking if we take into account that one hectare sown with star grass (*Cynodon nlemfluensis*) with a high level of fertilization and irrigation in the same conditions of climate and soils as mentioned at the beginning of this paper, has a maximum potential of production of 1,500 to 2,000 kg of meat per hectare per year.

Furthermore, from the social point of view with reference to the employment opportunities, this production system of cattle fed integral sugarcane and the integrated system of cattle and pig production based on fractionated sugarcane, generates respectively 4 to 6.5 times more employment than the intensive pasture production system. This is particularly crucial in developing countries often densely populated and with insufficient sources of employment.

References

Figueroa, V. and Ly, J. 1990. Alimentación Porcina No Convencional. GEPLACEA, publicación del grupo de paises Latinoamericanos y del Caribe. 215 p.

Leng, R.A. 1988. Limitaciones Metabólicas en la utilización de la caña de azúcar y sus derivados para el crecimiento y producción de leche en rumiantes. Memorias del Seminario Taller Sistemas Intensivos para la Producción animal y de energía renovable con recursos tropicales, CIPAV. p 1 a 23. Cali, julio 26 al 30 de 1988.

Mena A., 1988. La producción de cerdos con base en la caña de azúcar. Memorias del Seminario Taller Sistemas Intensivos para la producción animal y de energía renovable con recursos tropicales. CIPAV. p l28-135. Cali Valle, Colombia.

Molina, C. H., Molina, C. H., Molina, E. J., Molina, J. P., Gomez, M. E., Murgueitio, E., Rodriguez, L. and Sarria, P. 1994. Pruebas de campo en los trópicos en el uso de biomasa para sistemas integrados y sostenibles de producción animal. Documento presentado a la Organización de las Naciones Unidas para la Agricultura y la Alimentación FAO por la Fundación Centro para la Investigación en Sistemas Sostenibles de Producción Agropecuaria. Cali, Colombia.

Molina, C. H., Molina, C. H., Molina, E. J. and Molina J. P. 1994. Evaluación sobre Bloques Multinutricionales, realizadas en la Granja El Hatico, Valle del Cauca Colombia. Memorias del Seminario Internacional sobre utilización de bloques Multinutricionales. Guanare, Venezuela. Agosto 1994.

Molina, C.H., Molina, C.H., Molina, E.J. and Molina, J.P. 1992. Integración de agricultura y ganadería doble propósito en el Valle del Cauca. Estudio de caso de la Granja El Hatico en: International Foundation for Science y Universidad Autónoma de Yucatán; seminario Internacional sobre sistemas de producción Doble Propósito. Mérida, Yucatán.

Murgueitio, E. and Preston, T.R. Los sistemas sostenibles de producción como repuesta a la crisis de la producción pecuaria tropical. Convenio Interinstitucional para la producción Agropecuaria del Valle del rio Cauca, 19p.

Murgueitio, E. and Preston, T.R. 1992. Strategy for Sustainable livestock production in the tropics. Centro para la Investigación en Sistemas Sostenibles de Producción Agropecuaria (CIPAV). Cali, Colombia.

Ocampo, A. 1994. El sistema Palma Africana, una Alternativa Sostenible para el Trópico. Memorias del 3 Seminario Internacional Desarrollo Sostenible de Sistemas Agrarios. Maestría en Sistemas Sostenibles de Producción Animal en los Trópicos. p 91-118. Cali, Colombia.

Preston, T.R. 1988. El ajuste de sistemas de producción pecuaria a los recursos disponibles. Memorias del Seminario Taller Sistemas Intensivos para la producción animal y de energía renovable con recursos tropicales. CIPAV. p 1-15. Cali Valle Colombia.

Sarria, P. 1994. Análisis Comparativo de la Sostenibilidad de Sistemas para la Producción de Cerdos basados en Recursos Tropicales. Memorias del 3 Seminario Internacional Desarrollo Sostenible de Sistemas Agrarios. Maestría en Desarrollo Sostenible de Sistemas Agrarios, Maestría en Sistemas Sostenibles de Producción Animal en los Trópicos. p 195-211. Cali, Colombia.

Livestock in South-Eastern China

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Abstract
This paper describes the five important roles of the pig in a Chinese household, first as a garbage disposal plant to eat everything that humans do not want. Its wastes make it a power station providing biogas energy which can be converted into electricity, and then a fertilizer factory to supply nutrients to both water for polyculture of fish and macrophytes, and soil for multicropping of grains, vegetables, fruits and flowers. It also contributes to a feed mill, as the crop and processing residues are used as livestock feeds, and is finally a meat producing plant. These 5 useful functions make the pig a very special part in the life style of Chinese rural society, as it recycles all its wastes and residues most effectively and efficiently while contributing to its economic and social development in a sustainable manner. Following the same economic, ecologic and social principles, the integrated farming system has evolved, enhancing the farming and agroindustrial activities of every farm family to meet the needs of a modern society by providing the renewable means of production such as energy, fertilizers and livestock feeds.

KEY WORDS: Integrated farming system, China, pig, livestock, recycling, feed

Introduction
This paper deals with livestock production, using crop and processing residues from integrated farming systems as feeds, in the southern part of Pearl River delta, province of Guangdong in South-Eastern China, which lies in the subtropics with year-round agricultural production

where water is made available in polyculture fish ponds that have been in operation for many centuries. It covers 800 km2 of low-lying land and, before the modernization craze, had a population of 1,2 million people who were the most productive farmers in China, and probably the whole world, based on productivity per unit surface and human or artificial energy input, because of its most efficient waste recycling processes in an integrated livestock-fish-plant system.

Land Tenure

In the past, the whole region was divided into big properties owned by warlords or mandarins, and every property was sub-divided into small family farms on a share-cropping basis. The land tenure system did not change much despite changes in land ownership, private or state -- even during the Commune era, the family farm became the production unit and the village became the production brigade. But the farming system underwent dramatic changes, depending on the ingenuity of the farmers to make the most of their small plot of land and water, not only for survival but also to cope with the increasing population.

Farming System

Until the recent past, the usual livestock was 2-3 pigs per family behind the residence, raised not so much for meat production but as scavengers to eat anything that humans did not eat. They usually provided the meat for various festivals for families which were close relatives. Their wastes were taken daily to the field and used as raw fertilizers for the fish ponds to produce various plankton as fish feeds, and the only supplement was fast growing elephant grass grown on the edges of the ponds to feed the grass carp or other herbivorous fish.

The human faeces were retained in brick-lined pits in the courtyard and taken regularly in covered containers to the field and composted with coarser crop residues before being used to condition the plant beds -- the less coarse ones were used to supplement the pig feed. The human urine was always separated in a covered fired-clay jar used by males, and the females used chamber pots which were then emptied into the same jar. The fermented urine was used as fertilizer for vegetables which represented 80-90% of the human diet. The rest was provided by fish, duck eggs and bean or bean products. Ducks, also scavengers, were reserved for visitors or as festival fare.

No external input was provided for the livestock, fish or plants. Any surplus produce from the farm was preserved by the farm family without any input from outside, and nothing was burnt or thrown away. In fact, the whole life style was based on cycles and recycles.

Agro-industry

The most important export items, besides food and drink products which included sauces, pastes and other condiments, were silk and silk products. Mulberry bushes grown on half the dykes provided the leaves to feed the silkworms, and the silkworm excreta and feed residues were used to fertilize the fish ponds or feed the fish. The nutrient-rich pond water was used to irrigate and fertilize the mulberry bushes and other crops which occupied the other half of the dyke, and the pond mud was removed once a year, after harvesting the fish, to enrich the soil on the dykes.

Fish residues were also used to supplement the pig diet. Surplus fish was salted, then dried or canned, as export items. Surplus pork and ducks are marinated in soya sauce and air dried, and then exported in jars and later on in cans. Surplus duck eggs were salted or covered with clay and rice straw for preservation, and exported. Most crop residues, which could not be used as livestock feeds, were used for culture of mushrooms which were dried and exported, with the residues then used as feed or compost.

All these preservation and value-added activities were done at family farm level, and provided employment for all members of the family which became well-off by any standards. As a matter of fact, the productivity in that part of Guangdong province was so enormous that even if the whole of China was closed to the outside world for nearly 3 decades, this province was allowed to hold two Canton Fairs yearly, each lasting one whole month, to trade with visitors from various parts of the world. There was never any interruption, and they are still being held now.

When China opened up to the outside world in the early eighties, such strategies allowed many families to become the first 10,000 yuan farmers, when the salary of a university professor were less that 2,000 yuan yearly. After the recent agro-chemical invasion of Chinese agriculture in many coastal provinces, such strategies are proving useful again ...

Modern Farming

Such a philosophy has not changed much even with modernization, despite the special economic zones with foreign investments and technologies, and the agro-chemical invasion of Chinese agriculture in recent years. It is true that much harm has been done to the environment by the new industries and the increase in chemical fertilizer and fossil fuel uses, especially coal, but the Government has reacted effectively because of the solid farming foundations based on such a philosophy.

As the farmers became better-off, they increased the size of their livestock, with the pens built on the dykes next to the fish pond. In 1985, 3,000 hectares of integrated farms were added in 3 regions of the province, with bigger ponds and more livestock. Some additional feeds were used but they were limited to corn, peanut and soya cakes after oil extraction, and created some pollution due to non-consumed feed residues. However, it was the livestock wastes which became a limiting factor for the ponds because of oxygen consumption by the organic content of the increased raw wastes.

That was when I became a volunteer at the Academy of Sciences in Guangdong province, and I advocated the use of digester and shallow basins to pretreat the livestock wastes not only to solve this oxygen problem but also to increase substantially the number of livestock in the system for economic benefits, which I have been doing since 1969 at the South Pacific Commission in New Caledonia, and later on at United Nations ESCAP in Thailand. It took us nearly 4 years to put together an Integrated Farming proposal for consideration by DANIDA, but the Tiananmen incident shelved it, and I left China to continue my work in Vietnam and other places until the United Nations University came up with the ZERI programme, and I was the only one they could find to implement it.

Integrated Farming System

If we are trying to help the poorest of the poor farmers in the third world, with limited land and monetary resources, there is no way they can grow fodder to feed their livestock, and they have to depend on residues from their food and raw material crops for local utilisation first, with any surplus for export. All available crop and processing residues, with simple physical processing and requiring no complex equipment or microbial processing taking advantage of the warm climatic conditions, should be used as livestock feeds. If required, they can be enhanced with solar and/or biogas energy produced on site. Use of fossil and other imported fuels can never be economic, and are NOT used as a recurrent input.

Only an integrated system of livestock, fish and crop with the wastes and residues of ALL three operations being used as feeds for livestock and fish, and as fertilizers for fish and crop cultures, can be viable economically, ecologically and socially -- see Annex I. All the processes involved can remain biotechnological, using simple locally-built structures and no external input , as the system produces the essential means of production such as feeds for livestock and fish production, fertilizers for fish and crop culture, and energy for domestic and farm uses. As the farming activities increase, keeping the same economic and ecologic principles, the integrated farm will become totally self-sufficient in feeds, fertilizers and energy for an agro-industrial complex which can become a prosperous enterprise.

A thorough analysis of all the processes involved will convince any biotechnologist that such achievements are feasible, as shown below. The most surprising feature is that they work best in the wet tropics, where water is available year-round, and marginal lands such as marshes are the best and cheapest sites for integrated farming systems.

Processes Involved

1. *Digestion* of livestock wastes up to 60% reduction in biochemical oxygen demand (BOD) in a digester which can be a simple plastic bag or a self-built brick tank with a domed roof that is made airtight with liquid barriers, while producing biogas fuel.

China is the most advanced country with digester technologies, with sizes ranging from 5 to 2,000 cubic metres, supplying cooking gas to millions of households and meeting the energy needs of huge farms or agroindustries. The biggest power station run on biogas has a capacity of 1.5 Megawatt.

2. *Oxidation* of digested effluent for a further BOD reduction of 30%, or of washwater, with algal growth in shallow basins to produce the needed oxygen naturally. The algae can also be produced, using solar or wind energy to move the liquid, for sale to manufacturers of health foods or cosmetic products. The effectiveness and efficiency of oxidation can also be enhanced in deeper ponds with contact oxidation media, resulting in substantial reduction of the space required. Some cheaper versions of oxidation consist of earth channels, where various kinds of macrophytes are grown as livestock feeds while producing oxygen, to partially treat raw livestock wastes before they flow into fish ponds.

China and other countries such as Cuba and Mexico produce algae for commercial purposes, with or without livestock waste treatment.

3. *Polishing* of the 90% treated effluent by dilution and aeration after it enters the deep fish ponds for polyculture of various kinds of fish feeding at different trophic levels. Such ponds are clean with prolific growth of various plankton in the water, and grass on the edges of the pond, to feed ALL the fish, which are not under stress even if the yield is very high compared with other forms of aquaculture worldwide, using artificial feeds.

Unfortunately, in most places of China, raw livestock wastes are used to fertilize polyculture fish ponds, but things are changing as more digesters are introduced.

4. *Aquaponic* culture of cereals, fruits and flowers on the edges of the pond and on half the pond surface using bamboo or plastic floats, with nylon netting below to protect the roots, to control eutrophication caused by excess nutrients from the bigger size of the livestock, without interfering with the fish polyculture.

For China, the economic implication is enormous when it is considered that there is twice as much water surface than land in an integrated farm. This breakthrough is also very meaningful from the environmental point of view, as China is losing more and more land to industry, urbanisation and highway communication -- half the huge water surface from the multitude of fish ponds, reservoirs and lakes are now available for food culture!

5. *Macrophyte* culture of useful chlorella, spirulina, azolla, lemna, pistia and even water hyacinth as livestock feed in shallow channels which distribute the nutrient-rich pond water to the fields for irrigation. The macrophytes are first used as substrate to grow mushroom to break down the ligno-cellulose and make the residue more digestible and even more palatable for the livestock, which eat more to grow faster and produce better wastes for the system.

This important strategy, which also uses all the available crop and processing residues, is widely practised in China, which produces over 50% of the world's mushroom output, using simple structures and methods in the backyards of most farmers in the south.

6. *Aeroponic & Multicropping* cultures of various vegetables and fruits on the dykes using the pond water to irrigate and fertilize them, have enabled farmers to increase food production without the use of chemical fertilizers or pesticides for centuries. It is certainly a much acceptable and more practical way of using livestock wastes to fertilize crops, instead of the big mess created and intensive labour required to handle organic wastes around the world.

China has increased its use of agrochemicals from practically nothing to 21.5 million tons in 1994, and is determined to reverse this disastrous situation with the new Chinese Ecological Agriculture (CEA) programme, implemented in ALL provinces. I cannot see the newly affluent farmers replacing the convenience of purchased fertilizers or pesticides with the messy handling of organic wastes as they did in the past. So the only solution to the chemical problem is for China to adopt the integrated farming system, which is only receiving lip service at the moment in most places.

7. *Processing* of produce for preservation and/or value added is the best way to prevent spoilage of valuable foods, and the simple processes at village level are well known, especially in Asia, without using complex processes and fossil-fuel operating equipment. In modern times, much bigger agroindustrial factories are required, but still maintaining the same economic and ecological principles.

China has demonstrated a few outstanding examples of stand-alone farms and factories which produce their own energy and fertilizers for big agro-industrial enterprises, with the crop and processing wastes used as livestock feeds, with and without further physical and/or microbial processing. The government should make such practices mandatory for all enterprises.

8. *Marketing* of produce and goods in some parts of Asia is quite impressive even in the rural areas where vegetables and meat are sold fresh, and fish and poultry are sold live. The government has a very important role to play by providing facilities for the farmers to sell their surplus crops at a fixed price to government stations, where the crops are processed for local and export trade.

China has such "import and export corporations" which are beneficial to the farmers, who are certain of a fixed price for any produce they cannot sell on the local market, and for the government which is assured of having the surplus crops for processing and export to maintain a healthy balance of payments for many decades.

Some concrete examples can be supplied to participants on request.

Annex I: Goals of Integrated Farming Systems

The goals of integrating livestock, fish and crop are described as follows:

1. Economic

The universally known problems of commercial farming in the developing world are the prohibitive costs of external inputs, such as feed for livestock and fish, fertilizer for crops, and energy for processing, while most wastes and residues are left to pollute and even degrade the environment when they should be recycled as useful resources. These problems are compounded with imported technologies which are inappropriate, costly and inefficient due to the wrong systems used and which do not take full advantage of local climatic and environmental conditions to make the processes more effective and less costly.

The Integrated Farming System demonstrates that the only way for commercial farming to be viable economically is to recycle all wastes and residues as means of production for maximum productivity at lowest costs. There is no other way for most developing countries without fossil fuel, mineral and other mining resources. They should capitalize on their sunny and hot climate for optimum microbial processes for recycling all their wastes and residues as fuel, fertilizer and feed to produce food, fibre and raw materials for economic development.

2. Ecological

For centuries, most developing countries have followed ecological principles for subsistence and self-sufficiency from their lush forests and rich aquatic life. The same principles can be used to meet the requirements of a modern society, instead of adopting systems that have been designed for other climatic and environmental conditions, requiring imported and costly input such as fossil fuels, agrochemicals and complex equipment, and can never be economic in most of the third world.

Some developing countries were even forced to accept polluting industries to locate in their poor communities to provide lowly paid jobs, without any provision for environmental pollution control or even workers' safety. There are enough horrible examples in some countries to make the concerned leaders stop such disastrous development strategies, and adopt more appropriate systems.

The Integrated Farming System shows that modern scientific knowledge and technological innovations can improve all the farming and agro-industrial processes involved without upsetting the ecological equilibrium, and provides a new concept of development that can prevent environmental degradation while benefiting both investors and communities concerned, with production of foods and renewable raw materials first.

3. Social

Past development in the third world depended heavily on the strategies of the administrative powers, which used the land, people and natural resources to meet the material and industrial needs of the metropolitan nations. This development used huge areas of prime lands for livestock ranches and monocultural plantations for primary produce for export, very often at the expense of local food production. It is unbelievable that such development still continues in most countries of the third world today, and it is not surprising that they remain poor or even become poorer.

In the past, there were also many man-made cultural constraints on reutilisation of wastes in many parts of the world, with many official bodies making things worse by arbitrary laws and regulations. They resulted in many human settlements living in squalor because the wastes were not disposed of properly. Many changes have occurred in recent years when the powers that be, including all the religious bodies, began to realize that the only way to solve such problems is to recycle the wastes as economic resources.

The Integrated Farming System demonstrates that the developing countries can have more viable agro-industries, with their wastes used as inputs in surrounding integrated farms, while solving the waste and pollution problems effectively and efficiently and making local enterprises highly rewarding in a healthier environment. So both industrialists and farmers benefit socially and environmentally from such collaboration. One additional aspect, which should not be overlooked, is the establishment of self-employment for the individual farm family with relatively small area of land and low investment which can be recovered within a couple of years, with the prospect of its members becoming entrepreneurs as the integrated farm expands.

Integrated Farming Systems in the Andean Foothills of Colombia (Preliminary Results)

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Abstract
This paper describes changes in farming systems in a community in the Andean foothills of Colombia dictated by altered circumstances and opportunities. The circumstances were the declining supply of water to the community due to deforestation provoked by extension of cattle grazing. The opportunities were: (I) the use of multi-purpose trees (for feed, fuel and soil fertility enhancement); (ii) high yielding biomass crops (sugar cane) providing feed and soil improvement; (iii) recycling of household waste water and livestock manure to produce fuel (biogas) and fertilizer (the effluent); (iv) use of earthworms to convert livestock manure into protein for chickens and organic fertilizer; (v) associated (multi-strata) cropping of horticultural plants with multi-purpose trees to increase biomass yield and enhance biodiversity; and (vi) simplification of the feeding system (giving whole sugar cane stalk and tree leaves to pigs during pregnancy).

Interim results are given showing effects on biomass yield and on soil fertility.

KEY WORDS: Livestock, integration, feed, tree, sugarcane, recycling, biogas, soil fertility

Background

This paper describes some of the results from the introduction of integrated farming systems in a small community (municipalities of La Union and El Dovio) located in the Andean foothills, 1,700m above sea level, in the north of the Cauca Valley in Colombia. The rainfall is 1,400mm and mean temperatures range from 24°C during the day to 14°C at night. The terrain is sloping (>25°) and mean daily hours of sunshine are 2.7.

Most of the farm families are of peasant (campesino) origin and own less than 15ha. Traditionally the region was dedicated to monocultural coffee with some fruit trees and vegetables.

The farming systems are now highly diversified as will be described in this paper. Income is derived almost exclusively from farm activities.

The first modifications to the traditional system were made in 1987 on the basis of recommendations by advisers of the Federation of Coffee Producers to introduce cattle in order to promote diversification of the traditional coffee monoculture. Faced with the problem of inadequate feed supply, help was sought from the Fondo DRI (Fund for Integrated Rural Development) which in turn approached CIPAV for advice as to appropriate forage crops that could be grown. CIPAV's first recommendations were:

1. Reintroduction of pigs and partial confinement of the cattle to provide manure for a biodigester to supply biogas as alternative to firewood (to decrease pressure on the remaining forest area) and organic fertiliser as alternative to purchased chemicals.
2. To establish sugar cane and forage trees (Chachafruto = *Erythrina edulis* and nacedero = *Trichanthera gigantea*) as feed sources for cattle and pigs through fractionation of the sugar cane into juice (for the pigs) and residual pressed cane stalk and the cane tops for the cattle. The "chachafruto" was chosen as a protein supplement for the cattle and "nacedero" for the pigs on the basis of CIPAV's experience with these trees in similar ecosystems.
3. Preparation of syrup from cane juice using an "earth" oven in the ground.

4. On-farm manufacture of multi-nutritional blocks using the "scums" from syrup manufacture as binder.
5. Installation of a low cost tubular polyethylene biodigester.
6. Purchase of soya bean meal to complement "nacedero" and the cane juice for the pigs.
7. Establishment of earthworm culture to provide protein (for poultry) and organic fertilizer for vegetables and coffee.

The Present Strategy: the Objectives

The introduction of high yielding forage crops (sugar cane and trees) had increased the offer level of feed for the livestock making it possible to diversify further the areas previously in pasture. This diversification was introduced gradually beginning in 1992 with the aim of:

1. Responding to environmental pressures to conserve the water resources, to improve soil fertility, to control erosion, and to increase biodiversity.
2. Integrating more closely crop and animal activities so as to optimize the recycling of nutrients and water.
3. Reducing the energy and economic costs of farm activities.

The following procedures were introduced:

Protecting the Water Source and Increasing the Efficiency of Water Use

The area dedicated to the protection of the water source had decreased because of the extension of pasture. The watershed had to supply the needs of the community of 12 families and the severe deforestation in the region had led to conflicts over the supply of water. The fenced (to prevent cattle grazing) watershed area was extended to facilitate natural regeneration of trees and shrubs. More trees, of multi-purpose use (eg: Bamboo), were planted in this area. Banks of multi-purpose forage trees were introduced to provide the joint function of protection and source of feed, replacing natural pasture which is highly susceptible to erosion in areas with slopes exceeding 30°.

The water originating from household and general farm activities was decontaminated by using it as the diluent for the manure put into the biodigesters and by passing the resulting effluent from the digester along a series of canals for sedimentation of residual solids and growth of water plants.

Increasing Plant Biodiversity

More multi-purpose trees were planted in areas previously dedicated to pasture with the aim of improving soil fertility, controlling erosion, providing feed for the livestock and eventually for construction purposes and sale as timber. Horticultural crops (Zapallo - Cucurbita maxima), fruit trees and shrub forages (Ramie - Boehmeria nivea and mulberry - Morus alba) were introduced into areas previously dedicated to a single specie. Areas of pasture were set aside for natural regeneration of shrubs and trees. The intensification of the recycling process included the growing of different water plants (water hyacinth, azolla and duckweed).

Increasing Animal Biodiversity

Pigs, poultry and fish were added to the farming system complementing the cattle that had been introduced previously.

Improving Soil Fertility

New plantings of forage trees were done as associations ("chachafruto" with "nacedero") not as single species. Areas previously in pasture were allowed to regenerate naturally. The recycling of crop and livestock wastes was intensified. Increasing amounts of leaf litter and fibrous residues became available for direct (in situ) return to the soil or for processing by earth worms.

Simplifying Farm Work

The system of fractionating sugar cane for the pigs was suspended and replaced by direct feeding of the whole sugar cane stalk to breeder pigs in free-range pasture. This had been facilitated by expansion and change of emphasis of the pig enterprise to concentrate on reproduction and sale of weaners rather than fattening. Fully grown pigs are able to chew up to 15-20 kg of cane stalk daily extracting the juice and "spitting" out the fibre. The "chewed" fibre and the pig excreta were allowed to mix naturally and later used as substrate for the earth worms.

Increasing Animal Feed Supply

This came about through the replacement of pasture by multi-purpose trees and the introduction of horticultural and forage crops into areas previously managed as monocultures (eg: the coffee and the protein banks). The increased efficiency of the recycling process was achieved by introducing water plants which in turn became sources of feed for the pigs and poultry.

Increasing the Self Reliance and Participation in Farm Activities of All Family Members

The diversification of the farming system, and the simplification of certain of the sub-systems, increased the labour demand. At the same time it created opportunities for increased participation by women and children in productive (income-generating) activities. The parallel reduction in labour demand in the nearby towns has been an important factor facilitating this process. Traditional coffee farming is highly demanding of labour but in specific seasons coinciding with the harvest of the beans. Labour was traditionally "imported" into the region to satisfy this "transient" need. In contrast, diversified farming offers steady year-round employment for all family members.

The Preliminary Results

An evaluation of inputs and outputs of this farming system on the farm belonging to Tiberio Giraldo in 1993 was made by Espinel (1994). It is not yet possible to assess the effect of the changes described in this paper as these are still in the introductory stage. Results of the recent evaluation of four of the sub-systems are summarized in Tables 1-4.

The data in Table 1 show the high yields of biomass obtained from sugar cane and associations of the two principal multi-purpose trees planted in the farm. The total areas planted with these crops are: sugar cane 2.1 ha and forage trees 0.7 ha.

Table 1: Mean annual yield of fresh biomass from plots planted with associations of trees (*Trichanthera gigantea* and *Erythrina edulis*) (sample areas was 3,500m²) or sugar cane (sample area 1,248m²). Data converted to hectares.

	Trichanthera gigantea/ Erythrina edulis	Sugar cane
Fresh foliage, mt/ha	81.9	104 (88.4+15.6)*
Dead leaves, mt/ha	13.0	14
Total biomass, mt/ha	94.9	118
Stem cuttings, No/ha	40,000	
Fractionation of sugar cane stalk, % fresh basis:		
Juice (for pigs)	45	
Syrup (family)	10	
Residual pressed cane stalk	45	

*Cane stalk + tops

Table 2: Yield of fresh biomass after 6 months regrowth from plots (3x2m) planted with associations of trees (*Trichanthera gigantea*, *Erythrina edulis* and *Morus alba*), perennial herbaceous species (*Boehmeria nivea*) and food crops (Maize, beans and pumpkin)*

	Plot 1	Plot 2	Plot 3	Plot 4
Fresh forage, kg/100m²				
T. gigantea	450	350	380	467
E. edulis	17	50	33	140
M. alba	38	-	33	-
*B. nivea***	-	463	-	450
Weeds	66	-	50	-
Maize, beans, pumpkins*				
Total (6 months)	571	863	496	1057
Annual yield, mt/ha***	114	173	99	211

*Not yet harvested **Mean for two harvests (2 month intervals) projected to 6 months
*** Projection to one year assuming similar yields in second 6 month period

The data in Table 2 indicate that it is highly beneficial, at least in terms of total production of biomass, to associate with the "chachafruto" and "nacedero" other horticultural and forage crops. The impact at the level of the livestock has still to be measured.

The fertility of the soil is one of the most important indicators of the sustainability of a farming system. Conventional ways of measuring soil fertility in chemical, physical and biological parameters are time consuming and expensive and require access to sophisticated laboratory equipment. The biological test of soil fertility (by measuring the growth over 20 days of maize planted in samples of soil from the test areas) is simple, inexpensive and quick. It gives no indication of the factors responsible for improvement or decline of soil fertility but it is an extremely useful tool for monitoring the effects of interventions in the farming system. The results from applying this technique in samples of soil taken from the principal sub-systems described in this paper are presented in Table 3.

The order in which the different sub-systems are placed can mostly be predicted on the basis of the importance of return of organic matter and of N-fixation by leguminous species. The poor rating of the "forest" sub-system indicates that the process of soil formation in tropical forests is a slow process and emphasizes the fragile and transitory nature of tropical soils; and that the maintenance and improvement of soil fertility in tropical ecosystems requires constant attention to the basic principles of soil conservation especially the role of organic matter. It is equally apparent that there need be no conflict between biomass yield and sustainability if the appropriate ecosystems are identified and promoted (eg: sugar cane and multi-purpose trees versus pasture).

The soil "bio-test" is also a useful way of showing farmers how particular crops and cropping systems influence soil fertility and provides a basis for adding an "environmental" element into traditional ways of economic assessment of farming systems.

The data in Table 4 are the production parameters for the pig herd since feeding began with whole sugar cane.

Table 3: Biological test of fertility (growth of maize plants in 21 days) of soil taken from cropping areas (0-25cm depth) (3 samples taken from each "crop" area with 4 repetitions from each sample)

	Height, cm	No of leaves
Red soil	5.56	2.35
Forest*	6.33	2.62
Pasture	6.40	2.78
Sugar cane	7.03	2.73
T gigantea	7.92	3.02
E edulis + *T gigantea*	8.49	2.91
Worm compost	9.12	3.20
SE	+/-0.28	+/-0.15
Prob	0.001	0.009

*Replanted on eroded red soil

Table 4: Pig production parameters in Cipres Farm (Oct 95- Sep 96)

Breeding performance:	
Total number of services	29
Number repeat services	4
Percent repeat services	14
Farrowing performance:	
Number of farrowings	21
Average pigs born alive per litter	10.1
Average birth weight, kg	1.2
Farrowing interval, days	176
Weaning performance:	
Number of litters weaned	19
Pig weaned per litter	8.2
Pre-weaning mortality	20.4
Average weaning weight, kg	7.3
Average age at weaning, days	51.3

Table 4. (Continued).

Population:	
Average female inventory	12
Feeding of sows:	
Feed per sow, kg/day (fresh basis)	
Sugar cane stalks	10
Soybeans	0.4
Foliage	2
By-products	0.3

Reference

Espinel, R. 1994. Sociedad y economia de campesinos cafeteros de la cordillera Occidental en el Norte del Valle del Cauca. Factores que inciden el la construccion de Sistemas Agrarios. Tesis de grado en Maestra en Desarrollo Sostenible de sistemas Agrarios. Universidad Javeriana-IMCA-CIPAV

Soya Bean Forage as a Source of Protein for Livestock in Cuba

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Abstract
The use of milk-stage soya bean forage as a source of protein for livestock production in Cuba is still in its infancy, and perhaps, the fact that the only performance data in this entire report refers to the average weaning weight of seven, 40-day-old piglets, as 8.8 kg, definitely supports this observation. The sow s diet consisted of sugarcane juice and soy forage, and the piglets, in addition to nursing, had access to the same feeds. Presently, in more than 100 sugarcane-sector farms or coops, green soya beans are being used as a source of protein for livestock. In Cuba, 156 sugar mills and 1300 cane coops employ nearly half a million workers, and all have to be fed. Since 1983, the cane-sector, the sector responsible for cultivating one-third of total arable land on the island, has endeavoured to produce all its agricultural-based food needs and has promoted livestock production. For this, a total of 95 thousand hectares are used to produce rice, beans, tubercles and fresh vegetables, as well as some animal feeds. The development of sustainable agronomic systems has been promoted; mostly, because all available machinery, fertilizers, insecticides, herbicides and petroleum have been prioritized for the production of sugarcane.

The use of milk-stage, soya bean forage as a protein source for livestock rather than imported soya bean meal or the whole bean, presently used mostly to produce yogurt for distribution to children, is an attempt to accommodate the new, tropics-oriented, zero-grain, livestock production system (Preston and Murgueitio, 1992) to the present agronomic and/or economic reality of the sugarcane-sector state farms and coops in Cuba.

KEY WORDS: Protein source, soya bean forage, soya bean hay, green soya, feed, pig

Introduction

Since 1983, the cane-sector, has endeavoured to produce its basic food needs and has promoted livestock production for its half-million workers and their families. For this, a total of 95 thousand hectares in 156 sugar mills is used to produce rice, beans, tubercles and fresh vegetables, as well as some animal feeds. In 1989, the sugar mills attempted to plant, for the first time, 5 thousand hectares of soya beans, for seed, in rotation with cane; it was a failure. Soon after, in 1993, the sugar mill cane plantations were reorganized into approximately 1300 cane cooperatives and most of the livestock belonging to the sugar mills, particularly the reproductive herds of pigs, rabbits and sheep, and the oxen, were given to the co-ops. All of a sudden, the co-ops found themselves, with animals to feed, sugarcane and some molasses as sources of energy, but zero protein feed resources.

Soya beans, until 1940, were used in the United States as forage, green manure, silage, and hay for horses; in fact, it was not until 1940, that production of soya beans for beans surpassed their production for hay. Recently, in Cuba, it was thought that the same plant, if fed green, while still in the milk-stage, prior to the presence of the anti-trypsin factor encountered in the seed, might serve as a source of protein for pigs. It worked, the idea spread (Perez 1995; 1996, and presently, in more than 150 cane co-ops and sugar mill farms, soya bean forage is used as the single-most important source of protein for many kinds of livestock. The system is developing at a very fast pace because it is sustainable and "farmer-friendly" and, following initial planting, within 8 or 9 weeks before the forage has had time to become insect or disease ridden, it is ready to harvest and feed. In addition, the input is very low: seeds, inoculant, water and care.

Zero-grain Livestock Production System

When grains are used for livestock, approximately one-half of the requirement for protein is met by the cereal component; however, in the case of "zero-grain" production systems in which the energy and protein components are offered separately (Table 1), due to the invariable low level of protein in the basal diet, almost all the requirements for amino acids must be supplied by the supplement (Preston 1995). In the case of the cane co-ops and sugar mill farms, they produce different energy sources, such as: sugarcane, cassava, sweet potato and bananas, but insufficient protein feed resources.

Table 1. Zero-grain pig feeding systems (20-90 kg) *

System**	Energy DM, %	ADG (g)	DM Conversion	Source
Fresh cassava	60-70	650-790	2.80-3.00	Maner *et al.*, (1977)
Cooked sweet potato	73	770	3.50-3.80	Dominguez *et al.*, (1991)
Ripe bananas	66-71	560-570	4.50-4.60	Solis *et al.*, (1985)
Palm press fiber	78	500-550	4.50-5.00	Ocampo *et al.*, (1990b)
Sugar palm juice	80	500	-	Preston (1995)
Sugar cane juice	80	650-700	3.50-4.00	Sarria *et al.*, (1990)
B molasses	70	500-550	4.00-4.50	Cervantes *et al.*, (1984)
C molasses	70	400-450	5.00-5.50	"

* current NRC (1988) performance guidelines for pigs, 50-110 kg, fed 80% maize & 20% soya bean meal: 820 g ADG and 3.40 DM conversion; **under normal farm conditions reduce performance by 10-15%

A further consideration related to the "zero-grain" feeding system is that, a fast growth rate, per se, one which would invariably involve feeding a biological optimum supply of dietary protein, is not necessarily the most profitable. For example, for pigs from 25-90 kg, "zero-grain" can perhaps best be summarized in terms of 500 g/day of protein supplement, approximately 200 g/day protein (Preston 1995).

An attempt to accommodate "the role of monogastric animal species in the sustainable use of tropical feed resources" (Ly 1993), by providing them locally-produced protein in the form of soya bean forage, is the subject of this preliminary report.

Soya Bean Forage Production System

The present production system involves planting one, 7-row plot of soya beans, weekly. Nine weeks later, 63 days, one row of soya bean forage is harvested daily, from Monday to Sunday (Perez and Ochoa 1996). This means that the first-harvested row of forage will be 63-days old on Monday, whereas the following Sunday, the last row of that same plot will be 70 days old, still presumably in the early milk-stage, not yet in full expression of the trypsin inhibitor. This means that the forage can be used directly for pigs, ducks and rabbits, even chickens. The protease inhibitors, first present in the formed seed, apparently play an important role as defense agents against insect attack or micro-organism infections and would explain the need to boil the whole seed for 20 minutes prior to feeding monogastrics (EMBRAPA-CNPSA 1994). However, there appears to be very little known about this factor in the whole soya bean plant.

Depending on the time of year, and variety, temperature, humidity, irrigation and inoculation, the entire system may vary from between 49-56 to 63-70 days. Excess or older forage could be sun-dried, perhaps in a manner similar to tobacco, and used as hay for rabbits or ruminants, or perhaps even ground and heat-treated (boiled), and used as whole soya bean plant meal. In this regard, the seed or bean is 50% of total biomass.

Planting

The recommended distance between rows for forage is 35 cm, as opposed to 70 cm, when planted for seed. Each plot will be approximately 2.5 m wide. By planting 20 seeds per meter at a depth of 2 cm and with 75% germination, the yield should be about 15 plants per meter, the current recommendation for one pig, daily. After completing the harvest of the last row on Sunday, the same plot is replanted the following week. In this manner, by replanting the same plot up to 6 times per year, a significant amount of forage can be produced in small area, and often adjacent to the enclosed animals.

In Vietnam, where soya beans have been planted in order to take advantage of 55 growing days between harvesting and planting the next rice crop, and ensiled, a total of 8.1 t/ha of soy forage was produced, the equivalent of 360 kg of protein or the same quantity that would have been obtained from one hectare of soya beans harvested as seed. Furthermore, the feed cost per kilogram of gain decreased by 24% in an experimental group of pigs that obtained 30% of their protein needs from the ensiled soya bean forage. (Chinh *et al.*, 1993). In Cuba, under commercial conditions, and a 75-day growing period, non-inoculated seeds produced a yield of 24 t/ha of forage compared to 46 t/ha, or practically double, when the seeds were inoculated (López and Frias 1986).

Inoculation of Soya Beans

The following refers to one plot of 7 rows, each row 50-meters long. Each 50 meter row should produce sufficient forage, daily, for about: 20 pigs, 40-50 rabbits and ducks, and part of the forage needs for 8-10 milking cows. Each plot will require approximately one kilogram of seeds, because: 1 m = 20 seeds; 1 g seeds = 5-8 seeds; 1 m = 3 g seeds; 50 m = 150 g seeds; and 7 rows = 1050 g seeds. To inoculate one kilogram of seeds:

1. Dissolve one teaspoon (2 g) of sugar in two tablespoons (20 g) of water or use diluted molasses or fresh cane juice.
2. Add one tablespoon (10 g) of inoculant and combine thoroughly.
3. Add this mixture to 1 kg of soya beans, mix thoroughly, place in the shade to dry.
4. Plant seeds as soon as possible, prevent contact with the sun.

Irrigation

Most of the farmers questioned agreed that for best results all plots require a weekly irrigation. Many methods are available, but perhaps, one of the simplest systems observed was to place a 55-gallon drum at the end of each plot, fill with water, and using a pail, apply one condensed-milk can full of water, at the base of every plant, every week!

Harvesting and Chemical Analysis

Harvesting is done by hand and, if the seeds were inoculated prior to sowing, the forage should preferably be cut in order to leave the roots with adhering nodules in the soil. The following information (Table 2) was obtained using milk-stage soy forage (INIFAT V-9) grown on non-fertilized, garden-leached soil in Havana. Even though the crude protein level of the forage was low, the in vitro ileal digestibility of nitrogen was 67%, which compares favorably to the average digestibility of this nutrient in soya bean meal, 75%, and to the average digestibility of nitrogen in most forages, reportedly, of between 35 and 40 percent.

Table 2. Proximal analysis and essential amino acid composition of the aerial part of soya bean plant*

Proximal components	% DM	Essential amino acids	% DM
Ash	9.97	Arginine	0.46
Calcium	1.38	Cystine	0.17
Phosphorus	0.51	Isoleucine	0.43
Crude fat	4.75	Leucine	0.72
Crude fibre	34.23	Lysine	0.44
Crude protein	12.62**	Methionine	0.13
		Threonine	0.34
		Valine	0.57

IIP (1995); * non-inoculated seeds; ** in vitro ileal digestibility, 67%; The dry matter (DM) was 29.4% and Mj/kg DM was 16.65.

Soya Bean Forage for Livestock: Guidelines

The use of soy forage for livestock is too recent to publish guidelines, hopefully, this communication will help remedy that situation. In fact, the only performance data for this entire report was the 8.8 kg average weaning weight of seven, 40-day-old piglets, from a sow fed free-choice sugarcane juice and soy forage in a sugar mill pig farm in central Cuba. The piglets received no additional feed but had access to the sow, and naturally, some of the same ration.

PIGS: feed twice-daily soya bean forage, approximately one meter/pig/day, and a free-choice source of energy: sugarcane juice, diluted molasses, cassava or ripened bananas. Change diets over a one week period, approximately. In several provinces, the present idea is to set up small pig fattening units directly in the banana plantations, adjacent to the weighing/grading stations, and completely enclose one pig pen to use it as a banana ripening room. The protein will be planted alongside: soya bean forage.

RABBITS: growers and fatteners can be fed exclusively on free-choice soy forage, however, for good teeth maintenance in the reproductive herd, in addition to soy forage, sugarcane stalks are sometimes offered. One meter of soy forage, depending on the quality, should be enough for 4 to 5 growing rabbits, daily. One sugar mill farm reported cutting 0.8 t daily for a total of 527 rabbits or about 1.5 kg/rabbit/day. The leftover lower stems were fed to ruminants.

DUCKS: after starting ducks on concentrates or green-feed, described for chickens, they can be fattened using a free-choice energy source, cane juice or diluted molasses, and fresh, whole soya bean plants. Once accustomed to soy forage, they will devour the leaves and most of the stem. The lower stem can be collected for feeding pigs or ruminants.

LAYING HENS: cassava and soy forage, in a 50:50 ratio, ground together, is being promoted as "green-feed" for layers.

COWS: soy forage is being promoted for milk cows until the co-ops and sugar mills produce sufficient forage from protein trees. Depending on the quantity and quality of the other feed resources, the present recommended amount is one meter per cow per day.

Conclusions: Concerns and Problems

The author has been re-called to sugar mills, where the use of soy forage, formerly promoted, was questioned, because the younger pigs, 25-50 kg, were not growing as fast as previously. The answer appeared to be in the age of the forage, more than 70-80 days, and definitely, with some pods showing near full-size green beans. There appears to be a "point of no return", that is, a precise moment at which time "something" drastic happens, that "something" possibly meaning the appearance in the bean of the trypsin inhibitor, and its subsequent effect on effective protein digestion. This, hopefully, will constitute a key area of research, along with determining, for the tropics, the preferred forage varieties for the wet and dry seasons. Interestingly, it has already been suggested, that the "inhibitor" problem could be avoided by using a strain of soya beans, the Kunitz strain, that does not produce the major inhibitor (e-mail/G. Seidel /14/08/96).

In conclusion, certain aspects are already obvious: 1) that, for the low-income farmer that cannot obtain soya bean meal, soy forage is an interesting and local alternative as a source of protein, and fatty acids, since it does contain almost 5% crude fat (Table 2); 2) that, this technology requires only 60-70 days, approximately half the time required to produce the dry bean; 3) that, because it requires a shorter growing period, there is less probability for insect and disease attack; 4) that, soy for forage, if inoculated, and planted 15 days after planting first crop irrigated cane, could improve cane yields by up to 19% (Perez *et al.*, 1992), and finally, 5) reportedly, for some legume forages, more protein per hectare is obtained when the forage is harvested in the milk stage (Oyawoye *et al.*, 1990).

References

Cervantes A, Maylin A and Ly J 1984 Utilizacion de distintos tipos de mieles de cana suplementadas con levadura torula en crema para cerdos en ceba. Cien Tec Agric Ganado Porcino 7(1):21-36

Chinh B V, Tao N H and Minh D V 1993 Growing and ensiling soya bean forage between rice crops as a protein supplement for pigs in North Vietnam. Livest Res Rur Devel 5(1):6-11

Dominguez P L, Cervantes A, Mederos C M, Frometa M and Castellanos M 1991 Uso del tuberculo y la parte aerea del boniato (Ipomoea batatas (L) Lam) en la alimentacion de los cerdos en ceba. Resúmenes IV Congreso ALVEC La Habana Cuba NA-6

EMBRAPA-CNPSA 1994 Tropical Soya bean Improvement and production. FAO/Rome pp 254

IIP (Instituto Investigaciones Porcina) 1995. Informe interno.

Lopez M and Frias R 1986. Inoculacion de la soya para granos y forrajes en áreas comerciales. Memoria X Reunion ALPA Acapulco Mexico

Ly J 1993 The Role of Monogastric Animal Species in the Sustainable Use of Tropical Feed Resources. World Conference on Animal Production Edmonton Canada p 95-117

Maner, J H, Buitrago J, Portela R and Jimenez I 1977 La yuca en la alimentacion de cerdos. Bogotá, ICA pp 116

NRC 1988 Nutrient Requeriment of Domestic Animales. Nutrient Requirement of Swine 9th revised ed. National Academy Press Washington

Ocampo A, Castro C and Alfonso L 1990b Determination del nivel optimo de proteina al utilizar cachaza de palma africana como fuente de energia en raciones para cerdos de engorde. Livest Res Rur Dev 2(2):67-76

Oyawoye E O, Oyikin M E and Shehu Y 1990 Studies in the nutrition of rabbits. 1. Chemical evaluation of some tropical legumes as replacements for alfalfa in rabbit diets. J Appl Rabbit Res 13:32-34

Perez R 1995 CARTA AGROPECUARIA AZUCARERA No. 95.5: El forrage verde del frijol de soya como fuente proteica. Minaz La Habana

Perez R 1996 Tecnicas agropecuarias para los asentamientos ecologicos del Minaz Ministerio del Azucar La Habana pp 71

Perez R y Ochoa J 1996 La soya forrajera como fuente proteica. Livest Res Rur Dev (en imprenta)

Perez L, Crespo R, Creach I and Berra E 1992 Rotacion e intercalamiento de cultivos en plantaciones caneras. IV Jornada Cientifica INICA La Habana

Preston T R 1995 Tropical animal feeding: a manual for research workers. FAO Animal Production and Health Paper FAO Rome pp 305

Sarria P, Solano A and Preston T R 1990 Utilizacion de jugo de cana y cachaza panelera en la alimentacion de cerdos. Livest Res Rur Dev. 2(2):92-100

Solis J, Campabadal C and Ledezma R 1985 Evaluacion de diferentes formas de suplir el banano en la alimentacion de cerdos durante la etapa de crecimiento y engorde. Resumenes X Reunion ALPA. Acapulco Mexico p 40

New Research and Development Strategy for a Better Integration of Pig Production in the Farming System in Cuba

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Abstract
In Cuba, emphasis has been placed on a research and development strategy for pig production based on unconventional feeds. The collection of processed food waste from institutions (hospitals, schools and hotels), slaughter-houses, fish-processing plants and agriculture is systematically carried out. The total DM digestibility (77%) and precaecal digestibility (69%) of processed waste in pigs are slightly lower than those of cereals. However, for growing/ finishing pigs, processed waste can be used to substitute up to 50% of the dry matter of cereals with no effect on feed conversion. For pigs from 25 to 90 kg, a diet of 37% organic wastes, 33% sugarcane molasses and 30% concentrates gave acceptable results (ADG: 620 to 710 g/d; and feed conversion: 4.50 to 4.14) and the nutrient balance can be further improved by mineral-vitamin and essential amino-acid supplementation (live weight gains may be increased by more than 100 g/d).

Systems for the preservation of animal slaughter and fish processing wastes, based on the use of inorganic acids or molasses, have been designed to produce protein paste. Protein digestibility is similar to that of soya bean meal and superior to that of meat meal and torula yeast, while N retention was higher than in other protein sources studied. When protein paste contributed some 26.5% of dietary protein, the results (ADG: 780 g/d; Feed conversion: 2.95) were satisfactory. However, when the level was increased to more than 50% of the protein in the diet,

a decrease in average daily gain of pigs was observed (ADG: 700 g/d; Feed conversion: 3.33).

Fish silage has been preserved with 30 ml/kg of sulphuric acid solution and could be satisfactorily used to supply up to 50 percent of the protein in this type of diet. A mixture of 10 per cent molasses and 10 per cent wheat bran, with 80 per cent ground inland fish, placed in a polyethylene bag with a water seal in order to obtain anaerobic conditions, has also been used. The pH was 3.9 with no pathogenic microorganisms in the fish silage. Animal performance was better (ADG: 740 g/d; FC: 2,94 versus 670g/d and 3.46) when fish silage replaced 40 per cent of the soya bean meal in a molasses diet.

Cooked and mashed sweet potato has been used to totally replace maize for fattening pigs with a supplement of soya bean meal (ADG: 770 g/d and FC: 3.51 versus 770 g/d and 3.01). Substituting 0, 25 and 50% of soya bean meal with fresh foliage as the protein source in a sweet potato-soya bean diet showed that the high level of foliage worsened performance (ADG: 770, 690 and 640 g/d; FC: 3.51, 3.55 and 3.81 respectively).

Citrus pulp silage can replace up to 40% of final molasses with better feed conversion (4.08 versus 4.54) and similar live weight gain (600 versus 680 g/d).

Finally, the recycling of piggery waste is used for the production of biogas and the effluent from biodigesters is used to fertilize duckweed (Lemna) which can replace 20 percent of soya bean meal in a diet of sugarcane molasses with no adverse effects on pig performance (ADG: 630 v/s 640 g/d and FC: 4.58 v/s 4.57) .

KEY WORDS: Pig feeding; unconventional feeds; processed food wastes; animal wastes; fish wastes; sweet potato; citrus pulp; duckweed

Introduction

Cuba does not have the climatic conditions or technical development which allow production of valuable cereal crops and protein sources nor the necessary foreign currency to import conventional feedstuffs to support intensive pig production.

In Cuba, emphasis is placed on a research and development strategy for pig production based on unconventional feeding, such as: the recycling of wastes and by-products from restaurants and canteens and from agricultural and industrial activities; and the development of an animal feeding strategy based on perennial tropical crops with a high efficiency of energy yield per unit area, such as sugarcane, bananas and plantains and sweet potato. These systems have been applied to large and medium-sized pig farms. The recycling of excreta, with the production of energy (biogas), fertilizer (humus) and feed (aquatic plants and earthworm biomass), is another component of a sustainable farming system. In addition, the use of wastes and by-products and the recycling of excreta also offers the possibility of reducing environmental pollution.

Processed Food Waste

Wastes or by-products from institutions (hospitals, schools and hotels), slaughter-houses, fish-processing plants and agriculture have been used for pig feeding in Cuba for many years.

The collection of these materials is systematically carried out by tanker trucks following established routes throughout the country. The wastes are sent to industrial plants designed specifically for transforming them into feed for pigs (Del Rio *et al.*, 1980), without sanitary risks. In these plants, the wastes are submitted to selection, grinding, sterilization and mixing with sugarcane molasses, before being conveyed by pipelines to pig fattening units adjacent to the processing plant. Recently, Cuban engineers have designed and developed an autoclave (130 deg C and 2 atmospheres pressure) with mechanical agitation which adequately processes not only kitchen and vegetable wastes but also wastes from slaughter- houses and even dead animals. The advantage of this system compared to dehydration is the savings in fuel oil and the lower investment cost of the equipment.

Analysis of this processed waste shows that it offers a considerable potential as an alternative feed resource for pigs in the tropics. It contains from 14-19% dry matter, 8-16% ash, 18-22% crude protein, 6-12% crude fiber, 6-10% ether extract and a gross energy of 16 to 19 MJ/kg DM (Dominguez, 1985). Processed waste varied in composition and this variation was dependent mainly on the source of the waste material. It differed from conventional swine feeds in its low dry matter content and its relatively high crude protein.

The digestive utilization of the main nutrients of processed swill is slightly lower when compared to cereals (Table 1). Nevertheless, the total and precaecal digestive coefficient of nitrogen and energy, the nitrogen retention and the digestible energy may be considered acceptable and show that processed swill is an important alternative feed resource for pigs.

Table 1. Total and precaecal digestibility in pigs of processed waste.

	Precaecal	Total
Digestibility,%		
Dry matter	68,9	77,1
Nitrogen	65,2	76,0
DE, MJ/kg DM	13,0	14,6
ME, MJ/kg DM	-	13,9
Nitrogen retention, g/day	15,3	16,4

Source: Dominguez *et al.* (1987)

It has been shown (Gonzalez *et al.*, 1984) that for growing/ finishing pigs, processed waste can be used to substitute up to 50% of the dry matter of cereals; there was no effect on feed conversion. However the low dry matter content of processed wastes tends to affect growth due to a reduction in total dry matter intake. Water per se is not believed to reduce efficiency of utilization of the ration components; it does, however, limit consumption when present in excessive amounts in the ration. When processed waste is used as the only source of feed, and the water content is very high (for instance, 80-84%) pigs are forced to consume large quantities of water in the feed, thus limiting the total daily consumption of nutrients. The high water content of processed waste is the most serious problem for young growing pigs up to 50 kg because of the limited capacity of their gastro- intestinal tract. As the pig develops in size, the greater gut capacity tends to minimize the importance of diet concentration. Nevertheless, the use of a dry meal supplement would not appear to be necessary in a processed waste feeding system for pigs when high quality and high dry matter content are available in the processed waste (Table 2).

Table 2. Use of processed waste in growing finishing pigs.

Balanced cereals	100	40	20	-
Processed waste	-	60	80	100
Intake, kg DM/day	2,40	2,21	2,09	1,98
Daily gain, kg	0,86	0,82	0,81	0,75
Feed conversion, kg DM/kg	2,85	2,69	2,59	2,65

Source: Grande *et al.* (1995)

In spite of the variability in the chemical composition of the waste products, the experience in Cuba has been of a relatively stable concentration of dry matter and crude protein in the feed. It has allowed the study of the mixture of processed waste products with other feedstuffs, with the aim of widening the volume of processed waste and increasing the level of dry matter of the diet for pig fattening. Since a great volume of sugarcane molasses is available, it is a common practice in Cuba to mix the processed waste with sugarcane molasses in the plants, at about 10% of the volume of fresh feed produced. The mixture with molasses increases the dry matter of the processed waste by up to 25%, depending on the proportion in the mixture. However, since the sugarcane molasses is essentially a source of carbohydrates, it thus decreases the level of crude protein and energy density of the feed on a

DM basis, and this resulted in poorer feed conversion (Dominguez, 1985). The immediate solution was to add a dry cereal concentrate or a protein source to the mixture. Therefore, the major commercial feeding system used in the last 20 years in Cuba for pigs from 25 to 90 kg consisted of 37% organic wastes, 33% sugarcane molasses and 30% concentrates.

Table 3 shows the results that can be obtained with different mixture of processed wastes which are acceptable in these diets, taking into consideration that the nutrient balance can be improved with adequate mineral-vitamin and essential amino-acid supplementation.

Table 3. Performance of pigs fed different mixtures of processed waste.

	------- per cent of diet --------		
Processed wastes	-	27,8	39,4
Final molasses	-	34,6	49,3
Torula yeast	-	7,9	11,3
Balanced cereals	100	29,7	-
Intake, kg DM/day	2,47	2,92	2,78
Daily gain, kg	0,72	0,71	0,62
Feed conversion kg, DM/kg	3,38	4,14	4,50

Source: Dominguez and Cervantes (1978)

An aspect to take into consideration in these kinds of diets is that the increasing level of final molasses in the ration results in a linear increase in feed conversion without giving any improvement in daily weight gain (Dominguez 1985). These results have led towards studies on the substitution of final molasses by other intermediate or enriched molasses from the sugar industry (Dominguez, 1990), with better results than those obtained with the mixture of final molasses and further justified by differences in the energy density in the molasses.

Nevertheless, Dominguez *et al.* (1988) have reported that, when these foodstuffs are suitably supplemented with minerals (including copper sulphate), vitamins and methionine, live weight gains were increased by more than 100 g daily, irrespective of the type of molasses used (Table 4) and animal behaviour problems with diets of processed waste and final or B molasses decreased notably.

Table 4. Performance of pigs fed processed waste, cereal concentrate and final or B molasses, with or without additives.

	Molasses/Additives			
	Final No	B No	Final Yes	B Yes
Intake, kg DM/day	2,47	2,52	2,71	2,75
Daily gain, kg	0,53	0,62	0,68	0,71
Feed conversion, kg DM/kg	4,78	4,07	4,01	3,89

Source: Dominguez *et al.* (1988)

In fact, the regression analysis of daily gain on the consumption of these types of diets, either supplemented or not, demonstrates that, independently of the level of consumption of the supplement, these diets guarantee between 100 and 150 g more daily gain (Dominguez 1990).

The supplementation of these diets is more important than the kind of molasses used. On the other hand, when molasses are not used at levels higher than 30% of the ration on a dry matter basis, characteristics of behaviour are very similar between processed waste and different sugarcane molasses diets (Table 5).

Table 5. Performance of pigs fed processed waste and different types of molasses.

	Corn	Processed waste + torula yeast		
	Torula yeast	Molasses C	Molasses B	Enriched molasses
Intake, kg DM/day	2,56	2,74	2,61	2,57
Daily gain, kg	0,78	0,74	0,77	0,77
Feed conversion, kg DM/kg gain	3,29	3,67	3,37	3,31

Source: Perez *et al.*(1991)

Slaughterhouse Waste And Dead Animals

The industrialization of animal slaughtering and fish processing for human consumption produces large amounts of wastes that can be used for animal feeding. With regard to the situation in Cuba, processing lines have been designed for these wastes which provide a final product or paste with a high protein content (protein paste).

Systems for the preservation of products for various lengths of time, based on the use of inorganic acids or sugarcane molasses, have been designed. In this connection, the nutritive value of protein paste preserved with inorganic acids has been evaluated by including it as the sole protein source in molasses diets and compared to protein sources of well-known biological value such as soya bean meal, torula yeast and meat meal (Dominguez 1991). Protein digestibility data have revealed it to be similar to that of soya bean meal and superior to that of meat meal and torula yeast, while N retention was higher than in other protein sources studied.

The results with fattening pigs fed protein paste preserved with sugarcane molasses were satisfactory when protein paste contributed some 26.5% of dietary protein. However, when the level of protein paste was increased to more than 50% of the protein in the diet, a decrease in average daily gain of pigs was observed (Table 6). Initially, all this implies the possibility of transforming these organic wastes (which are serious pollutants) into protein sources with a high biological value for pigs.

Table 6. Performance of pigs fed protein paste in cooked sweet potatoes diet.

% crude protein from:			
Torula yeast	62,9	40,9	19,1
Protein paste	-	26,5	52,8
Intake, kg DM/day	2,36	2,30	2,33
Daily gain, kg	0,78	0,78	0,70
Feed conversion, kgDM/kg	3,03	2,95	3,33

Source: Dominguez (1991)

Fish Silage

In a Cuban method for the preparation of fish silage, Alvarez (l972) used a solution of sulphuric acid and water (1:1 by volume) at a rate of 60 ml of acid solution per kg of fresh fish waste. The mixture of fish waste and acid solution was stored in closed plastic tanks and stirred for three minutes, three times a day, for a period of five days. The pH lowered to 1.8, and bacterial putrefaction was avoided, thus allowing the silage to be stored for several months. Cervantes (1979) showed that, if ground fish waste was to be used, it could be preserved by using only 30 ml of acid solution per kg.

Table 7 shows the results of using acid fish waste silage preserved with 30 ml/kg of sulphuric acid solution. The fish silage substituted for fish meal in a diet based on processed swill and final molasses for growing-finishing pigs (Cervantes, 1979). Performance was lower when all the fish meal was replaced by silage and it was concluded that the acid fish silage could be used up to 50 percent of the protein supplied in this type of diet.

Table 7. Substitution of fish meal for acid fish silage in diets based on processed waste.

	Substitution of fish meal, %			
	0	25	50	100
Intake, kg DM/day	2,1	2,1	2,1	1,9
Daily gain, kg	0,54	0,55	0,54	0,44
Feed conversion, kg DM/kg	4,10	4,00	4,00	4,40

Source: Cervantes (1979)

In the case of biological fish silage, some results of pig feeding are presented in Table 8. The silage was prepared using a mixture of 10 per cent of molasses and 10 per cent of wheat bran, with 80 per cent of ground inland fish (mixture of common carp, silver carp, bighead carp and Tilapia sp.) placed in a polyethylene bag with a water seal in order to obtain anaerobic conditions. After three months, the pH was 3.9 with no pathogenic microorganisms in the fish silage. Animal performance was better when fish silage replaced 40 per cent of the soya bean meal in a molasses diet.

Table 8. Use of biological silage as protein replace of soya bean meal in molasses diet.

	Level of soya bean meal substitution, %		
	0	20	40
Intake, kg DM/day	2,07	2,31	2,17
Daily gain, kg	0,63	0,67	0,74
Feed conversion, kgDM/kg	3,34	3,46	2,94

Source: Delgado and Dominguez (1996)

Sweet Potatoes

The starchy roots and tubers harvested in many tropical areas are an important energy source in human and animal feeding. Traditionally, sweet potatoes have been cultivated in tropical countries of Latin America and the Caribbean almost exclusively for tuber production to be used as a staple food, while its foliage has always been considered as a residue. The productive potential of certain varieties of sweet potatoes can reach from 24 to 36 t/ha/crop of roots (Morales, 1980) and the foliage production can vary from 4.3 to 6.0 t dry matter/ha (Ruiz *et al.*, 1980).

The chemical composition of sweet potato roots shows a low protein, fat and fibre content, but high nitrogen free extractives, thus indicating their potential value, mainly as an energy source. Vines are higher in fibre and protein and their principal value is as a source of vitamins and protein. On the other hand, the cooking of sweet potatoes is necessary for two reasons, improvement of starch digestibility and neutralization of trypsin inhibitors.

Taking into account that, in Cuba, intensive and specialized pig production uses liquid feeds for fattening pigs, most of the Cuban experience is with cooked sweet potato tubers offered mashed to pigs (18-20% DM).

Table 9. Utilization of differents sources of protein for pigs fed cooked sweet potato.

	Corn soya bean meal	Sweet potatoes soya bean meal	Sweet potatoes torula yeast
Intake, kg DM/day	2,30	2,71	2,36
Daily gain, kg	0,77	0,77	0,78
Feed conversion, kg DM/kg gain	3,01	3,51	3,03

Source: Dominguez (1992)

Table 9 shows the performance of pigs fed on cooked sweet potato diets compared with a maize/soya bean diet (Dominguez, 1992). These results provide evidence that cooked and mashed sweet potato can totally replace maize for fattening pigs if adequate protein supplementation is given.

The results of partially substituting 25 and 50% of soya bean meal by fresh foliage as the protein source in a sweet potato- soya bean diet show that the high level of foliage worsened some performance traits (Table 10).

Table 10. Sweet potato foliage as a source of protein for pigs fed the tuber.

	Level of soya bean meal substitution, %		
	0	25	50
Intake, kg DM/day	2,71	2,46	2,46
Daily gain, kg	0,77	0,69	0,64
Feed conversion, kg DM/kg	3,51	3,55	3,81

Source: Dominguez (1992)

Citrus Silage

The cannery residue produced by the citrus fruit juice industry is traditionally the raw material for the production of dried citrus pulp. This residue consists of the peel, pulp and seeds of oranges after juice extraction. The pulp thus produced contains a fairly large quantity of highly digestible fibre and nitrogen free extractives.

The silage of citrus pulp has advantages over traditional drying methods because less energy is used and there are improvements in the palatability of the product (Dominguez, 1991). On the other hand, citrus pulp silage can replace final molasses with better feed conversion and the same liveweight gain (Table 11).

Table 11.Performance of pigs fed citrus silage as a replacement for final molasses in processed waste diets.

Citrus silage,%	0.0	12.0	25.0	40.0
Final molasses,%	49.3	37.3	24.3	9.3
Intake, kg DM/day	2,8	2,9	2,6	2,5
Daily gain, kg	0,68	0,62	0,59	0,60
Feed conversion, kg DM/kg	4,54	4,64	4,37	4,08

Source: Dominguez and Cervantes (1980)

Recycling of Piggery Wastes

The modern method of raising animals in confinement has resulted in daily production of large quantities of manure which, when aggravated by a high ambient temperature, serves as the breeding place for flies that spread disease.

The biogas process is an improved anaerobic treatment for animal manure and it is possible to obtain from 80 to 89 per cent recovery of the total solids in the waste (Chao *et al.*, 1996). The solid waste resulting from the biogas process can be turned into useful compost by earthworms. This resulting compost possess a good structure and reasonable quantities of plant nutrients (Garcia *et al.*, 1996).

The liquid effluent from the biodigester can be used to fertilize duckweed or other floating macrophytes in ponds. Some results of feeding fresh duckweed to pigs are presented in Table 12. Duckweed can replace 20 percent of soya bean meal in a diet of sugarcane molasses with no adverse effects on pig performance.

Table 12. Performance of pigs fed fresh duckweed (Lemna spp.) in final molasses diets.

	Level of requirement, %		
Soya bean meal	100	80	80
Fresh lemna	-	20	-
Intake, kg DM/day	2,89	2,89	2,80
Daily gain, kg	0,64	0,63	0,56
Feed conversion, kg DM/kg	4,57	4,58	5,98

Dominguez and Molinet (1996)

Bibliography

Alvarez, R.J. 1972. Estudio comparativo del valor nutricional de la proteina del ensilaje de pescado. Rev. Cubana Cienc. Agric. 6:231.

Cervantes, 1979. Ensilaje y harina de pescado en la ceba de cerdos. Informe de Tema. Ministerio de la Agricultura, Ciudad de La Habana 75 p.

Chao, R, M. Leal, J. del Rio y A. Pineda, 1996. Produccion de biogas a partir de residuales porcinos. Memorias Porcicultura 96. 5to. Congreso de la OIP. La Habana.

Del Rio, J., A. Pineda y R. Chao, 1980. Criterio tecnologico en el diseno de nuevas plantas procesadoras de desperdicios alimenticios. Cienc. Tec. Agric. Ganado Porcino 3(2): 35.

Delgado, E. y P.L. Dominguez, 1996. Elaboracion de ensilaje de pescado y evaluacion de su uso en dietas para cerdos en crecimiento. Memorias Porcicultura 96. 5to. Congreso de la OIP, La Habana.

Dominguez, P.L. 1985. Busqueda y optimizacion de fuentes nacionales que posibiliten el incremento del volumen de desperdicios y subproductos alimenticios disponibles. Informe de Tema. Instituto de Investigaciones Porcinas, La Habana, 29 p.

Dominguez, P.L. 1990. Sistema de alimentacion porcina con desperdicios procesados y otros subproductos agroindustriales. En: Taller Regional sobre "Utilizacion de los recursos alimenticios en la produccion porcina en America Latina y el Caribe" FAO. Roma, Instituto de Investigaciones Porcinas, La Habana.

Dominguez, P.L. 1991. Sistemas de alimentacion de cerdos con desperdicios alimenticios procesados y otros subproductos industriales. Serie de Trabajo y Conferencia No. 1, CIPAV, Cali-Colombia, 41 p.

Dominguez, P.L. 1992. Feeding of sweet potato products to monogastric animals. In Proceedings of the FAO expert consultation on roots, tubers, plantains and bananas in animal feeding, Cali,Colombia. Animal Production and Health Paper No 95, pp 217-233. FAO, Rome.

Dominguez, P.L. y A. Cervantes, 1978. Uso de los desperdicios procesados suplementados con miel final, cereales y levadura torula en la ceba de cerdos. Cienc. Tec. Agric. Ganado Porcino 1(4): 39.

Dominguez, P.L., A. Perez y A. Maylin, 1987. Total and prececal digestibility of processed swill. IV Int. Sem. Physiol Digestion in the Pig (Abstr) Warzaw.

Dominguez, P.L., L. Blanco, J. Gonzalez and A. Perez. 1988. The use of typical cuban diets based on swill and cane molasses for growing-finishing pigs. Proceeding of the VI World. Conference on Animal Production Helsinki p. 316 (Abstract)

Dominguez, P.L. y A. Cervantes, 1980. Ensilaje de citricos en la ceba de cerdos. Rasgos de comportamiento y canal. Cienc. Tec. Agric. Ganado Porcino 3(1) 77-95.

Garcia, Mary D., P.L. Dominguez, F. Martinez y M. Covas, 1996. Obtencion de humus y lombrices de tierra (Eisenia foetida) a partir de residuales porcinos y desechos de la industria azucarera. Revista Computadorizada de Produccion Porcina 3:1, 1-7.

Gonzalez, J., C.P. Diaz, P.L. Dominguez, J. Ly y Yolanda Torres, 1984. Evaluacion de los desperdicios procesados como sustituto del pienso comercial para cerdos en ceba. Cienc. Tec. Agric. Ganado Porcino 7(4): 57.

Grande, D, L. Sangines, J. Carmona, F. Perez Gil, B. Suarez y P.L. Dominguez, 1995. Potencial de la produccion porcina con residuos de consumo humano. I. Comportamiento productivo de cerdos para abasto alimentados con residuos organicos del consumo humano a diferentes niveles de sustitucion. Revista Computadorizada de Produccion Porcina 2:3, 73-82.

Mora, L.M., P.L. Dominguez, R. Calderon, J. Quintano, 1992. Nota sobre la utilizacion del bejuco de boniato (Ipomoea batatas) en dietas de cerdos recien destetados. Zootecnia de Cuba 2 (3-4) p. 85-90.

Morales, A. 1980. El clon de boniato CEMSA 74-228. Centro de Mejoramiento de Semillas Agamicas (CEMSA) Villa Clara, Cuba 26 pp.

Perez, A., J. Gonzalez, P.L. Dominguez y V. Figueroa, 1991. Efecto de la suplementacion en cerdos alimentados con miel B y desperdicios procesados. Livestock Research for Rural Development 3(3): 46.

Pineda, A., R. Chao, J. del Rio, J. Alfonso y M. Leal, 1986. Tecnologia para el procesamiento de cadaveres de animales y residuos de matadero. Jornada Interna. Instituto de Investigaciones Porcinas, La Habana, p. 5.

Ruiz, M.E., Pezo, D. and Martinez, L. 1980. El uso de camote (Ipomoea batatas (L) Lam) en la alimentacion animal. I. Aspectos agronomicos. Produccion Animal Tropical 5:157-165.

The Role of Multinutrient Blocks for Sheep Production in an Integrated Cereal-livestock Farming System in Iraq

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Abstract

One of the main limiting factors affecting sheep production in Iraq is the shortage of feed resources, especially protein. Cereal stubble grazing and hand-feeding of chopped straw are the main components of the sheep diet for a considerable part of the year.

Multinutrient blocks were manufactured from urea and locally available agro-industrial by-products. The potential of multinutrient blocks as supplementary feed for sheep was investigated in several on-station and on-farm experiments. The results of these experiments indicate the value of multinutrient blocks as supplementary feed for sheep in Iraq. Using multinutrient blocks during cereal stubble grazing improved the ewes' weight gain (47-100%), conception rates (7-27%) and twinning percentage(26%). Using multinutrient blocks during the ewes' hand-feeding period resulted in replacement of 40% of costly barley grain. The adoption of multinutrient blocks by sheep owners is considered as a major breakthrough in animal feeding in Iraq. Although this technique was introduced to Iraq only a couple of years ago, the total of multinutrient blocks produced during 1995-96 campaign has reached 15,000 tons manufactured mainly by private plants (13 out of 14), and used by nearly 4,000 sheep owners buying the blocks at cost price plus 30% marginal profit.

KEY WORDS: multinutrient block, urea, sheep, stubble, straw, agro-industrial by-product, supplement, barley

Introduction

One of the main factors limiting sheep productivity in Iraq is the shortage of feed resources which can meet their nutrient requirements. This is due to the deterioration of the rangeland and shortage of green forages resulting from the priority for cultivation of land for human food and cash crops. The shortage of feed grain (barley), which is diverted to human consumption, is another factor behind the reduction in sheep productivity. On the other hand, there has been a considerable increase in the available quantity of crop residues in recent years, mainly due to the expansion in food crop production. These residues contribute about 45% of total feed resources available for ruminants in Iraq. There are constraints to the use of these crop residues in ruminant feeding due to their low energy digestibility (35-45%)and low protein content(3-4%).

Sheep Feeding System

Sheep feeding systems in Iraq are well integrated with the cereal cropping system. Sheep depend mostly on grazing cereal stubble, hand-fed chopped straw (*tibin*) and whole barley grain for a considerable part of the year.

During summer (June-September), which coincides with the mating season, sheep depend mainly on cereal crop residues from stubble grazing. No supplement is given during this time. In winter sheep depend on hand feeding which is mainly tibin and whole barley grain. Some sheep owners move their flocks to the desert and steppe. The majority of ewes are in late pregnancy and early lactation during this period which has the highest nutrient requirement. In spring, when ewes are in mid to late lactation the natural pasture can support requirements, depending on rainfall and temperature during the previous winter.

This type of feeding system is likely to result in a serious protein deficiency, especially during summer (stubble grazing) and winter (hand feeding) which may explain the low productivity of sheep in Iraq.

With the existing sheep feeding system, strategic supplementation is the most appropriate way to improve sheep productivity. Experience in other countries has shown that multinutrient blocks manufactured from urea and agro-industrial by-products can be used as a supplement for improving the productivity of sheep which are dependent on low, quality roughage as their main diet (Sansoucy *et al.*, 1988; Leng *et al.*, 1991; Hadjipanayiotou *et al.*, 1993b).

Recently, the IPA Agricultural Research Center in cooperation with Mashreq Project(ICARDA/UNDP/AFESD.RAB.89/026, Iraq, Jordan and Syria) has successfully implemented a project to produce and disseminate multinutrient block technology among sheep owners in Iraq.

Manufacture of Multinutrient Blocks

The manufacture of multinutrient blocks(MB) without any molasses was promoted by the Food and Agricultural Organization of the United Nations in different parts of the world (Hassoun, 1989; Hadjipanayiotou *et al.*, 1993a). In Iraq, different MB formulae were used with different levels of urea, binders and varieties of agro-industrial by-products which are available locally (Table 1). The main ingredients were high moisture by-products (date pulp, sugar beet pulp, brewers' grains, tomato pomace and whey) together with poultry litter, wheat bran, rice bran and ground corn cobs. The other ingredients were fertilizer grade urea as a source of nitrogen, calcium sulphate and salt (NaCl). Quick lime was used as a binder. Inclusion of high moisture date pulp which is available in Iraq in commercial quantities gave excellent hardness and compactness. Therefore our strategy was to use this top quality feedstuff as the main ingredient in the blocks in the manufacturing plants.

Effect of Using Multinutrient Blocks on Weight Gain of Awassi Sheep Grazing Cereal Stubble

Several on-station and on-farm experiments were conducted to evaluate the use of multinutrient blocks as supplementary feed for Awassi sheep grazing cereal (wheat and barley) stubble as their basal diet. The results of an on-station experiment (Table 2) with yearling rams showed that using multinutrient blocks as supplementary feed during cereal stubble grazing could replace costly cotton seed meal(CSM). Both groups gained weight (100 and 93 g/head/d for multinutrient blocks group and CSM group respectively).

Table 1: Some formulae of multinutrient blocks manufactured in Iraq.

	Formulae No									
Ingredients	1	2	3	4	5	6	7	8	9	10
Urea	7	8	6	7	5	5	7	4	7	6
Wheat bran	32	20	27	25	32	32	30	10	17	22
Rice bran	22	15	-	-	-	-	5	5	-	5
Poultry litter	20	-	-	5	5	5	5	35	5	15
Date pulp	-	38	-	35	46	-	-	-	35	10
Beet pulp	-	-	-	-	-	46	22	-	-	-
Brewer grain	-	-	45	-	-	-	-	-	-	-
Tomato pomace	-	-	-	-	-	-	-	-	-	12
Ground straw	-	-	-	-	-	-	-	-	8	-
Corn cobs	-	-	5	10	-	-	-	-	10	11
Reed	-	10	-	-	-	-	10	34	-	-
CaO	12	10	10	12	8	8	14	6	12	12
CaSO4	2	2	2	2	1	1	2	1	2	2
Salt	5	5	5	5	3	3	5	4	5	5
Whey	-	-	-	-	-	-	-	1	-	-

Feeding Awassi ewes multinutrient blocks (Table 2) during cereal stubble grazing improved their weight gain by about 72% and 21% as compared to control (no supplement)group and sunflower meal supplement groups respectively. Similar trends were observed in the on-farm experiments which were conducted in three villages in Mosul area (north of Iraq) (Table 3). Ewe weight gain increased considerably(48-400%) as a result of multinutrient block supplementation as compared with farmer practice (no supplement). The response to feeding multinutrient blocks in on-farm experiments were even more pronounced than that obtained on-station. Better responses could be due to a longer grazing time than the ewes on the station.

Table 2: Effect of using multinutrient blocks on weight gain of Awassi sheep grazing cereal stubble,(On-station, Baghdad)

Experiment 1(yearling rams)		MB	CSM
No. of animals		11	11
Initial Weight(kg)		41.6	41.8
Final Weight(kg)		46.15	46.2
Weight gain(g/d)		100	93
Supplement intake(g/d)		122	100
Experiment 2(ewes)	**No supplement**	**MB**	**SSM**
No. of ewes	29	28	30
Initial Weight(kg)	39.5	39.6	39.4
Final Weight(kg)	41.9	43.7	42.4
Weight gain(g/d)	30	51	44
Supplement intake(g/d)	-	144	150

MB=Multinutrient Blocks
CSM=Cotton seed meal
SSM=Sunflower seed meal

Table 3: Effect of multinutrient blocks (MB) on weight gain of Awassi ewes grazing cereal stubble (on-farm, Mosul area)

	Village					
	Al-Shallat		Al-Muside		Al-Irbid	
	C	MB	C	MB	C	MB
No. of ewes	49	48	28	27	30	30
Initial weight(kg)	46.9	47.2	48.4	44.4	46.6	46.0
Final weight(kg)	47.7	51.2	50.8	53.6	48.5	48.8
Weight gain(g/d)	8	40	66	115	52	77
Blocks intake(g/d)	-	150	-	243	-	252

C=Farmer practice(No supplement)
MB=Multinutrient blocks

These results confirmed previous studies which indicated that multinutrient blocks improved the weight gain of ewes dependent on low quality forages as their main diet (Habib *et al.*, 1991, Hendratno *et al.*, 1991 and Hadjipanayiotou *et al.*, 1993b).

Effect of Multinutrient Blocks Supplementation on the Reproductive Performance of Awassi Ewes.

Farmers in Iraq do not use any supplementation for ewes grazing on cereal stubbles during the mating season. The lengthy mating season together with no supplementation may be responsible for the low conception, lambing and twinning rates.

The effect of using supplementary feed on the reproductive performance of Awassi ewes grazing cereal stubble has been investigated in one on-station experiment. The results of this experiment are presented in Table 4. Using during stubble grazing multinutrient blocks enriched with cotton seed meal (a source of by-pass protein) and vitamin A, D and E resulted in considerable improvement in conception rate (11%), lambing percentage (26%), cycling activity and twinning percentage (15%) as compared to the control non-supplemented group. Supplementation with multinutrient blocks also considerably improved the reproductive performance of goats (Hendratno *et al.*, 1991).

The improvement in the reproductive performance of Awassi ewes due to feeding multinutrient blocks can be considered the most important aspect of this technology in Iraq and in WANA countries where sheep depend heavily on cereal stubble grazing during the mating season.

Using Multinutrient Blocks As Supplementary Feed During Sheep Hand-feeding Period

The hand-feeding period is considered the most critical time for sheep farmers in Iraq because of the shortage of grazing. Currently, sheep depend on whole barley grain and stored chopped straw (tibin) as their main diet. Barley grain is directed to human consumption in Iraq and there is therefore great interest among farmers in replacing barley grain with other cheaper feed resources.

Table 4: Effect of multinutrient blocks on reproductive performance of Awassi ewes grazing cereal stubble (on-station)

Measurements	C	MB
No. of ewes	27	27
No. of ewes lambed	21	24
No. of ewes lambed from 1st cycle	12	16
No. of ewes lambed from 2nd cycle	7	8
No. of ewes lambed from 3rd cycle	2	-
No. of ewes giving twin	3	7
Conception rate(%)	78.0	89.0
Lambing(%)	89.0	115
Twinning(%)	11.0	26.0
Block intake	-	227

C: Farmer practice (no supplement)
MB: Multinutrient blocks

Using multinutrient blocks during the hand-feeding period, which coincides with the ewes' late pregnancy and early lactation was tested by on-station and on-farm experiments. The results of the on-station experiment (Table 5) showed that using multinutrient blocks or sunflower seed meal as protein supplements resulted in a significant reduction in the amount of barley grain required (40%) as compared with the control group. The results of on-farm experiments, which were conducted at two locations in the Mosul area, gave a better indication of the benefit of using multinutrient blocks during the hand-feeding period. These results (Table 6) showed that using high energy MB resulted in a significant replacement of costly barley grain (50-100%). The majority of the farmers who used multinutrient blocks for sheep feeding during the last three years observed that they can successfully replaced of 50% of barley grain. We believe this is the main reason behind the success of multinutrient blocks in Iraq.

Table 5: Effect of feeding multinutrient blocks on the performance of Awassi ewes during late pregnancy and lactation period (on-station)

	Control	Multinutrient Blocks	Sunflower seed meal
No. of ewes	23	22	22
Days on test	132	132	132
Initial ewe weight(kg)	44.67	42.09	43.35
Final ewe weight(kg)	43.13	41.63	40.81
Lambs birth weight(kg)	4.84	4.71	4.83
Lambs weaning weight(kg)	25.41	24.24	24.43
Milk yield(g/ewe/d)	402	888	867
Feed Intake(g/ewe/d):			
Whole barley grain	660	430	430
Wheat bran	400	360	360
Straw	527	416	390
Blocks	-	268	-
Sunflower seed meal	-	-	185

Table 6: Effect of feeding multinutrient blocks (MB) on the performance of ewes during late pregnancy and early lactation (on-farm, Mosul area)

	Nazah area		Al-Jernaff area	
	Control	MB	Control	MB
No. of ewes	20	20	15	15
Days on test	85	85	72	72
Initial ewe weight(kg)	51.9	52.5	48.3	47.6
Final ewe weight(kg)	37.1	37.4	40.5	42.6
Lambs birth weight(kg)	3.2	3.1	3.2	3.1
Lambs weight at 8 weeks(kg)	12.3	13.4	13.2	11.7
Milk yield(gld)	342	358	500	362

Table 6 (Continued):

	Nazah area		Al-Jernaff area	
	Control	MB	Control	MB
Feed Intake(g/ewe/d)				
Whole barley grain	412	-	712	356
Straw	265	500	370	370
Block	-	347	-	416
Feed cost(L.D/head)	2326	1442	3341	2614

Price of straw = 100 I.D./ton
Price of barley grain = 60000 I.D./ton
Price of MB = 27000 I.D./ton

Transferring Multinutrient Blocks Technology to Sheep Owners and Manufacturers in Iraq

The success in transferring multinutrient block technology to sheep owners and manufacturers in Iraq was mainly due to adoption of step-by-step methodology (Mohammed *et al.*, 1995).

This methodology consisted of the following stages:

- Initial experimentation in the manufacture of multinutrient blocks.
- Testing the manufactured blocks in several on-station trials together with chemical analysis to evaluate the nutritional value.
- Conducting on-farm trials to verify the results obtained at the research station and testing the degree of acceptance of the new feed source by sheep owners.
- Conducting field day demonstrations in various parts of the country to show the animal owners the importance of blocks as top quality supplement.
- Conducting training courses for extension workers of the Ministry of Agriculture to gain their active involvement in disseminating the new technology.
- Expansion of the production of multinutrient blocks through contracts with private investors.
- Large scale adoption and dissemination of the new technologies through provision of inputs and technical support.

Conclusions

The success of multinutrient blocks technology is considered as the major breakthrough in animal feeding in Iraq. This is mainly due to wide ranging adoption of the technology by manufacturers and sheep owners. It is well established that using multinutrient block improved the performance of sheep during stubble grazing and considerably reduced feed cost during the hand-feeding period.

The methodology of making multinutrient blocks is simple and does not need sophisticated equipment. Also multinutrient blocks can be made by making use of a wide variety of by-products which are available locally. With increasing demand for multinutrient blocks by animal owners, fourteen manufacturing plants have been established in various provinces in Iraq.

The total of multinutrient blocks produced by IPA and the private plants during 1995-1996 season was 15000 tons which were distributed to 3986 sheep owners at cost price plus 30% marginal profit.

References

Habib G., Basit Ali Shah S., Wahidullah G. and Ghuffranullah. 1991. The importance of urea-molasses blocks and by-pass protein in animal production. The situation in Pakistan. 133-145. In Isotope and Related Technigues in Animal Production and Health by International Atomic Energy. Vienna.

Hadjipanayiotou, M., Verhaeghe, L., Allen, M., Kronfoleh, A. R., Labban, L. M., Shurbaji A., Al-Wadi M., Dassouki M., Shaker B. and Amin M. 1993a Urea blocks. I. Methodology of block making and different formulae tested in Syria. Livestock Research for Rural Development 5(3).

Hadjipanayiotou, M., Verhaeghe. L., Kronfoleh, A. R., Labban, L. M., Amin, M., Al-Wadi, M., Badran A., Dawa, K., Shurbaji, A., Houssein, M., Malki, G., Naigm, T., Merawi, A. R. and Harres, A. K. 1993b Urea blocks. II Performance of cattle and sheep offered urea blocks in Syria. Livestock Research for Rural Development 5(3).

Hassoun, P. 1989. Manufacture of urea block without molasses. Mimeogragh, FAO, Rome, Italy.

Hendratno, C., Nalan, J. V. and Leng. R. A. 1991. The importance of urea-molasses multinutrient blocks for ruminant production in Indonesia. 157-169. In Isotope and Related Techniques in Animal Production and Health by International Atomic Energy Agency. Vienna.

Leng, R. A., Preston, T. R., Sansoucy, R. and George Kunju, P. L. 1991. Multinutrient blocks as a strategic supplement for ruminants. World Animal Review 67:11-19.

Mohammed. A. H., Salman, A. D., Shideed, K. H. and Sudad, S. H. 1995. The mechanism of feed block technology transfer to manufacturers and sheep owners. Regional Symposium on Integrated crop-livestock systems in the Dry Area of West Asia and North Africa, 6-8 November, Amman, Jordan.

Sansoucy, R., Aarts, G. and Preston, T. R. 1988. Molasses-Urea blocks as multinutrient supplement for ruminants. In Sugarcane as Feed, Proc. of an FAO Experts consultation held in Santo Domingo, Dominican Republic, 7-11/7/1986. FAO Animal Production and Health Paper No 72. 319 pp.

Feeding Urea and Molasses on a Straw Diet: Urea Molasses Block vs. Urea Molasses Straw

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Most of the cereal straws are very low in fermentable energy, protein and some macro- and micro-minerals. To optimize the rumen environment of straw fed animals in terms of the availability of readily fermentable carbohydrates, ammonia N and minerals, supplementation of urea and molasses in the form of block or as liquid feed is often suggested (Preston and Leng, 1987). In the Bangladesh Livestock Research Institute, a technique called UMS has been developed where straw is enriched with 3% urea and 15% molasses (on dry matter basis). The relative performance of cattle fed UMS was compared with that of the urea-molasses block (UMB) containing: molasses 55%, urea 10%, rice bran 13%, wheat bran 15%, calcium oxide 6% and salt 1%.

A feeding trial was conducted with 8 native (*Bos indicus*) bulls of approximately 256 kg live weight. Half of the animals were given ad libitum dry rice straw along with UMB (DSUMB) and the other half was given ad libitum UMS (dry rice straw 82%, molasses 15% and urea 3%). Average amount of brans daily licked by the block fed animals was also given to the animals fed UMS. In both groups, data on the rumen fermentation pattern (pH, ammonia-N, DM degradability), intake, digestibility, microbial N yield, growth rate and feed conversion ratio of the bulls were recorded.

Table 1. Degradation characteristics of a straw sample incubated in the rumen of animal fed either DSUMB or UMS.

Items	DSUMB	UMS	SED
Digestion rate (% per hour)	2.29	2.36	0.65
Extent of digestion (%)	49	59	9.8
48 h DM degradability (%)	32	34	3.3
Rumen pH	7.80	7.71	0.12
Rumen ammonia-N (mg/l)	101	173	22.1

Although not statistically significant ($P > 0.05$), both rate and extent of straw DM degradability were higher in the UMS than the DSUMB. Significantly ($P< 0.05$) higher rumen ammonia N concentration may partly be responsible for a better rumen environment for straw digestion in the UMS fed animals. Complete mixing of urea, molasses and straw probably provided more available fermentable energy, N and minerals to the microcolonies of bacterial cells attached to the fibre or in the fluid than those provided by the DSUMB.

Table 2. Digestibility (%) of different nutrients in animals fed either DSUMB or UMS

ITEM	DSUMB	UMS	SED
Dry matter	47	45	1.9
Organic matter	53	50	3.5
Crude protein	53	55	6.6
Acid detergent fibre	49	52	1.3

Digestibility coefficients of the different nutrients were not different (Table 2) but the intake of straw DM, digestible organic matter, metabolizable energy and digestible crude protein (Table 3) were significantly ($P < 0.05$) higher in the UMS than in the DSUMB. This is probably due to higher rate and extent of straw DM degradability (see Table 1) with the consequent reduction in the retention time of solid digesta in the former than the latter.

Table 3. Intake of different nutrients in animals fed either DSUMB or UMS

ITEMS	DSUMB	UMS	SED
Straw DM intake (kg/d)	3.95	4.65	0.18
Digestible OM intake (kg/d)	2.16	2.61	0.21
ME intake (MJ/d)	34.1	41.2	3.32
Digestible CP intake (g/d)	279	341	35.3

Table 4. Microbial N yield and growth rate of animals fed either DSUMB or UMS

ITEMS	DSUMB	UMS	SED
Microbial N yield (g/d)	23.8	23.8	3.20
Growth rate (g/d)	93	233	51.8
Feed conversion ratio (g feed/g LW gain)	58	26	22.8

The microbial N yield was similar for both DSUMB and UMS, but the growth rate and feed conversion ratio were significantly better in the latter than the former. These differences in the performances of DSUMB and UMS may not be explained by the differences in nutrient intake per se of the two groups of animals. One of the possible reasons could be that the continuous supply of molasses and urea mixed straw (UMS) may synchronize the supply of energy and amino acids at the tissue level which brings the necessary changes in the hormonal level for better growth and feed conversion efficiency. On the other hand during block preparation, molasses was heated above 70oC in the presence of urea which may lead to the formation of 4-methyl imidazole (4Me-I) causing hyperexcitability in cattle (Tillman *et al*., 1957; Perdok and Leng, 1987). Although bulls in the present trial ate about 600 to 750 g of block/d and did not show any symptoms of hyperexcitability, but 4Me-I may cause unavailability of Ca and Mg to the animals due to chelate with the minerals (Vosloo, 1985). This may also affect the overall performances of animal.

The idea of feeding urea molasses multinutrient block is unique in a sense that in addition to correction of nutritional imbalances of straw diets, transportation of molasses may be done through it. However, blocking of molasses and urea with other feed ingredients incurs costs of manufacturing and its preservation in a hot humid climate like Bangladesh needs the inclusion of preservatives. Thus UMB may not always be the effective method of correcting the nutritional imbalances of ruminants in a subtropical humid situation like Bangladesh. In one of our survey study (Huque, 1993), farmers stated that preparation and feeding of blocks are cumbersome process and possibility of its toxicity can not be ruled out if animals bite them. However, UMS found to be much easy, economic and acceptable method of feeding urea and molasses provided molasses is available to the farmers at a reasonable price.

References

Perdok, H.B. and Leng, R.A. (1987) Hyperexcitability in cattle fed ammoniated roughages. Anim. Feed Sci. Technol., 17:121-143.

Preston, T.R. and Leng, R.A. (1987) Matching Ruminant Production System with Available Resources in the Tropics and in the Sub-tropics. Panambul Books, Armidale, Australia.

Tillman, A.D. Gallup, W.D. and Woods, W. (1957) The utilization of ammoniated cane molasses by sheep. J. Anim. Sci. 15:25-35.

Vosloo, L.P. (1985) Onlangse ontwikkeling op die gebied van ruvoervoorsiening aan herkouers. S. Afr. J. Anim. Sci. 15:86-90.

The Sugarcane Industry and Rabbit Feed Manufacture

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Abstract
Results on the utilisation of sugarcane molasses as a binder and a source of energy in the formulation of blocks and crumbs for rabbits are reported.

Good growth performance (31.0±9.3 g/d) was obtained with blocks containing 40-45% molasses, used to supplement fresh forage-based diets. Poor growth was obtained with complete blocks (10.2±5.1 g/d) and with supplementary blocks fed with poor quality forages (9.2±3.8 g/d).

These limits were overcome with crumb feeds with a lower level of molasses (10-15%), which could be fed as a sole feed or even to supplement poor quality roughage. Daily growth rates were 25.8±6.9 g/d and 22.4±5.2 g/d respectively.

Blocks and crumbs are easily manufactured at farm level. The technology is suitable for developing countries and can be used on a large scale by the sugarcane industry to produce feeds which are not perishable and easy to store and transport.

KEY WORDS: Rabbit, sugarcane, molasses, integration.

Introduction
The importance of livestock integration in the sugarcane industry has been underlined by Perez (1996). Our experience on this topic is limited to rabbit feed formulation.

Molasses-based multi-nutritional blocks for rabbit feeding have been tested (Finzi and Amici 1996; Perez 1994; Velasco *et al.* 1994), but unsatisfactory results have sometimes been obtained. In fact, a fresh soya bean forage feeding system is now overtaking the use of molasses blocks in Cuba (Perez 1996). Fresh forage gives better results than multi-nutritional blocks where the amount of molasses ingested by rabbits may be excessive. Still better results can be obtained when molasses blocks are used to supplement a diet based on fresh leguminous fodder (Amici and Finzi 1995).

Materials and Methods

The following aspects of the problem have been studied:
1) Formulation of supplementary and/or complete feeds.
2) Physical characteristics of feeds (blocks, crumbs).
3) Use of binders.
4) Manufacturing schedule.
5) Chemical and nutritive characteristics of available forages.

Experimental conditions are summarised in Table 1.

Results

Results can be summarised as follows:
Blocks can be manufactured using molasses (max 50%), cement (max 10%) and/or starch-rich flour (mixed with warm water) as binders. To prepare blocks the ingredients should be milled to a particle size less than 2-3 mm. When milling devices are not available, larger ingredients such as broken rice, bran and alfalfa hay leaflets are also suitable. Excessive particle size makes the product difficult to mix, and very light and friable.

The best shape for blocks was cylindrical, measuring 8x15 to 10x25 cm. They are easily manufactured by rolling the mixture in any kind of paper (including newspaper). The wrapped cylindrical blocks are easy to transport immediately to a suitable place to be sun dried in a few days (3-6 according to temperature and solar radiation,) to obtain a water content of about 10-14%, which is suitable for storage. The paper which absorbed molasses avoids losses and is also eaten by rabbits.

Table 1: Feed formulation, chemical composition and nutritive value (as fed basis)

Feeds	Blocks				Crumbs	
Components	Complete	Supplement			Complete	Supp.
Alfalfa meal(dehydrated)	-	-	-	-	-	-
Alfalfa hay (milled)	14.7	17.2	17.2	-	-	-
Alfalfa hay (leaflets)	-	-	-	27.4	-	14.4
Wheat straw (milled)	16.3	-	-	-	20.9	-
Broken rice (unmilled)	-	11.3	7.1	8.8	-	10.8
Wheat bran (unmilled)	-	17.5	17.6	10.6	24.2	49.2
Wheat meal	-	-	-	-	20.0	12.8
Soya bean meal	17.6	-	-	-	21.2	-
Barley meal	-	-	-	-	-	-
Corn meal	-	-	-	-	-	-
Wheat middling	-	-	-	-	-	-
Carob meal	-	-	-	-	-	-
Mineral mix	-	-	-	-	-	-
Molasses	48.1	50.8	50.1	50.0	11.9	11.8
Cement	3.3	3.2	8.0	3.2	1.8	1.0
Crude protein (%)	14.2	9.3	9.0	12.5	15.5	12.5
Crude fibre (%)	12.0	6.5	6.6	5.9	13.1	8.0
DE* (MJ/kg)	10.1	10.8	9.5	11.2	9.8	10.8

*Calculated: Maertens *et al*, 1988

Trials with complete blocks alone, or to supplement poor quality hay or straw, gave poor performances (10.2±5.1 and 9.2±3.8 g/d respectively; Table 2). This was probably due to the excessive ingestion of soluble carbohydrates (Morisse *et al.* 1983) since poor quality forages are ingested in limited quantities (Perez 1994).

Table 2: Results obtained with different block formulations

Technological conditions	COMPLETE	SUPPLEMENT Fresh forages ***	SUPPLEMENT Hay (or straw)
MOLASSES*			
<45 %	Breakable (excessive losses)	Breakable (excessive losses)	Breakable (excessive losses)
45-50 %	Good hardness (no losses) Good palatability Reduced intake	Good hardness (no losses) Good palatability Good performance (ADG 31 ±9.3 g/d)	Good hardness (no losses) Good palatability Excessive block vs. hay intake
	Soft faeces Poor performance (ADG 10.2 ±5.1 g/d)		Soft faeces Poor performance (ADG 9.2 ±3.8 g/d)
CEMENT *			
2 -4 %	No effect	No effect	No effect
> 10 %	Not tested	Very hard Poor intake	Not tested
PARTICLE SIZE			
Milled (or small particles)	Good hardness Good density	Good hardness Good density	Good hardness Good density
Non milled (chopped straw**)	Formulation problems	Too light Friable	Too light Friable

* in addition to molasses.
** Only technological test of manufacturing have been performed.
*** Mainly alfalfa or alfalfa with grass not exceeding 25 %.
ADG = average daily gain.

In fact, when blocks containing 45-50 % molasses were administered together with fresh palatable forages, satisfactory growth performance was obtained (31.0±9.3 g/day; Table 2). Similar results were also observed by Velasco *et al.* (1994).

Table 3: Results obtained with different crumb formulations

Technological conditions	COMPLETE	SUPPLEMENT Fresh forages ***	 Hay (or straw)
MOLASSES*			
10-14 %	No losses Sufficient performance (ADG 25.8 ±6.9 g/d)	Not tested	No losses Sufficient performance (ADG 22.4 ±5.2 g/d)
> 15 %	Not tested Supposed molasses excess	Not tested	Not tested
PARTICLE SIZE			
Milled (or small particles)	Suitable particles No powder	** Suitable particles No powder	Suitable particles No powder
Non milled (alfalfa leaflets)	** Formulation problems	** Rather light Enough suitable	Rather light Enough suitable

*In addition to 2-4% cement and 10-12% starch from wheat flower.
**Only technological test of manufacturing has been performed.
***Mainly alfalfa or alfalfa with grass not exceeding 25%.
ADG = average daily gain.

Problems of formulating complete blocks were overcome by producing crumbs (Table 3) which needed only 10-15% of molasses. Cement (2-4%) and starch from wheat flower (10-12%) were useful additions to molasses. Satisfactory growth performance was obtained with complete crumbs (25.8±6.9 g/day) or with crumbs used to supplement poor forages such as hay or straw (22.4±5.2 g/day). It was also easier to include alfalfa hay leaflets in crumb diets.

Conclusions

Results confirm that leguminous forages give better results than complete molasses blocks, as found by Perez (1996). Still better results can be obtained by blocks balanced to augment green leguminous fodders. When fresh palatable forages are not available and only hay is on offer, better results are obtained with crumbs.

Blocks and crumbs need only simple manufacturing technologies that allow the utilisation of local feedstuffs and by-products in developing countries. Small-scale industrial production is also possible. In this case, the best location of the plant is adjacent to the sugarcane mills where molasses is produced.

References

Amici A. and Finzi A. 1995. Molasses blocks as supplementary feeds for growing rabbits. World Rabbit Science. 3 (2): 69-73.

Finzi A. and Amici A., 1996. Unconventional feeding techniques for rabbits in developing countries. 6th World Rabbit Congress. 3: 341-345.

Maertens L., Moermans R. and De Grotte G. (1988). Prediction of the apparent digestible energy (ADE) content of commercial pelleted feeds for rabbits. J. Appl. Rabbit Res. 11: 60-67.

Morisse J.P., Andrieux J., Boilletot E. and Maurice R. 1983. Toxicite pour le lapin d'un produit issu de la fermentation de la melasse de betterave. Rev. d'Alimentation Animale. 67: 18-19.

Perez R. 1994. La alimentacion de conejos con enfasis en la cana de azucar. Ministerio del Azucar. La Habana, Cuba.

Perez R. 1996. Integration of livestock in sugarcane industry in Cuba. Second FAO Electronic Conference on Tropical Feeds Livestock feed resources within Integrated Farming Systems.

Velasco C.I., Cardona A. J. and Espinel R.G.M. 1994. Dos niveles de melaza y vinaza en bloques multinutricionales para conejos en la fase de engorde, suplementados con nacedero. Actas I Seminario Latinoamericano de Cunicultura. Guanare, Venezuela. 26-37.

Excess Feeding of Stovers from Sorghum and Maize for Small Ruminants and Cattle in Cereal-based Integrated Farming Systems in Africa

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Abstract
Surveys of small-scale farmers growing sorghum in Ethiopia and maize in Kenya showed that stover was used as livestock feed during the dry season. Feeding method generally involved offering crudely-chopped (i.e. machete), stover in large quantities, with refusals either re-offered to less valuable animals (eg. donkeys in Ethiopia), and/or used as fuel, mulch or compost with excreta. Experiments were undertaken to quantify the effect

of varying extents of excess feeding on stover intake and livestock production; cottonseed cake and minerals supplementation was provided. In Ethiopia, using machine-chopped sorghum stover, sheep offered 25, 50 or 75 g stover/kg live weight (M), daily (d), increased their intake and growth rate with increasing excess rate (intake, g DM/kg M.d: 22.1, 31.1 and 32.5; growth rate, g/d: 28.2, 54.1 and 62.2). With increasing excess rate, sheep consumed more leaf and less stem. Amount of stover refused also increased with excess rate (g/kg offered: 51, 318 and 526). Goats responded similarly. In another study, the effects of increasing the excess rate (25 vs 50 g/kg M.d) and chopping were additive in improving intake and growth rate of sheep. However, with cattle, chopping reduced intake of stover, but increasing the excess rate of unchopped stover improved performance. In a comparison of stover from a bird-resistant and non-bird-resistant variety, there was no difference in intake by sheep, but in the same trial, increasing the excess rate from 25 to 50 g/kg M.d increased intake. In Kenya, when mid-lactation, cross-bred cows were fed minerals and 3.2 kg DM/d cottonseed cake and offered 30, 60 or 90 g DM/kg M.d of unchopped maize stover, intake of stover (kg DM/d: 8.1, 11.3 and 13.2) and yield of milk (l/d: 10.0, 11.3 and 12.3) increased with increasing excess rate. The experiments demonstrate improved animal productivity from an excess feeding-rate strategy for sorghum and maize stovers. It is concluded that integrated farming systems involving excess feeding strategies now need to be modeled, so that interventions to improve the systems may be identified. However, to develop the models, it will be necessary to generate further input/output information, especially regarding strategies for utilising refused stover.

KEY WORDS: Excess feeding, straw, sorghum, maize, stover

Introduction

Farmer group surveys in sorghum-growing areas of Ethiopia (Nazret, Eastern Hararghe and Ada) showed farm sizes to range from 1.6 to 5 ha, with up to 54% of the cultivated area in sorghum (Osafo, 1993). Despite problems of grain damage by birds, farmers preferred local, non-bird-resistant varieties of sorghum to modern, bird-resistant ones, because of higher palatability of grain and more drought resistance. Sorghum stover and teff straw were major livestock feeds in the dry season, with draught oxen and milk cows having priority over small ruminants and donkeys, in access to crop residues. Stover feeding involved in situ grazing and stall feeding, the latter using either long stover, or crudely chopped (i.e. machete). Stems were used for fencing. Because of acute shortage of fuelwood, uneaten stover was used as fuel, often mixed with cow faeces and tree leaves (e.g. Eucalyptus). There was little use of residues for mulching or composting.

Surveys (Methu *et al*., 1996; Wais, 1996) showed that smallholder dairying in Central Kenya Highlands (Kiambu) based on cut-and-carry feeding with exotic dairy breeds (mainly Friesian and Ayrshire), is a major enterprise on small-scale (2 ha) farms. Crops grown involve Napier grass (0.8 ha), maize (0.36 ha, two crops per year) and horticultural crops. Except in the dry season, napier grass is the major basal component of dairy rations. Maize stover (approximately 2.6 t DM/ha.year) could play a larger role in dry-season feeding if problems of low intake and low nutritive value were alleviated. Omore (1996) reported milk yields averaging only 5.8 kg/d over lactations extending beyond 24 months. Concentrate feeds from commercial dairy meals, cereal brans and oilseed cakes were purchased by over 70% of farmers, but concentrates were fed at very low levels.

In both Ethiopia and Kenya, there was no evidence of farmers adopting technologies such as urea-ammonia treatment of sorghum and maize stovers to improve intake and nutritive value. Farmers surveyed in Kenya were unaware of residue upgrading technologies (Methu *et al*., 1996). This confirms the earlier findings of Owen and Jayasuriya (1989) and the recent conclusions of Devendra (1996).

Research by Wahed *et al*.(1990) using barley straw, and Zemmelink

(1980) using tropical grasses and legumes, showed that an `excess feeding' strategy resulted in increased intake of digestible organic matter. In view of this, a series of experiments was conducted with sorghum and maize stovers to investigate whether excess feeding would increase intake and productivity of ruminants. It was hypothesised that this approach would provide an adoptable and sustainable strategy for alleviating the problem of low nutritive value of stovers.

Experiments Undertaken

The Excess Feeding Approach

The method involved offering differing amounts of stover, on the basis of the live weight (M) of animals, such that the proportion refused increased dramatically above the conventional *ad libitum* rate of 0.15 kg refused/kg offered. Except for one experiment (Osafo *et al*., 1993a), supplements of cottonseed cake and minerals were provided. Measurements were made of the quantity and quality (botanical fractions) of stover offered and refused.

Three experiments with sorghum stover were conducted at the International Livestock Research Institute (ILRI), Debre Zeit, Ethiopia and one with maize stover at the Kenya Agricultural Research Institute (KARI), Muguga, Nairobi.

Experiment 1: Effects of Amount of Chopped Sorghum Stover Offered in Goats and Sheep

The stover used (Seredo, bird-resistant variety) was coarsely chopped using a tractor-driven chopper (Alvan-Blanch Maxi chaff cutter). Both goats and sheep increased their intake of stover with increasing amounts of stover offered, and this was reflected in increasing growth rates (Table 1). As the amount offered increased, the content of leaf and sheath in the stover consumed increased and that of stem decreased, indicating selection for the more nutritious leaf and sheath components. Also clearly evident, was the increasing proportion of refused stover as the amount offered increased (Table 1).

Table 1: Effects of amount of chopped sorghum stover offered, in goats and sheep in Ethiopia (Aboud *et al*., 1993)

	Goat			Sheep		
Amount offered (g/kg M.d)	25	50	75	25	50	75
Number/treatment	7	7	7	8	8	7
Initial weight (M) (kg)	15.4	16.3	16.3	14.7	16.3	16.5
Stover refused (kg/kg offered)	0.15	0.43	0.57	0.05	0.32	0.53
Stover intake (1) (g DM/kg M.d)	19.9	26.3	29.1	22.1	31.1	32.5
Growth rate (1) (g/d)	9.4	23.4	31.6	28.2	54.1	62.2

(1) Measurements over 75 d following a 21-d preliminary period, supplements given: 150 g/d cottonseed cake and mineral licks; s.e.d. for stover intake, 1.09; s.e.d. fo growth rate, 8.70

Experiment 2: Effects of Amount of Stover Offered and Chopping in Sheep and Cattle

The stover used was a non-bird-resistant variety (Dinkamash). Both sheep and cattle showed greater intakes when the amount of stover offered was doubled, and this was reflected in increased growth rates (Table 2). However, chopping increased intake in sheep, but decreased intake in cattle. This result has an important practical implication in view of the fact that chopping (albeit ill-defined) is widely advocated when feeding sorghum and maize stovers.

Experiment 3: Effects of Amount of Chopped Stover Offered and Variety of Stover in Sheep

Experiment 3 tested the hypothesis that stover from bird-resistant sorghum would be less nutritious than stover from non-bird-resistant sorghum because of the higher anti-nutritive factors in bird-resistant varieties (Reed *et al*., 1987). Table 3 shows that although digestibility was lower in the bird-resistant stover, intake was unaffected. This was probably due to the higher leaf-plus-sheath to stem ratio in the bird-resistant stover used.

Table 2: Effects of amount of stover offered and chopping, in sheep and cattle in Ethiopia (Osafo *et al*., 1993b)

Form of stover	UNCHOPPED		CHOPPED	
Amount offered (g/kg M.d)	25	50	25	50
SHEEP (1)				
No. of pens (2)	4	4	4	4
Initial weight (M) (kg/pen)	51.8	51.0	50.4	51.2
Growth rate (3) (g/animal.d)	30.5	56.0	45.8	70.5
Stover offered (kg DM/pen.d)	1.25	2.56	1.23	2.60
Stover refused (kg/kg offered)	0.21	0.52	0.11	0.38
Stover intake (4) (kg DM/pen.d)	0.98	1.24	1.08	1.60
Stover intake (g DM/kg M.d)	18.9	24.3	21.4	31.3
CATTLE (5)				
No. of steers	8	8	7	8
Initial weight (M), kg	204	204	200	203
Growth rate (6) (kg/d)	0.25	0.43	0.36	0.44
Stover offered (kg DM/d)	4.9	9.5	5.1	9.9
Stover refused (kg/kg offered)	0.24	0.51	0.29	0.62
Stover intake (7) (kg DM/d)	3.7	4.7	3.6	3.9
Stover intake (g DM/kg M.d)	18.1	23.0	18.0	19.2

(1) Measurements over 56 d, supplements given: 310 g/d cottonseed cake and mineral licks;
(2) 3 rams/pen;
(3) s.e.d. 4.86;
(4) s.e.d. 0.100;
(5) measurements over 49 d, supplements given: 800 g/d cottonseed cake and mineral licks;
(6) s.e.d. 0.083;
(7) s.e.d. 0.22

Osafo (1993) found large variation in the leaf-plus-sheath:stem ratios between varieties of both bird-resistant and non-bird-resistant sorghums. Experiment 3 involved offering stover without supplementation to simulate farmer practice. It is notable that sheep offered the higher rate of stover maintained weight.

Table 3: Effects of amount of chopped sorghum stover offered and variety of stover, in sheep in Ethiopia (Osafo *et al*., 1993a)

Variety	Non-bird resistant (1)		Bird resistant (2)	
Amount offered (g DM/kg M.d)	25	50	25	50
INTAKE TRIAL (3)				
No. of rams	12	12	12	12
Initial weight (M) (kg)	20.0	20.1	20.1	19.9
Growth rate (4) (g/d)	-25.3	3.5	-16.1	-4.0
Stover offered (g DM/d)	548	1019	537	1011
Stover refused (kg DM/kg DM offered)	0.13	0.38	0.11	0.38
Stover intake (5) (g DM/d)	474	633	478	628
DIGESTIBILITY TRIAL (6)				
No. of rams	4	4	4	4
Live weight (M) (kg)	17.8	18.2	17.8	17.0
Stover offered (g DM/d)	622	1093	619	1067
Stover refused (kg DM/kg DM offered)	0.13	0.39	0.10	0.37
Stover intake (g DM/d)	544	670	558	676
OM digestibility (7)	0.58	0.56	0.53	0.54
NDF digestibility (8)	0.61	0.57	0.55	0.55

(1) Mixture of Dinkamash and 76T123 varieties), leaf-plus-sheath:stem, 0.82;
(2) Seredo, leaf-plus-sheath:stem, 1.25;
(3) measurements over 42 d, supplement given: mineral licks only;
(4) s.e.d 6.2;
(5) s.e.d. 16.0;
(6) measurements over 7 d, supplement given: mineral licks only;
(7) s.e.d. 0.024;
(8) s.e.d. 0.029

Experiment 4: Effects of Amount of Maize Stover Offered in Milk Cows

In both Latin squares, intake of maize increased as the amount offered increased, and this was reflected in greater milk production, though responses were non-significant (Table 4). The proportions of leaves and husks in the stover consumed were greater than in the stover offered, suggesting selection for these components as opposed to selection against stems and sheaths. As in Experiments 1 to 3, the proportion of stover refused increased markedly with increasing offer rate. The milk yields achieved in this experiment, from mid-lactation cows on a basal diet of maize stover, were substantial, although it is acknowledged that 3.2 kg DM/d cottonseed cake was fed.

Conclusions

The experiments confirmed the hypothesis that excess feeding of sorghum or maize stover is a method of increasing intake and productivity of small ruminants and cattle, thus alleviating the problem of low nutritive value of stovers.

At first sight, the large amount of refused stover generated by excess feeding would be conceived as unsustainably wasteful. However, as indicated by surveys in Ethiopia, residues uneaten by ruminants have a value as feed for donkeys or substitute for fuelwood.

Stovers refused in an in situ grazing system would be available for soil incorporation to increase organic matter (Powell *et al.*, 1995). However, refused stovers, which would tend to be dominated by the stem fraction, would contain high C:N ratios. Not only are such residues slow to decompose under field conditions, but may also immobilise mineral nitrogen making it unavailable for plant growth.

In Kenya refused maize stover is used as bedding in zero grazing units. Farmers combine urine-soaked stover with cattle faeces in heaps or pits for composting prior to application to crops. Collaborative research being conducted by KARI and ILRI is currently examining how interactions between the quality of diets based on maize stover, bedding, manure management and composting techniques influence the quality of organic fertilizers produced.

Table 4: Effects of amount of maize stover offered, in lactating cows in Kenya (Methu *et al*., 1996)

	1994 stover (1)			1995 stover (2)		
Amount offered						
(g DM/kg M.d)	29	57	87	33	60	87
Live weight (M) (kg)	425	436	439	424	438	437
Stover offered (kg DM/d)	12.3	24.7	38.2	13.8	26.5	38.0
Stover intake (3) (kg DM/d)	8.3	11.5	13.2	7.9	11.0	13.2
Stover refused						
(kg DM/kg DM offered)	0.32	0.54	0.65	0.41	0.58	0.65
Milk yield (4) (kg/d)	11.2	11.3	13.0	8.8	11.2	11.5
Stover Offered (%)						
Stem	42	42	42	50	50	50
Leaf	17	17	17	12	12	12
Sheath	15	15	15	13	13	13
Husk	25	25	25	24	24	24
Stover Consumed (%)						
Stem	19	21	31	20	12	20
Leaf	24	28	29	18	19	17
Sheath	23	12	6	22	20	9
Husk	34	39	34	40	49	54

(1) 3 Ayrshire cows in 3x3 Latin square, 24 d/period, supplements given: 3.2 kg DM/d cottonseed cake and 150 g/d mineral premix;
(2) 3 Friesian cows in 3x3 Latin square, 24 d/period, supplements given: 3.2 kg DM/d cottonseed cake and 150 g/d mineral premix;
(3) s.e.d. for Ayrshires, 1.12, s.e.d. for Friesians, 0.46;
(4) s.e.d. for Ayrshires, 1.54, s.e.d. for Friesians, 0.71

Under the intensive farming systems practised in the highlands of East and Central Africa, excreta is a highly valued output of the livestock sub-system.

In Indonesia, excess feeding of indigenous forages is already practised by farmers with the main intention of maximising yield of manure-compost production made from refused forage and excreta (Tanner *et al.*, 1996). In Indonesia, excess feeding therefore not only increases animal productivity per se, but also maximises outputs from the livestock enterprise which are of benefit to crops.

There is a need to model input-output relationships concerning the excess feeding approach and the use of supplements in order to optimise the sustainable use of sorghum and maize stovers in cereal-based integrated farming systems in Africa and elsewhere.

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References

Aboud, A.A.O., Owen, E., Reed, J.D., Said, A.N. and McAllan, A., 1993. Feeding sorghum stover to Ethiopian sheep and goats; effects of amount offered on intake, selection and performance. In: Animal Production in Developing Countries (ed. M. Gill, E. Owen, G.E. Pollott and T.L.J. Lawrence), Occasional Publication No. 16 - British Society of Animal Production, pp 202-203.

Devendra, C. 1996. Crop residues for feeding animals in Asia: technology assessment and adoption for crop animal systems. Proceedings of International Workshop on Crop Residues in Sustainable Mixed Crops/Livestock Farming Systems, 22-26 April, 1996 at ICRISAT, India, sponsored by International Livestock Research Institute. CABI, Wallingford, UK (in press).

Methu, J.N., Owen, E., Abate, A. and Scarr, M., 1996. Effect of level of offer of maize stover on the performance of lactating dairy cows. 23rd Tanzania Society of Animal Production Conference, Arusha, 21-23 August, 1996.

Omore, A. 1996. Unpublished data, University of Nairobi.

Osafo, E.L.K. 1993. Sorghum stover as a forage: cultivar effects on yield and effects of chopping, amount offered, supplementation and variety on intake, selection and live-weight gain in Ethiopian sheep and cattle. PhD Thesis, The University of Reading.

Osafo, E.L.K., Owen, E., Said, A.N., Gill, E.M. and McAllan, A.B. 1993a. Feeding chopped sorghum stover to Ethiopian sheep: effects of sorghum variety and amount offered on intake, digestibility and live-weight change. Animal Production 56(3): 470.

Osafo, E.L.K., Owen, E., Said, A.N., Gill, E.M. and McAllan, A.B. 1993b. Feeding sorghum stover to Ethiopian sheep and cattle: effect of chopping and amount offered on intake and selection. In: Animal Production in Developing Countries (ed. M. Gill, E. Owen, G.E. Pollott and T.L.J. Lawrence), Occasional Publication No. 16 - British Society of Animal Production, pp 204-205.

Owen, E. and Jayasuriya, M.C.N. 1989. Use of crop residues as animal feeds in developing countries - a review. Research and Development in Agriculture 6(3):124-138.

Powell, J.M., Fernandez-Rivera, S., Williams, T.O and Renard, C.(eds) 1995. Livestock and Sustainable Nutrient Cycling in Mixed Farming Systems of sub-Saharan Africa. Volume II: Technical Papers. Proceedings of an International Conference held in Addis Ababa, Ethiopia, 22-26 November, 1993. ILCA, Addis Ababa, Ethiopia. 568 pp.

Reed, J.D., Tedla, A. and Kebede, Y. 1987. Phenolics, fibre and fibre digestibility in the crop residue from bird-resistant and non-bird-resistant sorghum varieties. Journal of Science of Food and Agriculture 39: 113-121.

Tanner, J.C., Holden, S.J., Owen, E., Winugroho, M. and Gill, M. 1996. Ruminant feeding strategies for sustainable agricultural production in upland mixed-farming systems of Indonesia. Second FAO electronic conference on tropical feeds.

Wahed, R.A., Owen, E., Naate, M. and Hosking, B.J. 1990. Feeding straw to small ruminants: effect of amount offered on intake and selection of barley straw by goats and sheep. Animal Production 51: 283-289.

Wais, W.K.N. 1996. An economic analysis of effects of risk management strategies on dairying in smallholder farms in Kiambu District, Kenya. MSc Thesis, University of Nairobi.

Zemmelink, G. 1980. Effect of selective consumption on voluntary intake and digestibility of tropical forages. Doctoral thesis. Pudoc, Wageningen.

New Developments in Livestock Systems based on Crop Residues in China

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Abstract

Since 1992, when livestock based on crop residues was included in the State Agriculture Comprehensive Development Project, significant progress has already been made.

A. A number of State-level demonstration 'counties' with cattle-raising based on crop residues have been established. By 1996, the number had reached 147 counties. Some concentrated and adjoining areas have already developed into demonstration 'prefectures'.

B. Demonstration projects expanded to include sheep-raising, also based on crop residues. Between 1995 and 1996, the State ratified 20 demonstration counties with sheep-raising based on crop residues.

C. Large scale extension campaigns have been carried out on the crop residue treatment technique. In 1995, crop residue silage (anaerobic fermented and preserved corn or sorghum straw without heads and ears) reached 75.1 million tons nationwide and ammoniated crop residues, 21.5 million tons. Together they saved about 19.8 million tons of feed grain. 7 million farming households adopted the ammoniated crop residue technique.

D. There has been a large increase in beef and mutton production. In 1995, beef production reached 4.1 million tons, an increase of 25.1% compared to 1994, fulfilling the Eighth Five Year Plan target by 275%, and becoming the most rapidly growing item in livestock products. For 1996, beef production is forecasted to exceed 5 million tons, and mutton

to reach 2.6 million tons, with a continuing high growth rate.
E. Livestock systems based on crop residues provide 1 billion tons of organic fertilizer, which can support 20 million hectares of farmland, not only lowering grain production costs, but also promoting the development of sustainable agriculture.

KEY WORDS: Crop residues, cattle, sheep, straw, urea, silage, manure, China

Historical Origin

In the last ten years, China's grain production increased by only about 1% annually, but the growth of animal production averaged about 10%. It is obvious that China's grain production can definitely not bear the rapid growth of livestock. The only option is to utilize feeds other than grain, and to establish a grain-saving livestock structure. In the mid 80's, the Ministry of Agriculture (MOA) began establishing demonstration sites for the utilization of crop residues as feed and, in 1987, FAO implemented the TCP project in China for the utilization of crop residues as feed. Both were successful.

In 1990, Guo Tingshuang and 13 other specialists submitted a statement to the Central government, proposing the development of livestock systems based on crop residues to ease the problem of insufficient grain supply in China, to greatly increase beef and mutton production and to partly replace pork. Previously pork made up 80% of consumer meat supply. Beef and mutton would also improve the meat supply structure of the population. This proposal received great attention and approval. In 1992, the State Council ratified the implementation of a demonstration project for cattle raising based on crop residues and 10 State-level demonstration counties were established. This undertaking developed rapidly. By 1996, the number of demonstration counties increased to 147 in 29 provinces.

In 1995, the State extended the successful experience with cattle rearing to the sheep sector. In the same year, the first batch of 6 State-level demonstration counties with sheep (or goat) rearing based on crop residues were established and another 14 were set up this year. Thereafter, sheep production began to develop rapidly in cropping areas. A census showed that, in the first nine months of this year, the total production of mutton reached 1.2 million tons, 34.4% higher than for the same period last year. From now on, both cattle and sheep will be included in the project. In October 1996, the State Council has officially issued the National Development Programme for Livestock based on Crop Residues 1996-2000 and it is now not only the responsibility of the MOA but also an established national policy.

From 1992 onwards, the State Council entrusted the MOA to convene four national conferences to implement the work. 200 million yuan were allocated by central and local governments to be used for the project. At the same time, funds raised by farmers for the same purpose reached well over 10 billion yuan. Urea and polyethylene film were also provided to support this work. FAO and UNDP attached great importance to these projects and supported the work with experts and material resources. In 1993 and 1995, FAO (in cooperation with MOA) convened two International Conference on Increasing Animal Production from Local Resources in China and some FAO specialists and consultants were sent to China to give instruction (Rene Sansoucy, F. Dolberg, E. Orskov, J.C. Chirgwin, F. Sundstol and others). With the efforts of FAO and the Chinese Government, great progress has been made in China.

Major Accomplishments

A. Increase in Beef and Mutton Supply

Between 1992 and 1995, beef production increased by 27.8% annually. By 1995, beef production reached 4.1 million tons, over-fulfilling the Eighth Five Year Plan target by 275%. For the first nine months of 1996, beef production increased by 29.6% compared to the same period last year, and is forecasted to reach 5 million tons by the end of the year. By extending the same principle to sheep (and goat) rearing, China has also increased mutton production which was previously stagnant. The annual growth was 9.9% in 1993, 17% in 1994, and 22% in 1995. In the first nine months of this year, mutton production increased by 34.4% compared to the same period last year.

By developing livestock based on crop residues, vast cropping areas have already taken the place of pastures, and are rapidly developing into China's main base for ruminant production.

B. Economizing on Feed Grain

China produces about 570 million tons of crop residues annually, of which about 25% is used as feed. In 1995, 75 million tons (fresh weight) of crop residue silage (anaerobic fermented and preserved corn or sorghum straw whithout heads and ears) were produced, together with 21.5 million tons of ammoniated straw and stover (Table 1), thus saving nearly 20 million tons of feed grain (calculation of grain-saving is based on the so-called "oat feed unit": 1kg of dry straw equals to 0.2 unit; 1kg of ammoniated straw equals to 0.4 unit; 1kg of fresh straw silage equals to 0.15 unit).

Table 1: Number of farmers treating straw and quantities of treated straw

Year	Farmers (Million)	Treated Straw (Million tons)
1990	0.8	2.6
1991	1.2	3.7
1992	2.3	7.1
1993	3.8	11.7
1994	5.3	15.9
1995	7.1	21.5

C. Integration of Livestock with Grain Production

Rearing cattle in cropping areas can provide 1 billion tons of farmyard manure which can support 20 million hectares of farmland. The extensive use of farmyard manure can reduce the use of chemical fertilizer, thus not only lowering costs but also improving soil conditions and promoting agricultural production. Fuyang in Anhui Province and Zhoukou and Shangqiu in Henan Province are areas with well established systems of cattle rearing based on crop residues. In recent years, their agricultural growth rate has been well above the national average. Formerly deficient in grain, they are now rapidly achieving grain surpluses.

D. Growth of Industry

The rapid development of cattle and sheep rearing has promoted the growth of the slaughter and meat processing industry, leather processing, and also bone, blood and viscera processing, giving impetus to the marketing of live animals and their processed products. The result has been to provide more jobs in the urban and rural areas, benefiting the farmers, increasing revenue to local governments and putting new vitality into the agricultural and village economy.

E. Disease Prevention and Reduction in Environmental Pollution

Many places along the Yangtze River are schistosomiasis endemic areas. Cattle grazing near the river (as well as lakes and water holes) become parasite hosts. Utilizing ammoniated crop residues to feed cattle, and moving from grazing to stall feeding, breaks the schistosome cycle and helps to control the spread of disease. Also, utilizing more crop residues helps to avoid atmospheric pollution from burning crop residue which is a problem in highly populated areas.

Development Prospects

Although the project of livestock based on crop residues has already achieved impressive results, from the point of view of the extent of resources and the vast market potential, the achievements gained can only be considered as a good beginning. Every year, 570 million tons of crop residues are produced. Up to now, only 25% has been used as feed. Last year, the per capita consumption of beef was only 3.42 kg and less than 2 kg for mutton. The aim is to speed up these developments. In October 1996, the State Council issued the National Development Programme for Livestock Based on Crop Residues 1996-2000 (Outline). Henceforth, the system of livestock based on crop residues became the responsibility not only of the agriculture institutions, but a basic national policy. We can forecast an even greater rate of development in the future.

There are now outline plans to establish 20 demonstration prefectures nationwide, and 400 demonstration counties (250 for cattle and 150 for sheep and goats).

The Outline provides that, by the year 2000, China's beef production will reach 7 million tons, or hopefully 10 million tons. Mutton production will reach 3 million tons, aiming to reach as high as 4 million tons. By then, the proportion of beef and mutton within the total meat production of China will be raised to 20% or so from the present 12%.

By the year 2000, the proportion of crop residues utilized for feed will be raised from the present 25% to about 40% (or 240 million tons). Crop residue silage will reach 120 million tons and ammoniated crop residue 60 million tons, together saving about 40 million tons of feed grain. The ammoniation technique will be extended to 20 million farming households.

By the end of the century, the number of cattle at the year end will reach 167 million head, with 300 million head of sheep and goats. Cattle, sheep and goats would produce 2 billion tons of organic fertilizer annually, which can be used on 40 million hectares of farmland. With the use of large quantities of manure, soil will improve and large areas of stable high yielding farmland will emerge.

Main References

1. Livestock Based on Crop Residues. Shanghai Science and Technology Publishing House, 1995.
2. A Statistical Survey of China (1996). China Statistical Publishing House, 1996.

Feeding Draught Milking Cows in Integrated Farming Systems in the Tropics - Ethiopian Highlands Case Study

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Abstract

The evaluation of multipurpose cattle (milk, meat and work) is of importance in many tropical regions because of its direct and indirect effects on livestock and crop production.

The costs and utilisation of dietary nutrients are major determinants in the evaluation of the biological efficiency of multipurpose cows. Work can lead to a competition for energy precursors which may affect milk production and reproductive efficiency.

This paper deals with studies on work output, feed utilisation and lactation of crossbred (F1 Friesian and Simmental x Boran) dairy cows used for draught in the Ethiopian Highlands. Over a period of three years, work output of dairy cows averaged more than 200 MJ per cow per year of net energy which was greater than that required by farmers for land cultivation. The diet fed to cows contained 18 g/kg of N, 613 g/kg NDF (composed of 75% natural pasture hay and 25% concentrate). Work increased dry matter intake of roughage and in vivo dry matter digestibility by 10.7 and 6%, respectively. Digestion kinetics could explain only partially the possible mechanisms responsible for greater

roughage intake and digestibility in working cows. How work could affect either rumen fermentation processes or digestion in the lower digestive tract, as well as other processes involved in intake regulation of roughage diets, is uncertain.

Milk yield of two consecutive lactations was not significantly different for non-working and working cows. On-farm milk production of cows over a period of two years was similar for working and non-working cows (2,620 v. 2,980 kg, respectively).

Supplementation of working cows reduced liveweight loss by 73% and doubled the number of conceptions and parturitions compared to non-supplemented cows. Working cows that lost more than 15% of calving weight conceived when they had recovered 55% of their weight and 106% of their body condition loss, respectively. Even after extended periods of underfeeding, acyclic and anoestrous cows resumed ovarian cyclic activity in an average of 46 days and conceived in 75 days when fed about twice their maintenance energy requirements.

The economic analysis indicated that the value of work more than compensated for the small reduction in milk production and longer calving interval found in working cows when supplementation took place to ensure adequate nutrition.

In conjunction with the technical factors, systematic consideration needs to be given to the effects at the micro-level of socio-economic factors, including institutional and structural factors. The successful introduction of crossbred cows for milk and traction not only requires new feed production, feeding and management systems on-farm, but also would induce substantial changes in present mixed farming system practices. Therefore, there is a need to identify those technical and socio-economic factors which might affect such changes and hinder or promote these technologies.

KEY WORDS: Draught animal power, multipurpose, cow, milk, feed, Ethiopia

Introduction

In many developing countries, draught animal power is the best alternative power source at the intermediate technology level, because low wages and small farm size make it unattractive to substitute tractors.

The efficiency of animal traction in the smallholder context could be increased by adopting multipurpose animals to be used for meat and milk production as well as for draught power. Cows can use feed resources more efficiently than oxen and, if properly fed, can provide adequate work output for most cultivation practices (Matthewman, 1987). The use of cows for draught would allow males to be fattened and sold younger, and could also lead to greater security of replacements. More productive animals on farms could result in a reduction in stocking rates and overgrazing, thus contributing to the establishment of a more productive, sustainable farming system. Peri-urban farmers would be more inclined to change or modify their management system since their proximity to urban services would help minimise production risks (Gryseels and Goe, 1984).

In a growing number of tropical regions, cows are being used for draught particularly in areas where human population pressure on land has reduced farm size and thus has caused a decrease in feed resources for livestock (Matthewman, 1987). Research on the evaluation of multipurpose cattle (milk, meat and work) is of primary importance because of its direct and indirect effects on livestock and crop production. ILRI and the Ethiopian Institute of Agricultural Research (IAR) have studied different aspects of the use of dairy cows for draught work. This paper deals with on-station and on-farm studies on work output, feed utilisation and lactation of crossbred dairy cows used for draught in the Ethiopian Highlands. Information generated from ILRI and IAR research is used to elaborate the inter-play of factors affecting work output and lactation performance of dairy cows used for draught.

Work Output and Efficiency of Draught Dairy Cows

Results from Zerbini *et al.*,(1992) show that F1 crossbred dairy cows (Friesian x Boran and Simmental x Boran) were able to work at a rate of about 500 W. This represented about 14% of mean body weight with a work efficiency ranging from 7% to 26%. Over a period of three years, work output of dairy cows averaged more than 200 MJ per cow per year of net energy which was equivalent or above that required by farmers for land cultivation.

Feed Utilization in Multipurpose Cows

Feed is a dominant factor in animal production because of its major effect on milk yield, reproduction and work capacity. Furthermore, the costs and utilisation of the energy and nutrients in the ration are of great importance in the evaluation of biological efficiency of a multipurpose animal. Feed efficiency in cattle is influenced by diet and other environmental factors, genetic potential and physiological state of the animal (Korver,1988; Zerbini and Alemu G/Wold, 1995). Selection on gross feed efficiency could be relevant for multipurpose cows where the genetic correlation between work capacity or work output and feed efficiency has not yet been established.

Draught cows have higher nutrient requirements than oxen specially if they have to perform draught work during the early stages of lactation when nutrient supply has to cover the needs for work, lactation and reproductive activity. Under conditions where adequate feed is not available to maintain body weight, cows can still satisfactorily perform work by drawing on body reserves, but other functions such as lactation and reproduction could be impaired.

In multipurpose cows, especially those fed on poor quality diets, work may lead to competition for energy precursors which may in turn have an effect on milk production and reproductive efficiency. This effect could be greater than that occasioned simply by competition for energy-producing nutrients per se. When work is imposed on the lactating cow, it affects the partition of energy yielding substrates to the muscle and free fatty acids are mobilized from fat depots. At the same time, these metabolites are also precursors of milk components and competition will occur with other functions in the lactating, working cow. The diversion of amino acids away from protein synthesis might also be due to requirements by cows for glycogenic substrates to substitute for some of the roles that glucose normally plays under situations of glucose sufficiency. This is especially important in the dairy cow where glucose and amino acids are being used for milk synthesis in the mammary gland or in the gravid uterus.

Genotype may be important in the selection of cows that will adapt to draught work with minimal disruption to lactation. In addition, different physiological priorities in beef and dairy breeds will affect the efficiency of energy use and maintenance. A desirable trait of the lactating, working cows would be a large food intake capacity. Larger animals could be of considerable advantage in situations where high fibre roughages are utilised. Larger animals are more efficient chewers and spend less time chewing per kg of ingested cell wall constituents.

Multipurpose Cows: Performance in the Ethiopian Highlands

On-station Studies

Location and diet

The study was carried out at the Holetta Research Centre of the Ethiopian Institute of Agricultural Research (IAR) which is located in the central highlands of Ethiopia, 50 km west of Addis Ababa, at an altitude of 2400 m and with an annual rainfall of 1060 mm. Mean maximum temperatures range from 18.7 to 24.0 deg. C.

Crossbred cows (Friesian x Boran and Simmental x Boran) worked 4 hours/day, 100 days/year for three years. Work started two weeks after and was stopped one month before the expected calving date. Mean body weight of the cows was 412 kg. The diet was formulated to meet nutrient requirements of cows for maintenance, milk production, pregnancy and work (Australian Agricultural Council, 1990) and included natural grass hay fed ad libitum, 3 kg of concentrate (mix of 800 g/kg of noug cake (Guizotia abissinica), 150 g/kg of wheat mids, 30 g/kg salt and 20 g/kg bone meal; 25% CP and 11.4 MJ ME/kg DM) and mineral lick. Chemical composition and degradability parameters of the diet are shown in Table 1.

Table 1. Chemical composition and degradation characteristics(1) of the diet(2) fed to F1 crossbred cows used for draught.

	mean	s.d.
Dry matter	907	11
Organic matter	900	17
Nitrogen	18.0	2.1
NDF	613	40
a	18.9	0.7
b	52.9	4.8
c	0.03	0.004

1 Orskov and McDonald (1979)
2 Include 75% natural pasture hay and 25% concentrate.

Diet intake and utilization

Dry matter intake was greater for working compared to non-working cows (Table 2). Working cows increased DMI above that of non-working cows by 10.7% over a period of three years. Work increased DM and OM in vivo digestibility. Working cows must have absorbed more nutrients as indicated by the greater intake and greater digestibility of the feed. Digestion kinetics could explain only partially the possible mechanisms responsible for greater roughage intake and digestibility in working cows (Zerbini *et al.*, 1995).

A number of studies have reported no significant effect of work on feed intake in oxen (Lawrence, 1985) and buffalo cows (Bakrie and Teleni, 1991). Other studies indicate an increased feed intake in working buffalo cows (Ffoulkes *et al.*, 1987) and dairy cows (Gemeda *et al.*, 1995). Furthermore, some authors have reported negative or no effect of work on digestion in buffalo and cattle, depending on the diet fed (Pearson and Lawrence, 1992; Pearson, 1990), while others have shown a positive effect of work on digestibility (Pearson and Lawrence, 1992; Ffoulkes *et al.*, 1987).

Table 2. Organic matter digestibility and cumulative dry matter intake and work output of F1 crossbred cows used for draught over a period of three years.

Treatment	% n	Dry matter digestibility	Dry matter intake(kg)	Work output (MJ)
No work	10	51.0	10,603	-
Work	10	54.0	11,841	705.2
s.e.		0.7	375	-
F Work		P<0.05	P<0.05	-

How work could affect either rumen fermentation processes or digestion in the lower digestive tract, as well as other processes involved in intake regulation of roughage diets, is uncertain.

Degradation rate was not measured separately in working and non-working animals. It is, however, unlikely that physical work of the animal could affect the microbial degradation rate of fibre. Increased body temperature observed in crossbred cows at work (Zerbini *et al.*, 1992) could decrease gut motility, increasing retention time of feed in the rumen and feed digestibility. However, a decreased rumen retention time of solids due to work was not apparent.

Live-weight change and reproduction

Cows tended to maintain or gain body weight over three years. Body condition score was similar between working and non-working cows at the end of three years from the beginning of the study. Over a period of two years, supplementary feeding reduced body weight loss of cows by 80%. Supplementation of working cows reduced liveweight loss by 73% and doubled the number of conceptions and parturitions compared to non-supplemented cows.

Calving intervals of working cows (Table 3) were on average 90 days longer than those of non-working cows. Differences were greater and significant in the second calving interval.

It is possible that the depletion of body reserves to certain critical levels had signalled metabolic controls to switch off non-vital processes such as ovarian function. A clear definition of body weight and condition at the start of the work season and rate of weight loss which are compatible with normal ovarian activity is desirable, as well as the effect of interaction between work and body reserve nutrients on cyclic activities in cattle and buffaloes.

Work did not influence the conception ability of supplemented cows, but had a substantial influence in non-supplemented cows.

Table 3. Calving intervals of F1 crossbred cows used for draught over a period of three years.

Treatment	Calving intervals			
	n	1	n	2
No work	10	415.6	8	397.8
Work	9	491.6	7	502.0
s.e.		31.2		31.5
F work		NS		$P<0.05$

Lactation parameters

Ninety per cent of non-working and 70% of working cows completed two lactations over a period of three years (Table 4). Milk yield of two consecutive lactations was not significantly different for non-working and working cows. However, days in milk were significantly greater for working cows.

The greater calving intervals observed in working cows is consistent with the delay in conception after parturition reported for working/supplemented compared to non-working/ supplemented cows by Zerbini *et al.* (1993). The relatively fewer number of lactations completed as well as conceptions, and greater days in milk of working cows, over a period of three years, reflects the delayed conception in working cows. Once pregnancy was established there was no effect of work on maintenance of pregnancy

Table 4. Lactation yield (kg) and days in milk of F1 crossbred cows used for draught

Treatment	Lactation 1			Lactation 2		
	n	milk yield	days	n	milk yield	days
No work	10	1777.7	321.0	9	1446.7	303.3
Work	10	2010.8	443.2	7	1685.5	427.0
s.e.		247.7	38.3		181.8	41.0
F work		NS	P<0.5		NS	P<0.07

Even under conditions where adequate feed supplementation was not vailable to maintain body weight, such as for working/ non-supplemented cows, animals could still satisfactorily perform work by drawing on body reserves and increasing dry matter intake. However, Gemeda *et al.* (1995) indicated that if such a situation exists for as long as one year, cows could lose more than 15% of their calving body weight and reduce milk production by more than 50% compared to working/ supplemented cows.

Working cows that lost more than 15% of calving weight conceived when they had recovered 55% of their weight and 106% of their body condition loss, respectively. Body weight gain appears to lag behind condition score increases and recovery of body weight seems to be less important than recovery of body condition for conception to occur. Even after extended periods of underfeeding, acyclic and anoestrous cows resumed ovarian cyclic activity in an average of 46 days and conceived in 75 days when fed about twice their maintenance energy requirements. The economic implications of long periods of low productivity or maintenance in working and non-working cows, and the requirements for resuming reproductive activity, need to be evaluated in detail especially for farming systems with large fluctuations in availability of feed resources.

On-farm Studies in the Ethiopian Highlands

The on-farm testing of cow traction technologies was designed to evaluate the effect of draught work and management on production and economic performance of crossbred dairy cows on the smallholder farm. The approach used in testing the dairy-draught cow technology and its transfer on-farm has been interdisciplinary.

Pairs of crossbred cows (120 F1 Friesian x Boran) were purchased by selected farmers in 1993 and 1995 in the Holetta area. Stratification of participating farmers into low, middle and high income groups was based on land and livestock holdings, livestock type and labour availability, total farm assets and location.

Preliminary on-farm research results on cows performance (Table 5) have shown that milk production of working and non-working F1 crossbred cows on-farm was similar (2620 vs 2980 kg), ranging from 2010 to 3,400 kg for working cows and from 2018 to 3907 kg for non working cows. Calving intervals for working and non-working cows were 525 and 495 days, respectively. First lactation average milk yield and days in milk of working and non-working cows were 1,864 and 2252 and 376 and 410 days, respectively. Service per conception for working and non-working cows were similar. Over a period of two years cows worked an average of 26 days/year.

During working days, energy requirements of cows could increase by more than 1.5 maintenance. Increased feed requirements could be met by production and feeding of mixtures of grasses and legumes to increase digestibility and energy intake of cows to levels which would allow them to support both milk production, reproduction, and work with acceptable physiological body weight loss. Alternatively, feeding of natural pasture hays and improved quality crop residues associated with concentrate feeding or multipurpose tree foliage during early lactation and pregnancy could allow optimal performance of draught cows and make effective use of on-farm resources. Application of technologies for better use and conservation of natural sources of fodder during particular periods of the year needs particular attention.

Table 5.Performance parameters of draught crossbred cows under on-farm conditions.

Parameter	Working cows (n=14)	Non-working cows (n=14)
Milk Production (first Lactation, kg)	1,864	2,252
Milk Production (two years, kg)	2,620	2,980
Calving Interval (days)	525	495
Lactation Lengths (days)	376	410
Service per conception (No.)	2.1	1.9
Work days/Year	26	0

Anthropological Survey

An anthropological survey of farmers participating in the project and non-participating farmers suggests that, despite reservations, many farmers are willing to try cows for milk and draught work. Those who believe that cows can plough are younger and better educated, have slightly smaller households, and considerably smaller crop land, grazing land and herd size. More than a third of the farmers objecting to cow traction believe that there are pragmatic problems while less than a quarter believe there are cultural or technical problems. The most important technical problem mentioned by farmers relates to the cows' ability to plough and give milk simultaneously. Social reasons against cow traction relate to community pressure to stick to existing norms of behaviour, and the fear of acting in ways which do not conform. Cultural, moral and social reasons for not using cows for traction appear to be given when there actually are more important underlying reasons which can be overcome with sufficient farmer testing of the technology (Pankhurst, 1995).

While in the medium term the technical feasibility and the investment/cost ratio, as well as social factors, will affect the acceptance of cow traction technologies, in the long run, the diffusion of crossbred cows will depend on the extension of the results of the study. The environment for dairy development, including government policies and services, especially credit, veterinary and breeding services, will also be critical.

Indicators for on-farm cow traction technology adoption could include: 1) farmers continuing to use cows for ploughing after the research project ends; 2) farmers who have received crossbred cows reducing the number of their local cattle; 3) farmers in the research area who were against cow traction changing their mind; and 4) new farmers spontaneously adopting cow traction technologies.

Economic Implications

The potential of the use of crossbred cows for milk production and traction was substantiated by simulating the production parameters and investment returns over a three-year period using the ILCA bio-economic herd model (Shapiro *et al.*, 1994). The effect over time of introducing crossbred dairy cows into a typical farm herd of local cattle for work and milk production were also simulated and compared to using the local cows for milk production and local oxen for traction. Then the financial implications were investigated using incremental benefit/cost analysis. The incremental benefit/cost ratio of having supplemented working cows over the traditional system of local cows and oxen is about 3.5 and the internal rate of return (IRR) is 78%. The incremental benefit/cost ratio is high because of the very high productivity of the crossbred cows (5-6 times milk yield) relative to local cows.

The value of work more than compensated for the small reduction in milk production and longer calving interval found in working cows when supplementation took place to ensure adequate nutrition. The greater returns on investment in supplemented, working crossbred cows was thus mainly a result of the higher value of the work output, in spite of the higher feed costs and lower off-take (milk and calves).

In conjunction with the technical factors, systematic consideration needs to be given to the effects at the micro-level of socio-economic factors, including institutional and structural factors. This research would also help policy makers to choose more effective policies and programmes to develop and promote widespread diffusion of new technologies.

Conclusions

The results from this study indicate that draught work induced an increase in forage intake and digestibility. The attempt by working cows to increase intake to meet energy requirements even when fed relatively poor quality forage is important. Further experimentation needs to be conducted to identify and evaluate important traits in multipurpose cattle which could allow increased efficiency of resource utilisation. These traits could then be used in crossbreeding and selection programs to produce the most appropriate cattle type to optimise utilisation and equilibrium of on-farm resources. Genetic aspects of traits related to feed utilisation and work capacity should receive particular attention.

The successful introduction of crossbred cows for milk and traction not only requires new feed production, feeding and management systems on-farm, but also would induce substantial changes in present mixed farming system practices. Herd composition and requirements of farms are expected to substantially change, and result in a more efficient/higher productivity system (Shapiro e al., 1994). Therefore, there is a need to identify those technical and socio-economic factors which might affect such changes and hinder or promote these technologies.

As regards feeding multipurpose animals, much fundamental work still needs to be done to obtain a better understanding of the factors which affect the partition of nutrients between work, milk production and liveweight gain. In particular, their preference over oxen could contribute to a better utilisation of already scarce feed resources. Additional research should be done on the management and nutritional requirements of the lactating draught cow and possible ways to meet its nutrient needs, especially in early lactation when the high energy demand for lactation is associated with work energy needs. Research and extension must therefore determine ways of producing adequate feed on the farm for draught animals and to evaluate locally available sources of supplements .

Multidisciplinary research projects should investigate the technical and economical relationships between alternative combinations of animals, implements and soil in diverse regions. A system-analysis-approach-based model should be developed to describe the systems.

References

Australian Agricultural Council (AAC). 1990. Feeding Standards for Australian Livestock. Ruminants. Ruminant subcommittee, CSIRO, Australia.

Bakrie , B. and Teleni, E. 1991. The effect of time of feeding in relation to work in draught animals. 1. The effect of feeding high fibre diet either before or after work on feed utilisation and physiology of working buffaloes. Draught Animal Power Project, DAP Project Bulletin, No. 1, pp. 39-45 James Cook University, Townsville (Australia).

Bamualim, A., Ffoulkes, D. and Fletcher, I.C. 1987. Preliminary observations on the effect of work on intake, digestibility, growth and ovarian activity of swamp buffalo cows. Draught Animal Power Project, DAP Project Bulletin, No. 3, pp. 6-10. James Cook University, Townsville (Australia).

Ffoulkes, D., Bamualim, A. and Panggabean, T. 1987. Utilization of fibrous feeds by working buffaloes. In: Ruminant feeding systems utilizing fibrous agricultural residues. R.M Dixon (ed.). p 161-169. International Development Program of Australian Universities and Colleges. Camberra.

Gemeda, T., Zerbini, E., Alemu G/Wold and Dereje Demissie. 1995. Effect of draught work on performance and metabolism of crossbred cows. 1. Effect of work and diet on body weight change, body condition, lactation and productivity. Animal Science 60:361-367.

Gryseels, G. and Anderson, F.M. 1985. Use of crossbred dairy cows as draught animals: experiences from the Ethiopian highlands. In Research Methodology for Livestock on farm trials. Proceedings of a workshop held March 25-28 at Aleppo, Syria. p.237-258. International Development Research Centre, Ottawa.

Gryseels, G. and Goe, M.R. 1984. Energy flows on smallholder farms in the Ethiopian highlands. International Livestock Centre for Africa, Addis Ababa, Ethiopia. ILCA bulletin 17:2-9.

Korver, S. 1988. Genetic Aspects of Feed Intake and Feed Efficiency in Dairy Cattle: A Review. Livest. Prod. Sci. 20:1-13.

Lawrence, P.R. 1985. A review of the nutrient requirements of draught oxen. In: Draught Animal Power for Production, Copland, J.W. (ed), ACIAR Proceedings 10:59-63.

Matthewman, R.W. 1987. Role and potential of draught cows in tropical farming systems: a review. Tropical Animal Health and Production 19:215-222.

Orskov, E.R. and McDonald, I. 1979. The estimation of protein degradability in the rumen from incubation measurements weighted according to rate of passage. Journal of Agricultural Science Cambridge 92:499-503. Pankhurst, A. 1995. Crossbred cows for dairy production and traction. A report based on case studies of 131 farmers and their attitudes to the Holetta project. ILRI Internal report. 95 pp.

Pearson, R.A. 1990. A note on live weight and intake and digestibility of food by draught cattle after supplementation of rice straw with the fodder tree Ficus auriculata. Animal Production 51:635-638.

Pearson, R.A. and Lawrence, P.R. 1992. Intake, digestion, gastrointestinal transit time and nitrogen balance in working oxen: studies in Costa Rica and Nepal. Animal Production 55:361-370.

Shapiro, B.I., E. Zerbini and Takele Gemeda. 1994. The Returns to Investment in the Dual Use of Crossbred Cows for Milk Production and Draught in the Ethiopian Highlands.

Zerbini, E., Gemeda, T., O'Neill, D.H., Howell, P.J. and Schroter, R.C. 1992. Relationships between cardio-respiratory parameters and draught work output in F1 crossbred dairy cows under field conditions. Animal Production 55:1-10.

Zerbini, E., Gemeda, T., Franceschini, R., Sherington, J. and Wold, A.G. 1993. Reproductive performance of F1 crossbred dairy cows. Effect of work and diet supplementation. Animal Production 57:361-369.

Zerbini, E., Gemeda, T., Wold A.G. and Dereje Demissie. 1995. Effect of draught work on the metabolism and reproduction of dairy cows. 2. Effect of work on roughage intake, digestion.

Zerbini, E. and Alemu G/Wold. 1996. Output/Input ratios in multipurpose cattle. Proceedings of the 4th. National Livestock Improvement Conference, institute of Agricultural research, Addis Ababa, Ethiopia.

The Role of Low-cost Plastic Tube Biodigesters in Integrated Farming Systems in Vietnam

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Abstract
The introduction of polyethylene tube digesters on small farms in Vietnam has made a good impact because of the low costs, the simplicity of construction and operation, high rate of benefit, positive effects on the environment and improvement of women's lives in rural areas. The biodigesters have become an important component of integrated farming systems in rural areas.

The conclusions of this study point to the importance of farmers' participation in technology feedback, and farmer-to-farmer teaching. To ensure adequate farmer motivation, the "demonstrators" should be "real" farmers in areas where alternative fossil fuels and firewood are expensive. Access to credit facilitates uptake by the poorest farmers. Subsidies are not necessary. Close linkages between farmers, extensionists and scientists are important for ensuring effective follow-up of the technology and to correct problems.

The low-cost plastic digester technology has still not been fully developed and more studies are needed, especially in regions with different natural and social conditions. Research based on farmer participation is proposed as the model for further activities.

KEY WORDS: biodigesters, farming systems, integration, socio-economics, on-farm development

Introduction

For the past 10 years or so, Vietnam has adopted modern farming techniques that use imported agro-chemicals and fossil-fuel products in order to increase exports of agricultural products and feed its population which has grown to 75 million. The rising environmental problems and costly socio-economic dependence on external inputs have alarmed certain leaders and many of the population. Facing this situation, the use of environmentally-friendly techniques at all levels of farming have had an important role in rural development. Low cost plastic biodigesters make efficient use of manure in the integrated farming system to produce gas for cooking and effluent to fertilize ponds for fish, aquatic plants and crops, bring advantages to the economy and to the environment. They have been adapted from the "bag" digester or Taiwan model, simplified by using cheaper polyethylene tubular film to replace the welded PVC sheet.

Many developing countries, such as Colombia, Ethiopia, Tanzania, Vietnam, Cambodia and Bangladesh, have promoted the low-cost biodigester technology, aiming at reducing the production cost by using local materials and simplifying its installation and operation. Within three years, more than 1000 polyethylene digesters were installed in Vietnam, mainly paid for by farmers. This report discusses the role of plastic biodigesters in integrated farming systems in Vietnam and describes experience with the introduction of biodigesters under local conditions.

Biogas in Developing Countries

After 1975, slogans such as "biogas for every household" led to the construction of 1.6 million digesters per year in China, mainly concrete fixed-dome digesters. Up to 1982, more than seven million digesters were installed in China (Kristoferson and Bokhalders, 1991). In 1980, more than 50% of all digesters were not in use (Marchaim, 1992). The rapid development of biogas in China received strong government support and sometimes subsidies from local government and village government were up to 75% (Gunnerson and Stuckey 1986). In recent years, the number of plants built each year has fallen dramatically because of the reduction in subsidies with a consequent switching from biogas to coal as a fuel.

The biggest constraint in the biogas programmes has been the price of the digesters. It was also learned that the popularization of biogas would only be successful when the direct benefits to the farmers were obvious.

In many respects, the same situation as in China prevailed in India where a rapid biogas digester implementation policy exceeded the capabilities of India's research and development organizations to produce reliable designs and to optimize digester efficiency. As a result, earlier digesters in the country were expensive and inefficient. This situation has been remedied somewhat in recent years. According to Kristoferson and Bokhalders (1991), new developments and designs are not incorporated as rapidly as they might, and improved coordination and feedback will be required if development is to be achieved. The poor performance of earlier biogas digesters can also be attributed to poor backup services. This situation, which is still largely prevalent, has led to a relatively high breakdown rate. Problems can be classified as (a) design faults; (b) construction faults (c) difficulty of financing; (d) operational problems due to incorrect feeding or poor maintenance and (e) organizational problems arising from the differences of approaches and lack of coordination.

Biogas production has been stimulated by popular publicity campaigns and subsidized construction of biogas plants by central and local governments. The floating cover design, introduced by the All-Indian Coordinate Biogas Programme, is the most common system currently in use in India. This system is more expensive than the fixed dome (Chinese) digester. Despite having the world's second largest number of installed biogas digesters, the biogas program has mainly concentrated on the expensive systems capable of being installed only by the wealthier inhabitants in the rural areas (Kristoferson and Bokhalders, 1991). India has placed far more emphasis on the survival of small-scale farmers than ensuring their efficiency and growth in a competitive environment through various policy instruments like the biogas programme.

The situation is almost the same in many other developing countries, such as the Philippines, Thailand, Nepal, Brazil. For example in Nepal, many authors considered that, with the installation of more than thirteen thousand biogas plants, the strategic plan and activity of biogas program implementation was gaining more popularity and becoming a well developed example of technology dissemination. The government has provided up to Rs 7000 for a plant built in the lowlands and Rs 10000 in the hill areas (about 30-70% of the cost for construction). According to a report from the Consolidated Management Services Nepal, although biogas was introduced in Nepal about two decades ago, the present infrastructure seems so weak that there is still the dependency upon foreign countries for supply of some biogas accessories and equipment. With subsidies of more than 50% of the cost of a family size plant, many farmers who demanded biogas plants were more attracted to the amount of available subsidies than by the utility of the plant as such. Many newly-formed private companies were finding their business quite profitable and a considerable part of the government subsidy was taken by these companies as profit (Karki *et al.*, 1994). Without subsidies the simple pay-back period varied between 6 and 12 years in Nepal.

In many developing countries, frequent changes in government policies on interest rates and subsidies have also had negative impacts on biogas dissemination. These changes have disappointed the investors in long-term biogas development. The progressive farmers who would like to have biogas also become doubtful about their long-term biogas investments.

Biogas production was introduced into Vietnam more than 10 years ago as an alternative source of energy to partially alleviate the problem of acute energy shortage for household uses. Biodigesters of various origins and designs were tested in rural areas under different national and international development programmes, using household or farm wastes as fermentation substrates. Indian-type, Chinese-type and ferro-cement-type digesters were installed and evaluated in many provinces but concentrated in urban areas (Thong *et al.*, 1989; Khoi, 1989). However, few farmers used them in practice.

The poor acceptability of these concrete digesters was mainly due to: (a) high cost of the digesters; (b) difficulty in installing them; and (c) difficulty in obtaining spare parts for replacement. A digester of a size adequate for the fuel needs of an average family would normally cost

VND 1.8 to 3.4 million (US$ 180 to 340) (Thong, 1989). This scale of investment is considered unaffordable by the average farm family (An *et al.*, 1994). In addition, it would take about 2.5 to 3.5 years to pay back the initial investment (Thong, 1989; Khoi *et al.*, 1989). Besides, the replacement of worn-out parts posed another technical problem, apart from the fact that such spare parts are not always locally available. Khoi *et al.*, (1989) reported that 33% of biodigesters installed in Cantho City had stopped functioning while only 8 out of 17 of those set up in Quangnam-Danang Province were still operable.

Vietnam is a nation with a low gross national product per capita, so getting support for any kind of environmental program is difficult. Without the support from the Vietnamese government or from overseas, the concrete digester development is progressing slowly. Only the richest farmers in rural or peri-urban areas can afford the construction of concrete digesters. The development of concrete biogas digesters is therefore not sustainable in rural areas. To disseminate the biogas fermentation technology in rural areas, it is necessary to reduce the cost and use simple means of construction.

Low-cost Polyethylene Tubular Digester

In the light of these constraints, many developing countries such as Colombia, Ethiopia, Tanzania, Vietnam, Cambodia, Bangladesh have promoted the polyethylene tubular digester technology, aimed at reducing the production cost by using local materials and simplifying its installation and operation. To this end it was decided to use a continuous-flow flexible tube biodigester based on the "Taiwan" model and later simplified by Preston and co-workers (An *et al.*, 1994). The low-cost biodigester technology has been well received by poor smallholder farmers in Vietnam for producing a clean fuel to replace firewood. Within three years, more than 800 polyethylene digesters were installed in Vietnam, mainly paid for by farmers (An and Preston, 1995).

Data on the design parameters and cost of digesters around Ho Chi Minh City are presented in Table 1. The average length of the digesters was 10.2 m with an estimated digesta volume of approximately 5.1 m^3 (length x 0.5 m^3). The material cost was slightly more than US$25 for a family digester.

Table 1: Mean values for some design parameters and cost of 194 digesters installed around Ho Chi Minh City

	Mean	Range
Length (m)	10.2	4 - 30
Digester liquid volume (m^3)	5.1	2 - 15
Distance to kitchen (m)	23	8 - 71
Material cost (US$)	25.4	14 - 82
Time to first gas production (days)	17	1 - 60
Digesters in rural areas(%)	91	
Floating digesters (%)	5	

Source: An *et al.*, 1996.

However, the biodigesters are still not fully integrated into the farming system as there is only limited use of the by-product (the effluent) as fertilizer for vegetables, fruit trees, fish and water plants (An *et al.*, 1994). The use of the effluent from biodigesters should be studied as a resource for small scale farmers. The farmers always put questions about quantities of manure fed to the digester, ratios between manure and water, time of cooking, quantities of gas produced and the useful life of biodigesters. The relevant data almost all comes from temperate countries and from concrete biodigester plants.

Extension of the technology has had different successes in different countries. It has been successful in Colombia, Vietnam and Cambodia but there have been negative reports from other countries such as Bangladesh, Nepal and Tanzania. The same technology was used but different results were obtained. The difference is not only between countries but also in different areas of a country (An *et al.*, 1996). Many authors presented the advantages of low cost and easy installation of the plastic digesters; meanwhile some have been doubtful of life expectancy of the digester and the ability to repair it.

It is necessary to study the constraints in each area carefully and seek experiences from institutions with knowledge in this field. All institutions and personnel who are involved in the biogas research and development should be informed about experiences and results obtained elsewhere. The electronic mail system is one of the most appropriate means to this end.

In most developing countries, when the subsidies from governments are reduced, the number of plants built each year falls dramatically. The most important problem in biogas programs in developing countries has been the price of digester plants. For example, the price of a concrete digester plant installed for an average family in Vietnam varied from 180 to 340 US$ (see above). Chinese designers tried to reduce the cost of red-mud digesters to 25-30 US$/m^3 (Gunnerson and Stuckey 1986) but it was still high in comparison with the polyethylene digesters (5 US$/m^3). This is obviously one important feature which makes the polyethylene digesters attractive and no farmer in the present study complained about the price.

Among the polyethylene digesters installed, 5% of them were floated in ponds, adding an innovative feature to the development. According to Khoi *et al.* (1989), in the Mekong Delta where most land is low-lying, the application of concrete digesters was very difficult especially when the water level went up. The floating digesters solved this problem and, as they also required little space, they were very well suited for use in low-lying areas. More than 90% of the plants were installed in rural areas indicating the good impact of the technology in these parts of Vietnam.

Introduction of Biogas to Small Farms in the Thuan An District

The effects of the introduction of digesters on small farms are presented in Tables 2-5 (An *et al.*, 1996). Most of the farms with biodigesters belonged to the medium-income group (sufficient food all year around). In this group animal production is a very important component of their farming systems and a sufficient number of animals is important for the dissemination of biodigesters. The expense for the digester plant was paid back within slightly more than 5 months, so most of the farmers found a great benefit from installing digesters.

Table 2: Economic aspects of biogas introduction in 31 small farms in Thuan An district, Vietnam

	MEAN	RANGE
Cooking time (hour)	4.4	1 - 9
Fuel saved in cooking (US$/month)	6.5	1.8 - 13.6
Biogas plant cost (US$/unit)	34.8	18 - 53
Number of pigs/farm	10.7	0 - 40
Payback time (month)	5.4	2 - 19

Source: An *et al.*, 1996.

Table 3: Farmers' participation and opinions on plastic biodigesters in Thuan An district, Vietnam

ALTERNATIVES	No.*
Getting first information from	
Neighbours or relatives	32
Mass media	3
Payment of the digester plants	
Farmers paid totally	33
Partially (demonstration)	2
Using slurry for	
Plants	3
Ponds	3
Nothing	31
Status of gas production	
Enough gas	26
Little gas	5
No gas	4
Advantages of biogas	
Saves money	34
Less pollution	35
Easy cooking	35

*No: Number of farmers
Source: An *et al.*, 1996

Table 4: Input and output of 31 digesters working at small farms around Ho Chi Minh City, Vietnam

	MEAN	RANGE
Size of family	5.9	3 - 12
Manure loading (kg/d)	16	2 - 27
Ratio Water/manure	5.1	2.9 - 8.1
Loading rates (kg DM/m^3)	0.7	0.1 - 1.2
Temperature of loading (deg C)	26.4	25.7 - 28.5
Temperature of effluent (deg C)	27.0	26.0 - 29.1
pH of loading	6.7	6.4 - 7.1
pH of effluent	7.2	6.8 - 7.5
Gas production (l/unit/day)	1235	689 - 2237
Vol. Gas/capita (l/person/day)	223	68 - 377
Methane ratio (%)	56	45 - 62
COD of loading (g/litre)	35.6	22.4 - 46.0
COD of effluent (g/litre)	13.5	8.8 - 23.9
COD removal rate (%)	62 4	2 - 79

COD = Chemical Oxygen Demand
Source: An *et al.*, 1996.

Table 5: Effect of biodigestion on some microorganisms of manure in small farms in Vietnam

	MEAN	RANGE
E. coli of loading (10^{3}cell/ml)	52,890	11,000 - 150,000
E. coli of effluent (10^{3}cell/ml)	75	2 - 450
Coliforms of loading (10^{3}cell/ml)	266,780	11,000 - 480,000
Coliforms of slurry (10^{3}cell/ml)	236	7 - 250

Source: An *et al.*, unpublished.

Among 35 farmers interviewed, four of them were poor (not enough food in certain months). The most important thing for them is food and they could not afford a sufficient number of animals for feeding manure to the digester. They wanted to borrow money to be able to raise animals. Four farmers had no gas when the interview was carried out. Three of them did not have animals because they found raising animals unprofitable if they had to borrow money from local lenders at 5-10% monthly interest. This was an important aspect, especially as resource-poor farmers cannot support the digester installation and keep animals, although they know the advantages of biogas.

The average DM percentage of manure was 25% and the loading rates ranged from 0.1 to 1.2 kg DM/m^3 digester liquid volume.

Previously, animal manure was an environmental problem in villages in the district, mainly in crowded and lowland areas where it caused pollution of the air, water and soil. After installation of the digesters, all 35 families recognized better environmental conditions, less smell, fewer flies, cleaner waste water, etc. Summarizing details of experiments conducted with pig slurries, Pain *et al.* (1990) concluded that the digestion reduced odour emission by between 70 and 74%. According to the women who were responsible for food preparation, use of biogas meant that they could attend to other work, while cooking. This is in contrast to the situation when using solid fuels such as firewood which require much closer supervision. The women stressed that they could now cook in a clean environment, free of smoke. Their pots and pans were clean and they did not have to spend time on tedious cleaning. They stated that they could cook all food items on gas.

In the study, biodigestion decreased COD from 35610 mg/lit in the inlet to 13470 mg/l in the effluent, indicating a process efficiency of 62% (COD removal rate). The digestion in biodigesters reduces the pathogens in waste water so it prevents contamination from animal production. The volume of gas per capita per day was about 200 litres, enough to cook three meals. The loading rates were low and gas production could be improved by increasing the amount of manure fed to the digesters. Beside cooking meals, five farmers cooked animal feeds, three made wine, one made cakes and two prepared tea and coffee in their cafeterias. This demonstrates that there are several reasons for uptake, as discussed by Dolberg (1993).

An on-farm study on the use of slurry for some crops was carried out to evaluate the effect of biodigesters in farm economics. The results were presented in table 9. The crops were Lilium flower, elephant grass and sweet potato. The use of slurry increased by 100% the benefit of biodigester introduction in comparison with gas use only.

Technical Problems with the Plastic Digesters

Main causes of damage to the digesters were the sun, falling objects, people and animals (Table 6).

Table 6: Technical problems with polyethylene tube digesters in Thuan An district, Vietnam

DAMAGE BY	LOCATION OF DAMAGE			
	Digester	Reservoir	Others	Total
Sun	4			4
Falling objects	2	1		3
People	2	1		3
Animal	1	1		2
Material quality	1		1	2
Wind		2		2
Overloading	1			1
Total	11	5	1	17
Self-help *	6	5	1	12

* Farmers fixed digesters by themselves
Source An *et al.*, 1996.

In cases when the digesters had been totally exposed to the sun, the plastic film was broken after 2 years. Seven digesters had films older than 2 years and four of them had been changed by technicians or farmers. The material cost for changing was about 15 US$ and one working day was needed. Most digesters installed during 1995 were protected by roofs made from local materials, mainly palm leaves. Also, simple fences were made around the digesters to prevent damage from animals or people.

Slightly more than 40% of the biodigester plants had problems especially with the plastic tubes. An interesting observation was that in 12 out of 17 cases the farmers could correct the problems by themselves and only in 5 of the cases did they need help from technicians. Repairs were mainly simple and farmers could teach each other. The first farmers who had digesters installed more than 2 years ago needed help from technicians, while farmers who had installed their digesters within the last year could resolve their problems by themselves. They had received information, experience and guidance from their neighbours. With increasing age of the plants more problems would be expected. Nevertheless, as more plants are installed in a village, there would be more experienced farmers to do repairs and the help required of technicians would therefore be less. Also if there are good written instructions summarizing experiences from users, demand for the technical personnel will be less. This result shows that technical problems with the polyethylene digesters were resolved more easily than with other materials, such as concrete, steel and red mud. In many developing countries, the biogas programmes have failed because of inefficient maintenance due to lack of technical personnel (Kristoferson and Bokhalders, 1991). When the farmers do not take care of the digesters, only a small problem can cause gas production to cease, making the farmers disappointed. The participation of the farmers has played an essential role in the dissemination of the technology. Some digesters which were not studied were installed by farmers themselves in the district.

Problems in the Extension of Biogas Technology

There are some constraints and problems in the dissemination of biogas technology in developing countries. The question is how to solve them and what priorities to make. Some of the biggest problems at Bavi and Thuduc areas were pointed out in Table 6 in order of priority. The number still working after 2 years is shown in Table 7. In Bavi, the most important problem was unsuitable selection of demonstration farms (where the main income was not from farming activities) which resulted in low feedback from farmers on the technologies of installing, maintaining and repairing the digesters (Table 8).

Table 7: Comparison of demonstration farms and digesters installed at two extensionist groups in Vietnam

	BAVI	THUDUC
DEMONSTRATION FARMS:		
Total participants	7	8
Main income from agriculture	1	6
Government employees	6	0
Enough fire wood	3	0
Enough wood & lack of manure	1	0
DEMONSTRATION DIGESTERS:		
Still working after 2 years	2	6
Enough gas produced	0	6

Source: An *et al.,* 1996.

Table 8: Problems in plastic tube biodigester development in order of priority according to the extensionists in two extension centres in Vietnam

	BAVI	THUDUC
1	Extension methodology	Investment of poor farmers
2	Installation technology	Plastic quality
3	Unstable animal production	Unstable animal production
4	Investment of farmers	Technical maintenance
5	Plastic availability	Efficiency of gas production & use
6	Plastic quality	

Source: An *et al.* 1996.

More careful selection of demonstration farms would increase the degree of farmer participation in digester introduction and provide technical feedback. In the first year, the Thuduc group installed 60 digesters on the principle of "farmer pays" in order to strengthen their motivation. Full-time farmers (most activities are on-farm) with high demands for fuel were selected as demonstrators. They devoted more time to their farming activities and were more motivated to look after the digesters carefully, and considered the digesters as "animals". Several meetings between farmers and extensionists were held. Many small but important innovations were learned from farmers when extensionists spent time working and discussing with them. After 3 years more than 200 units have been installed by the Thuduc group and the technology has been improving.

There have been many ways to spread the technology within and out of the country and the principles are as follow:

- Visits of groups of professionals, students, farmers to farmers where the technology is already in use, to exchange experiences
- Courses for farmers (small, medium and large scale) and for technicians and professionals
- Workshops and field days
- Manuals
- Videos and TV
- Through other NGOs and governmental institutions within and outside the country

Although biogas technology has been developing steadily around Ho Chi Minh City, there are still many questions from farmers, such as amounts of loading of on-land and floating digesters, how to prolong plastic life under farm conditions, how to use slurry for crops if the fields are far from the digester, incorporation of fish ponds and other uses of the gas, etc. Other issues, such as investment problems for poor farmers, variable animal production and plastic quality were also mentioned. Many aspects involved in the technology should be studied carefully under real farm conditions. Sustainable use of natural renewable resources will be facilitated when the feed is grown, the animals are fed and the excreta are recycled on the farm in ways that reduce the use of imported inputs including energy (Preston, 1995). This idea has been displayed in integrated farming systems in many developing countries in South East Asia. In this respect, Dolberg (1994) pointed out the need to develop the ability of researchers to be sensitive to the farmer's perspective and convert feedback from farmers into hypotheses for research and new possible solutions, which would then have to go through the same iterative process of trial and error. On-farm work will accelerate the research process and make it move faster than if the scientists confine themselves to the research station and laboratory. In order to realize this process, the professional agriculturists in developing countries should be re-trained for sustainable tropical agriculture in their home countries.

Allowing some time for the farmers to "digest" the biodigester technology is essential. It took about 3 months from the time the first digester was installed as a demonstration to the moment when the first digester was purchased by a farmer. It took an additional 6 months for the first digester to be installed by a farmer by himself (An and Preston, 1995). It is essential to strengthen the relationship between farmers and scientists in order to receive the feedback. An important condition for success of that approach is that the leading scientists take it seriously and are prepared to spend time in the field with farmers, showing how to deal with feedback from farmers and to convert it into researchable problems.

It should be noted that the technology of the polyethylene tubular digesters is not fully developed and the technology depends very much on natural, as well as socio-economic conditions. Therefore, it is necessary to study on-farm conditions in different areas in order to improve the technology. An exchange of experiences between institutions should take place which should improve results. Communication between the institutions and between technical personnel is not sufficient. A network of all institutions and people involved in biogas technology should be built within the country and overseas.

Conclusions and Recommendations

The plastic tubular biodigester technology is a cheap and simple way to produce gas for small-scale farms in Vietnam. It is appealing to rural people because of the low investment, fast payback, simple technology, positive effects on the environment, farming system and women's lives in rural areas. The farmers' participation is essential in technology feedback, maintenance, repair and education of other farmers. The extension of the technology requires the farmers' motivation which can be ensured by selecting full-time farmers with high fuel demands for demonstrations, supporting credit systems for poor farmers and strengthening farmer-extension-scientist relations. In future, research should start by involving farmers, creating feedback from the farmers and letting this feedback serve as a foundation for the formulation of research problems. One immediate problem to attend to is the use of the slurry.

Finally, an economic analysis of the benefits of biogas technology is shown in Table 9.

Table 9: The economic analysis of the introduction of biodigesters in some farmers around Ho Chi Minh City.

	Farmer 1	Farmer 2	Farmer 3	Average
Save from fuel (USD/month)	3.9	5.0	4.5	4.5
Gain from crops (USD/month)	3.6	5.9	3.6	4.4
Cost of biodigester (USD/unit)	30	45	35	37
Payback time (month)	4	4.1	4.3	4.1

Source: An, unpublished.

References

An But Xuan, Man Ngo Van, Khang Duong Nguyen, Anh Nguyen Duc & Preston, T R, 1994. Installation and Performance of low-cost polyethylene tube biodigesters on small scale farms in Vietnam. Proc. National Seminar-workshop in sustainable Livestock Prod. on local feed resources. Agric. Pub. House Ho Chi Minh, pp.95-103.

An Bui Xuan, Preston, TR and Dolberg, F, 1996. The introduction of low-cost polyethylene tube biodigesters on small scale farms in Vietnam, Livestock Research for Rural Development, 8:1.

An Bui Xuan and Preston, T R, 1995. Low-cost polyethylene tube biodigesters on small scale farms in Vietnam. Electronic Proc. 2nd Intl. Conference on Increasing Animal Production with Local Resources, Zhanjiang, China, p. 11.

Dolberg, F., 1993. Transfer of sustainable technologies in Vietnam. Development of Sustainable Livestock Technologies for Ecologically Fragile Zones in The Tropics. SIDA MSc course in sustainable livestock production systems Report.

Dolberg, F., 1994. The farmer-extension-scientist interface: a discussion of some key issues. Proc. National Seminar-workshop in sustainable Livestock Prod. on local feed resources. Agric. Pub. House Ho Chi Minh, pp.118-122.

Gunnerson C G and Stuckey D C, 1986. Anaerobic Digestion- Principles and Practices for Biogas Systems. The World Bank Technical Paper # 49 , Washington, D.C., pp 93-100.

Karki AB, Gautam KM and Joshi SR, 1994. Present structure of biogas sector in Nepal. In: Foo E.L.(foo@hq.unu.edu), "Ecotech 94" Electronic conference, Jun. 1994.

Khoi Nguyen Van, Vinh Huynh Thi and Luu Huynh Thi Ngoc, 1989. Evaluation of biogas digesters in Cantho City. Proc. First national workshop on biogas application in Vietnam. Polytechnic Univ. Press, Hochiminh City, pp 28-35.

Kristoferson L A and Bokhalders V, 1991. Renewable Energy Technologies: Their Applications in Developing Countries. Intermediate Technology Publications, London, pp 112-117.

Pain, B.F., Misselbrook, T.H. and Crarkson, C.R., 1990. Odour and ammonia emmissions following the spreading of anaerobically-digested pig slurry on grassland. Biological Wastes, 34:259-276.

Pokharel RK 1994. Effective plan and policy of biogas development in Nepal. In: Foo E.L., "Ecotech 94" Electronic conference, Jun. 1994.

Preston, TR, 1995. Research, extension and training for sustainable farming systems in the tropics. Electronic Proc. 2nd Intl. Conference on Increasing Animal Production with Local Resources, Zhanjiang, China, p.3.

Thong Hoang Van 1989. Some experiences on the development and the application on biogas digesters in Dongnai province. Proc. First national workshop on biogas application in Vietnam. Polytechnic Univ. Press, Hochiminh City, pp 66-69.

Rice-based Livestock Systems in Northeast Thailand - Strategies for the Integration of Fish Culture

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Abstract
An analysis of production and distribution of rice products within a village, Ban Thap Hai, in Udorn Thani, Northeast Thailand suggests that current patterns of utilisation constrains use in integrated fish culture. Most rice bran (80%) is used by the rice miller to feed pigs. The remaining 'grower's share' is split between use as a supplementary feed for scavenging poultry and for fish. The extent of, and constraints to, integration between livestock and fish in the current situation are discussed. Potential fish production through direct use of ricebran and from livestock wastes is modelled based on data from on-station and on-farm research. The impact of changing distribution and use of surplus rice paddy and rice bran in the village on livestock and fish production is then considered. Feeding management for scavenging poultry has an important effect on productivity of both poultry and, subsequently, the amount of wastes available for fish culture. Inorganic fertilisation increases fish yields from feeding limited amounts of rice bran directly to fish or via poultry by over 100%. Retention of rice byproducts by the growers could have a major impact on total poultry and fish production in the village, potentially doubling the amount of fish that can be produced. The importance of off-farm factors in constraining

smallholders' use of rice byproducts for livestock and fish will continue to increase.

KEY WORDS: Rice bran, fish, feed, integration, livestock, waste, recycling, manure, pig, poultry

Introduction

Monogastric livestock are a traditional component of farming systems in Indochina. Their future role on smallholder farms, however, is threatened by the forces of modernisation affecting even the poorer, rural areas of the region. The importance of pigs and poultry in the household economy, as a bank and source of readily available 'feast food' has been recognised. Resource-poor farmers may attach greater value to these attributes than productivity *per se*. Typically raised in small numbers, pigs and poultry were traditionally allowed to scavenge for a significant part of their diet, thus obviating the need for nutritionally complete diets. In Northeast Thailand rice paddy and it's byproducts are the major feeds used; nowadays pigs are typically penned and fed concentrate in addition to ricebran and broken rice but poultry may only be fed a little paddy grain to supplement scavenging. Poultry are normally managed as mixed flocks of native chickens and muscovy ducks, raised mainly for meat, together with egg-laying strains of domestic duck. Modernisation has led to increased availability of both 'improved' breeds and feeds. Intensification of livestock production has resulted, although typical rice growing households do not appear to have benefited. Indeed these changes may have stimulated a dichotomy of production (Little, 1995), in which smallholders in Northeast Thailand are increasingly excluded from livestock production. Part of this appears linked to macroeconomic changes in which the balance of rural livelihoods shifts towards urbanisation and specialisation. Thailand's steady economic development may have prevented the reversals of this process that have been observed in other parts of the World where external inputs have become limiting (e.g. Rodrigues, this conference, Ibrahim and Abdu, 1996).

A significant step in the effects of modernisation on rural livestock production in Northeast Thailand has been the change from manual to machine milling of rice. The convention has developed that the rice byproducts are ceded to the miller in lieu of a cash milling fee, a practice that inevitably results in the concentration of rice bran and broken rice in the hands of the rice miller, and poorer availability to the farmers who grew the rice. This is in contrast to some parts of Indo-China where rice growers pay a milling fee and keep their rice bran for their own livestock. Access to rice bran is particularly important if other feeds have not been traditionally fed to livestock, such as in Northeast Thailand. This contrasts with areas with more diversified cropping systems, such as the Red River Delta of North Vietnam, where a variety of feeds are purposefully cultivated for pigs.

Increasing the productivity of livestock systems could be a major strategy for increasing outputs of cultured fish. Ponds in Northeast Thailand, which are often stocked with young fish, typically lack nutrients and produce low fish yields (Edwards *et al.*, 1991). Although the use of livestock wastes for fish culture is traditional in other parts of Asia, such practices are relatively new to this, the poorest part of Thailand. Until recently wild fish had provided for peoples' needs but now, fish pond construction and the production of fish is being actively promoted and adopted by rice growing farmers. More fish culture could affect the village rice bran economy. Rice bran is currently the most common supplement fed directly to fish in farmers' ponds and rice fields (Edwards *et al.*, 1991). Most of this rice bran is obtained from mills within the village, perhaps resulting in competition with livestock for this limiting resource.

Several factors could increase the rice growers' livestock numbers and productivity, both to improve returns and to enhance the quantity and quality of waste available for fish culture. More on-farm feeds could be used to 'spare' the limited amounts of rice products available to rice growers. Alternatively feeds or additives could be purchased from off-farm sources. The introduction of improved strains or breeds of livestock into rural areas might utilise better diets more efficiently but be unsustainable unless overall management is changed to suit their requirements. Integration of livestock and fish may have an important role under conditions of nutrient scarcity, such as most rural areas of Northeast Thailand. Where nutrients are limiting, re-use in fish culture could improve overall efficiency and support a more diversified food production system. In contrast, when nutrients are locally super-abundant, such as around livestock feedlots, fish ponds can 'treat' the waste and reduce their impact on the local environment.

Objectives

This study attempts to investigate the effects of availability and use of rice bran from village rice mills and surplus rice paddy on livestock and fish production using a dynamic model. Using data derived from experimentation and observation of farmers' systems we will attempt to improve our understanding of livestock production systems in relation to these feed resources. The effect of different livestock feeding strategies on fish yields will be compared. It is hoped that the impacts of rice milling practices on livestock and fish culture can be illustrated and used in comparisons with other systems in Indochina.

Materials and Methods

The main sources of data for this model are from an analysis of paddy rice production and utilisation in two villages of Udorn Thani, Thailand (Thomas, 1989). Additional data for the current utilisation of rice byproducts for pig production was obtained recently in the same area (AIT Aquaculture Outreach, data). Household paddy utilisation in Northeast Thai villages was taken from Chayaputhi and Kongkajandr (1977) as cited by KKU-FORD (1982).

Input/output data for poultry-fish systems was obtained from research on and off AIT campus (AFE, 1992 and AASP, 1996-IDRC). Data concerning smallholder and commercial-scale pig-fish production systems are from Long (1995) and Poudyal (1990) respectively. The model was developed using STELLA (Systems Thinking, Experiential Learning Laboratory with Animation) II version 3.0 on the Macintosh computer.

Scenarios have been based on a wide variety of livestock and fish production systems (Table 2). The poultry used for on station trials were mainly Muscovy ducks (*Cairina moschata*) and domestic egg-laying ducks. Input/output data was obtained from controlled experimentation in earthen ponds and extrapolated from concrete tanks, for 180 day periods. This duration mirrors water availability in seasonal ponds in Northeast Thailand. The model assumes that poultry and pig wastes are used as far as is practical, i.e. pigs are penned and all the wastes (including urine) may be channelled and used for fish production. The wastes from poultry scavenging throughout the farm and its margins are assumed to be collected from night-time confinement and used the following day for fish production. The fish species cultured is the Nile tilapia (*Oreochromis niloticus*, stocked at densities of 2-4 fish/m^2).

Description of the Systems

The two villages studied, an irrigated lowland village, Ban Kan, and a rainfed upland, Ban Thap Hai, are representative of the range of rice growing conditions in the region. A single rice crop is grown in both villages; the greater planted area and higher rice yields in the irrigated area (2.6 MT/ha cf 2.25) increase the amount of paddy and, subsequently rice bran in the village. Rice millers retain most of the rice bran in both villages (80%). The greater quantities of rice bran from rice grown and milled in the village, together with additional amounts purchased by both millers and growers increase the total available in the irrigated area village. Thus, whilst in rainfed Ban Thap Hai only rice millers raise pigs, in irrigated Ban Kan pigs are also raised to some extent by rice growers. Typically pigs are fed rations in which purchased concentrate and broken rice is mixed with the rice bran.

In rainfed Ban Thap Hai, the remaining rice bran is purchased back by rice growers and used as supplementary feed for scavenging poultry (>80%) or fish (<20%). The size of poultry flocks appears to be most limited by the availability and price of this feed (Little *et al.*, 1992).

Farmers also use part of their unmilled rice paddy crop for feeding poultry, particularly chickens and egg-laying ducks. They may also improve the quality of the supplementary feed using purchased concentrates but this practice is most common for chicks and laying ducks and rare for growing/fattening birds.

Table 1 Comparison of two villages in Udornthani, Northeast Thailand in terms of rice production and byproduct distribution.

Village Type of land	Ban Kan Irrigated low land	Thap Hai Rainfed upland
Number of village household	250	162
Rice production (kg/rai/yr)	416	360
Land per household (rai)	13	13
Distribution of rice bran		
rice miller (%)	78.8	78.6
rice grower (%)	20.5	21.4
outside village (%)	0.6	0
Purchased rice bran by rice miller (kg/yr)	8,100	0
Purchased rice bran by rice grower (kg/yr)	1,670	0
Rice bran recovery (1) (%)	12.6	11.3
Result from model (180 days)		
Available rice bran for rice miller (kg/day)	332.8	155.3
Available rice bran for rice grower (kg/day)	85.4	42.3
Total rice bran in village (kg)	70,960	35,574
Available rice bran for rice miller (kg)	55,973	27,961
Poultry activity (kg)	1,078	56
Fish activity (kg)	419	419
Pig activity (kg)	58,470 (outside 3,994.5)	27,486
Available rice bran for rice grower (kg)	14,561	7,613
Poultry activity (kg)	6,993	6,188
Fish activity (kg)	2,336	1,425
Pig activity (kg)	6,056 (outside 430.9)	0

(1): % of paddy grain as rice bran

Almost all pigs are sold for slaughter outside of the village whereas most poultry products are consumed in the village and, very often, in the household. Fish is both consumed by the household and sold locally.

Options for Change

The range of scenarios modelled is given in Table 2 is based on Ban Thap Hai, the rainfed village more typical of the region. The table reflects the possible strategies to use the currently available rice bran in which rice growers retain only 20% of the total produced.

The scenarios relate to various feeding strategies to increase livestock numbers, rather than productivity per se, in order to increase livestock waste for fish culture. In particular, the effect of restricted feeding (case 1-3) and substitution of village rice bran by a mixture of sun-dried cassava root, leaf meal and ground rice husk were tested (case 4-8).

Also considered is the use of rice bran directly as a supplementary fish feed, with or without inorganic fertilisation of the fish pond (case 10-12). The use of rice bran or surplus paddy rice is also considered for egg-laying ducks. The use of rice bran for pig fattening is considered in cases 13-14.

The area of fish pond in which a given level of nutrients is added also affects the amount of fish that can be produced; more fish will be produced in a larger pond receiving the same amount of wastes than a smaller pond (Tables 3 and 4).

Table 2. Case Description.

Case	Description
1	Scavenging Muscovy ducks confined and fed village rice bran ad libitum at night; wastes collected and used to raise fish over a range of loadings (Ratio of duck: water from 1,500-2,500 ducks/ha); fish stocked at $2/m^2$ in 5 m^2 concrete tanks.
2	Scavenging Muscovy ducks confined and fed a restricted ration (75 % of voluntary intake) of village rice bran at night; wastes collected and used to raise fish over a range of loadings (Ratio of duck:water from 1,500-2,500 ducks/ha; fish stocked at $2/m^2$ in 5 m^2 concrete tanks)
3	Scavenging Muscovy ducks confined and fed a restricted ration (50% of voluntary intake) of village rice bran at night; wastes collected and used to raise fish over a range of loadings. (Ratio of duck:water from 1,500-2,500 ducks/ha; fish stocked at $2/m^2$ in 5 m^2 concrete tanks)
4	Scavenging Muscovy ducks confined and fed a supplementary feed [50 % cassava (a mixture of dried cassava leaf and root meal and ground rice husk) and 50 % village rice bran] ad libitum at night; wastes collected and used to raise fish at a high rate (62.5 Kg DM/ha/day); fish stocked at 2 fish/m^2 in 5 m^2 concrete tanks
5	Scaveging Muscovy ducks fed with supplementary feed [50 % cassava (a mixture of dried cassava leaf and root meal and ground rice husk) and 50 % village rice bran], allowed to feed ad libitum and wastes collected during overnight confinement of Muscovy ducks loaded at a low rate (32.7 Kg DM/ha/day) with urea (0.5 KgN/ha/day) and TSP (0.32 KgP/ha/day) ; Monoculture Tilapia (2 fish/m^2 in 5 m^2 concrete tanks)
6	Scavenging Muscovy duck fed with supplementary feed [50 % cassava (a mixture of dried cassava leaf and root meal and ground rice husk) and 50 % village rice bran], allowed to feed restricted (levels of 50 % the voluntary intake rate) and wastes collected during overnight confinement of Muscovy ducks loaded at a high rate (62.5 Kg DM/ha/day); Monoculture Tilapia (2 fish/m^2 in 5 m^2 concrete tanks)

Table 2. (Continued).

7	Scavenging Muscovy duck fed with supplementary feed [50 % cassava (a mixture of dried cassava leaf and root meal and ground rice husk) and 50 % village rice bran], allowed to feed restricted levels of 50 % the voluntary intake rate) and wastes collected during overnight confinement of Muscovy ducks loaded at a low rate (32.7 Kg DM/ha/day) with urea (0.42 KgN/ha/day) and TSP (0.31 KgP/ha/day); Monoculture Tilapia (2 fish/m^2 in 5 m^2 concrete tanks)
8	Scavenging Khaki campell (laying duck) fed with supplementary feed (village rice bran) ad libitum; stocking density 500 ducks/ha (water area); Monoculture of Nile tilapia at a stocking density of 2 fish/m^2 in 200m^2 earthen pond, also loaded with urea (1.7 KgN/ha/day)
9	Scavenging Khaki campell (laying duck) fed with supplementary feed (paddy rice) ad libitum; stocking density 500 ducks/ha (water area); Monoculture Tilapia with 2 fish/m^2, pond add urea to get Nitrogen loading at 1.7 KgN/ha/day
10	Direct village rice bran fed to Tilapia and Mrigal (25 Kg DM/ha/day) : fish stocking rate (Tilapia 3 fish/m^2 and Mrigal 1fish/m^2)
11	Direct village rice bran fed to Tilapia and Mrigal (25 Kg DM/ha/day) : fish stocking rate (Tilapia 3 fish/m^2 and Mrigal 1 fish/m^2); add urea 1.5 KgN/ha/day and TSP 0.75 KgP/ha/day)
12	Direct village rice bran fed to Tilapia and Mrigal (25 Kg DM/ha/day) : fish stocking rate (Tilapia 3 fish/m^2 and Mrigal 1fish/m^2); add urea 3.0 KgN/ha/day and TSP 1.50 KgP/ha/day)
13	Hybrid pigs fed a mixture of cooked village rice bran and water hyacinth (*Eichhornia crassipes*) at rates of 4% and 5% Body wt/pig/ day respectively on a fresh weight basis. All wastes loaded daily into earthen ponds (200m^2) at a ratio of 50 pigs/ha. Mixed sex Nile tilapia and hybrid clarias catfish stocked at rates of 2 and 0.25 fish/m^2; 3 month culture period.
14	Hybrid pigs fed a mixture of rice bran (14%), dried cassava chips (35%),maize (20%), concentrate (31%) by a commercial farm. Pigs raised at a ratio of 123 pigs/ha fishpond. Fish yields of 20 Kgs/ha/d from a tilapia/carp polyculture in 0.3 ha earthen ponds managed by 3 month partial harvest .

Table 3 Potential poultry and fish production of rice growers using different rice-based feeding strategies based on current availability of paddy and rice bran to rice growers in Bang Thap Hai, Udornthani (180 day production).

Case	Management	Type	Fish inputs	No. ducks
1	*ad libitum*	rice bran	-	300
2	75 % *ad libitum*	rice bran	-	482
3	50 % *ad libitum*	rice bran	-	675
4	*ad libitum*	50 % rice bran + 50 % cassava	-	433
5	*ad libitum*	50 % rice bran + 50 % cassava	add inorganic fertilizer(1)	433
6	50 % *ad libitum*	50 % rice bran + 50 % cassava	-	903
7	50 % *ad libitum*	50 % rice bran + 50 % cassava	add inorganic fertilizer(1)	903
8	*ad libitum*	rice bran	add inorganic fertilizer (2)	220
9	*ad libitum*	paddy rice	add inorganic fertilizer(2)	1,182
10	-	-	only rice bran	-
11	-	-	rice bran + low inorganic rate (3)	-
12	-	-	rice bran + high inorganic rate (4)	-

(1) Urea 0.108 g/m2/day and TSP 0.160 g/m2/day;
(2) 1.7 KgN-ha/day ;
(3) 1.5 Kg N and 0.75 Kg P/ha/day;
(4) 3.0 Kg N and 1.5 Kg P/ha/day

Table 3 Potential poultry and fish production of ricegrowers using different rice-based feeding strategies based on current availability of paddy and rice bran to rice growers in Bang Thap Hai, Udornthani (180 day production). (continued)

Case	Kg of flock or No. of eggs	Net fish yield (kg)	Pond area (m^2)
1	865	310.7-428.5	1,501-2,001
2	1,067	458-636	1,927-3,214
3	1,264	574-672	2,701-4,497
4	731	244	1,673
5	731	522	2,789
6	988	449	3,615
7	988	921	6,023
8	6,448 eggs	1,225	4,396
9	63,402 eggs	3,311	23,639.9
10	-	732	2,878.9
11	-	1,270	2,878.9
12	-	1,580	2,878.9

Table 4: Potential poultry and fish production using different rice-based feeding strategies based on retention of rice bran by rice-growers in Ban Thap Hai, Udorn Thani (180 day period).

Case	Management	Type	Fish inputs	No. ducks
1	ad libitum	rice bran	-	1,403
2	75 % ad libitum	rice bran	-	2,252
3	50 % ad libitum	rice bran	-	3,154
4	ad libitum	50 % rice bran + 50 % cassava	-	2,021
5	ad libitum	50 % rice bran + 50 % cassava	add inorganic fertilizer(1)	2,021
6	50 % ad libitum	50 % rice bran + 50 % cassava	-	4,221
7	50 % ad libitum	50 % rice bran + 50 % cassava	add inorganic fertilizer(1)	4,221
8	ad libitum	rice bran	add inorganic fertilizer (2)	1,027
9	ad libitum	paddy rice	add inorganic fertilizer(2)	1,182
10	-	-	only rice bran	-
11	-	-	rice bran + low inorganic rate (3)	-
12	-	-	rice bran + high inorganic rate (4)	-

(1) Urea 0.108 g/m2/day and TSP 0.160 g/m2/day;
(2) 1.7 KgN-ha/day ;
(3) 1.5 Kg N and 0.75 Kg P/ha/day;
(4) 3.0 Kg N and 1.5 Kg P/ha/day

Table 4: Potential poultry and fish production using different rice-based feeding strategies based on retention of rice bran by rice-growers in Ban Thap Hai, Udorn Thani (180 day period).(Continued)

Case	Kg of flock or No. of eggs	Net fish yield (kg)	Pond area (m^2)
1	4,041	1,452-2,002	7,015-9,349
2	4,985	2,139-2,974	9,002-15,021
3	5,905	2,681-3,139	12,622-21,014
4	3,416	1,140	7,820
5	3,416	2,440	13,033
6	4,619	2,098	16,892
7	4,619	4,306	28,143
8	30,132 eggs	5,725	20,540
9	63,402 eggs	3,311	23,640
10	-	3,420	13,452.6
11	-	5,935	13,452.6
12	-	7,383	13,452.6

Pigs

Most pig production is based on the feeding of a dry mash of freshly milled rice bran, broken rice and purchased concentrate. Traditionally, before concentrates from feed mills were available, rice bran was fed together with leftover human food and weeds.

If pig feed is prepared by cooking rice bran with water and vegetables, approximately 50 pigs can be supported on rice bran from a village of 162 households such as Ban Thap Hai. At a ratio of 50 pigs/ha of pond, over 1-1.2 MT of fish could be produced over a period of 180 days.

The use of concentrates and other ingredients can increase the herd size for a given amount of rice bran considerably. A reduction of rice bran to around 14% of a least cost, nutritionally balanced feed used by larger operations in the area allows a theoretical increase in standing herd size to over 400 animals and fish production to over 12 MT. This eight-fold increase in pig numbers is based on the use of rice bran together with maize and soya bean, which are imported into the village and dried cassava root chips which could be obtained within the village. Increases in waste quantity and quality are offset to some extent by higher ratios of pig:pond area.

The purchasing of concentrate to mix with broken rice and rice bran is the normal current practice for rice miller/pig raisers in the region. Based on a typical ration, a mean herd size of 59 pigs is maintained on rice bran available to rice millers in Ban Thap Hai. This suggests that rice millers feed their pigs fairly inefficiently, a practice perhaps encouraged by the availability of cheap rice byproducts.

Poultry

The efficiency of rice growers using smaller amounts of rice bran for scavenging poultry is clear. Although the amount of rice bran used for poultry is a fraction of that fed to pigs by the millers, relatively large amounts of poultry and fish can be produced despite the amounts of bran and flock size being small. The poultry scavenging for natural foods over a large part of the day also makes a proportion of wastes uncollectable. Based on the total amount of rice bran available for rice growers in Ban Thap Hai a total of around 300 muscovy ducks can be raised on rice bran alone and over 400 Kg of fish produced if the waste was used as an input to fish culture. If the amount of fish produced from feeding the small amounts of rice bran directly to fish is added, over 1 MT of fish can be produced in the village derived from the small 'grower's share' of the rice bran.

Amounts of poultry waste can be increased in several ways. In practice scavenging poultry are often fed limited rations rather than ad libitum. This allows a larger flock (>100%) to be raised from the same amount of rice bran, increasing the pressure for the birds to scavenge natural feeds. Growth of individual birds is slower (Table 3, case 1), but overall flock yield is higher. The slower individual growth may synchronise better with the main demand for fattened poultry occurring between rice harvest and Thai New Year (Little *et al.* 1992). Also, after rice harvest, a seasonal abundance of rice bran allows for fattening prior to slaughter. Moreover, the area of pond that can be fertilised and amount of fish produced also increases as individual feed levels are restricted and flock size increases. Whereas ad libitum feeding of poultry could produce an estimated 428 Kg fish, limiting feeding to 75% and 50% of these levels increases fish production to 636 Kg and 672 Kg respectively.

Flock size, and wastes available for fish production, can also be increased by 'sparing' rice bran with cassava byproducts, commonly grown on the farm. Using this measure, together with restricted feeding, flock size can be increased by a factor of 3 using the same absolute amount of rice bran (cf cases 1 and 6, Table 3). There appears to be no advantages to fish production, however. Digestibility and nutrient release studies suggest that little of the nitrogen in the cassava leaf may be available for either ducks or uptake by phytoplankton (AFE, 1992).

Use of rice bran as a direct supplementary feed, particularly in fertilised ponds, is the most efficient means to produce fish for the village. Only 5% of the rice bran produced was fed directly to fish in Ban Thap Hai but use of inorganic fertilisation to increase the levels of natural feed in the pond would improve its efficiency of use considerably. Fertilisation of ponds increased yields to 1270 Kg and 1580 Kg (@1.5KgN/ha/d and 3 KgN/ha/d respectively; N:P =2) compared to 732 Kg without fertiliser. A FCR of 1.77 of feeding rice bran directly to fish compares favourably to more than 9 if the amount of rice bran to produce fish via poultry is considered.

Supplementation with inorganic fertilisers boosts fish production from the waste of poultry fed the same amount of rice bran by over 100% (cf cases 4 and 5; 6 and 7, Table 3).

Current rice bran use could have greater impact on fish production in the village as a whole if ponds received inorganic fertilisers. In Ban Thap Hai, even with the limited availability of bran for ricegrowers to raise poultry and fish, approximately 5 MT of fish could be raised per year from this source in perennial ponds (e.g. case 7, Table 3) which is equivalent to around 30 Kg/household.

The direct use of rice paddy surplus to feed small numbers of scavenging egg-laying ducks is also common among ricegrowers; the wastes of these birds can also produce significant amounts of fish. The number of ducks raised by rural households relates to their paddy surplus compared to consumption needs, the desire for home-produced eggs and the value of paddy rice on the market. If the amount of rice paddy surplus to consumption and other requirements (seed, exchange, debt service, wages etc; KKU-Ford, 1982) is utilised as supplementary feed for scavenging egg ducks, a total flock of 1182 birds, producing more than 2 eggs/household/day, can be supported. The collectable wastes from these birds can, with minimal levels of inorganic fertilisation, produce over 100 g fish/household/day. These levels contribute substantially towards household consumption requirements (Mekong Committee,1992).

Scenarios

The following situations were simulated to estimate the effect of changes in rice bran utilisation on fish production in Ban Thap Hai. Scenarios 1 and 2 reflect the current control of rice and its byproducts in the village, but that the wastes of the livestock are utilised for fish production. Scenario 2 is based on the rice growers diverting all rice bran to fish and none for poultry.

Scenarios 3 and 4 indicate possible fish yields if rice growers retain control of all the rice bran produced in the village either using it for poultry and fish at the same ratio as currently (3) or using all of the extra rice bran for fish and maintaining poultry at current levels (4). The scenarios are characterised by the ratio of the millers share, mainly fed to pigs (M), to the amount fed by the grower to poultry (GP) to the amount fed by the grower to fish (GF).

(1) current (80:16:4)

This assumes that rice bran is used at current rates by ricemillers and growers for feeding pigs and poultry respectively and that all these wastes are used for fish culture. Additional fish is produced from direct feeding of rice bran and the range reflects the level of inorganic fertilisation. It also assumes that surplus rice paddy is used to feed egg-laying ducks, the waste of which is also used in fish culture.

(2) give up feeding rice bran to poultry and use all the rice bran that they can purchase (i.e. current growers share of all rice bran) for fish culture (80:0:20)
This option would lead to an estimated 6 fold increase in the fish produced by rice growers over levels in which all poultry wastes are used for fish culture. Mean fish production, assuming all the growers rice bran was used in this way, would vary between 52-114 Kg/household/year, depending on the level of inorganic fertilisation used in the fish ponds.

(3) purchase back all their rice bran and then use it for poultry and fish production at current ratios (0:80:20)
This would produce a similar range of fish yields as (1) and (2), but all of the fish would be produced by the ricegrowers rather than a large proportion by the miller.

(4) purchase back all their rice bran, maintain poultry at current levels and use the extra for fish production (0:20:80)
This scenario indicates the levels of fish production that might be possible if rice growers gained access to all of the rice bran produced and used most of the bran for fish culture. Assuming that they maintain poultry at current levels and integrate the wastes with fish culture, it is clear that this would support only a minor part of potential fish production. Yields approaching 40 MT/over a 6 month season are possible if most of the rice bran produced in the village is used as a supplement in fertilised fish ponds. Up to 9 hectares total of ponds would be required for such a scenario, which is nearly 30% of the planted rice area. In practice, fish production would likely be constrained at much lower levels by lack of perennial water and suitable sites. Only a fraction of this pond area (about 1 ha) was available at the time the survey was carried out. However the scenario does suggest the impact that local feed resources could have on local fish production.

Table 5 Potential range of fish production in Ban Thap Hai based on number of livestock and fish fed rice based feeds for 4 different scenarios of byproduct utilization (ratio of miller's share (M): growers & poultry (GP): growers & fish (GF))

Scenario ratio M:GP:GF	Feed	Route to	Fish production (kg/180 days) Miller	Grower	Total
1.Current 80:16:4	rice bran	livestock waste	1,686-12,228	244-1,225	
	rice bran	direct feed	215-465	732-1,580	
	paddy rice	livestock waste	-	3,311	
			1,901-12,693	4,287-6,116	6,188-18,809
2. 80:0:20	rice bran	livestock waste	1,686-12,228	-	
	rice bran	direct feed	215-465 8,440	3,910-	
	paddy rice	livestock waste	-	3,311	
			1,901-12,693	7,221-11,751	9,122-24,444
3. 0:80:20	rice bran waste	livestock	- 5,725	1,140-	
	rice bran	direct feed	-	3,420-7,383	
	paddy rice	livestock waste	-	3,311	
		-	7,871-	7,871-16,419	16,419
4. 0:20:80	rice bran waste	livestock	-	244-1,225	
	rice bran	direct feed	-	15,093-32,581	
	paddy rice	livestock waste	-	3,311	
		-	18,648-	18,648-37,117	37,117

Table 6 Area of ponds (m^2) required for fish production by rice millers and growers in Bang Thap Hai for 4 different scenarios of rice bran.

Case	Ratio	Miller	Grower	Total
1.	80:16:4	9,954-34,485	1,231-4,497	11,155-38,982
2.	80:0:20	9,954-34,485	15,380-23,640	25,334-58,125
3.	0:80:20	-	5,614-28,143	5,614-28,143
4.	0:20:80	-	1,201-59,370	1,201-59,370

Note : in 1988, Area of culture pond was 1.1 ha (11,000 m^2)

Constraints to Use of Millers' Pig and Growers' Poultry Manure for Fish Culture

Currently, the linkages between the rice millers' pigs, village poultry and fish are weak. A recent survey indicated that only 3 out of 25 mills used their pig manure to raise fish; much of the rest was utilised to some extent for rice fields, vegetables or given to neighbours. Cultural aversion to the use of livestock wastes, particularly pig manure, in fish culture exists but does not seem to be a major factor in preventing integration in most cases. Lack of labour and water for raising fish and the distance between pigs and ponds constrained integration. Twenty per cent of rice millers didn't use their manure for fish culture because they used their pond water for domestic purposes and didn't want 'dirty' water (AAOP data).

The likelihood of the rice millers' pigs becoming a significant source of nutrients for fish culture look unlikely for a variety of reasons. Currently, a good deal of potential fish production is lost through poor use of pig wastes by rice millers. The central location of rice mills in the village and the need for constant attendance probably limits the efficiency of its use by these actors. The lack of waste recycling into fish culture reflects the millers' main business foci and their higher-than-average economic status. Aquaculture has been found to be of both interest to middle-income households (AAOP data). The high proportion of millers that give waste away to their neighbours (>50%) suggests that some waste may finally be used for fish culture, although the urine, which is rich in both nitrogen and phosphorus, would be likely lost. Its use elsewhere in food production is also likely to be sub-optimal; seasonal aridity constrains the efficient use of manures in the rainfed cropping systems of the region and probably a major proportion of the nutrient value is lost.

The ponds of rice growers have also been found to be unintegrated with poultry production and various factors, particularly the distance between fish and poultry operations, are believed to be important constraints (Little, 1995). Recent on-farm trials, however, suggest that rice growers will collect the waste of their scavenging poultry from overnight pens and use it in their fishponds (AASP, 1996). In general, little sustained interest for intensification of backyard poultry was found among individual farmers who are mainly motivated to raise poultry to satisfy household needs (AASP, 1996). This may be explained partly by the marginal financial returns, risk of loss from disease and an increasing reliance on off-farm income. However, the continued interest by many households in raising a small mixed poultry flock for social and cultural reasons together with the control of most of the rice crops byproducts by rice millers probably prevents the potential rise of 'medium-scale' producers from obtaining enough rice bran. The sustainability of poultry systems in their current form looks linked to the future of village life generally. The high opportunity cost of labour has been a major factor in changing rural lifestyles; the rapid replacement of other livestock, such as water buffalos by mechanised tillers is explained partly by this factor. Raising poultry requires little labour and the typical small flock can be managed by older family members close to the home provided some rice bran can be purchased back from the mill.

The use of 'surplus' rice paddy for feeding egg-laying ducks is a common practice. The relatively small surplus does appear to restrict the practice to small flocks (<15) serving to producing eggs for household consumption; retention of larger amounts of paddy to raise ducks for selling eggs is not worthwhile. As a high proportion of duck eggs are consumed by children in school packed lunches, this may have strategic nutritional impact. Integration with fish culture could improve the overall returns of duck egg production based on rice paddy. The potential impact of using more inorganic fertilisers, with or without rice bran or rice bran-derived wastes, for fish production are great (Edwards *et al.*1991, Edwards, 1993). Farmers have accepted the supplementation of ruminant manure with small quantities of inorganic fertilisers, but current trials suggest that the higher levels used in this study are also adoptable and effective under village conditions. The use of inorganic fertilisers in the fish pond, as opposed to elsewhere on the farm, is a critical issue. Current use of inorganics on rice and other crops is low, partly because of the unpredictable response on the infertile and rainfed conditions (Ragland and Boonpuckdee, 1988).

The role of inorganic fertilisers, patterns of outmigration and habitation in the village and their impacts of mechanisation and labour utilisation all affect rice yields and the availability of byproducts. Further, fundamental changes in average land holding and strategies for maintaining output (Surinteraseree,1996) will all affect levels of rice production and maybe the marketability of poultry and fish products.

Conclusion

The control of rice byproducts after local processing has a major impact on the livestock and fish production of rice growers. The use of rice bran as a supplementary feed for scavenging poultry or part of the ration of feedlot pigs, could support significant fish production if the activities were integrated. In practice, although many factors limit livestock waste re-use for fish production under Northeast Thai village the dominance of rice bran use by rice millers is a major constraint. Lack of rice bran and its high price is a critical barrier to farmers producing more monogastric livestock, particularly poultry, and their integration with fish. The model illustrates the benefits that more control of rice bran by the rice growers could bring to their poultry and fish production. Moreover, such changes would likely improve the efficiency of nutrient use and efforts to diversify by rice growers.

Other mechanisms exist to increase synergism between activities including attention to poultry feeding strategies and the use of more non-rice ingredients. The feeding of paddy grain surplus to egg-laying ducks has potential to support household needs of eggs and contribute substantially towards fish consumption needs. More direct use of rice bran for fish culture optimises fish yields but would reduce the availability of feed for poultry production. Inorganic fertilisation improves the effectiveness of both poultry manure and rice bran as inputs to fish culture. Trends in production and consumption in the village, which are linked to macroeconomic changes, may have fundamental impacts on poultry and fish production.

References

AFE, Agricultural And Food Engineering, 1992. Final Report- Muscovy Duck Project : The development of economic feeding systems for Muscovy ducks (*Cairhina moschata*) in duck/fish integration in Thailand (15 May 1988-31 December 1991) . Agricultural And Food Engineering, Asian Institute of Technology, Bangkok, Thailand. 36 pages.

AASP, Agricultural and Aquatice Systems Program, 1996. Final Technical Report -IDRC : The development of feeding systems for fish and an integrated duck-fish system (30 December 1991 - 31 April 1996). Agricultural and Aquatic Systems Program, School of Environment, Resources and Development, Asian Institute of Technology. 41 pages.

AASP,Agricultural and Aquatic Systems Program, 1996. Final Report-ODA suppport for aquaculture at the Asian Institute of Technology (December 1992 - May 1995) and Aquaculture support project (June-November 1995). Agricultural and Aquatic Systems Program, School of Environment, Resources and Development, Asian Institute of Technology. 126 pages.

Edwards, P, K.E. Weber, Ed W. McCoy, C. Chantachaeng, C. Pacharaprakiti, K. Kaewpaitoon, S. Nitsmer, 1983. Small-scale fishery project in Pathumthani Province, Central Thailand: socio-economic and technological assessment of status and potential.

Agriculture and Food Engineering Division and Human Settlements Development Division, Asian Institute of Technology, Bangkok, Thailand. 256 pages.

Edwards, P., H. Demaine, S. Komolmarl, D.C. Little, N. L. Innes-Taylor, D. Turongruang, A.Yakupitiyage, T.J. Warren, 1991. Toward the Improvement of Fish Culture by- Small-scale Farmers in Northest Thailand. J. Asian Farm. syst. Assoc. 1, 287-302. Edwards, P. 1993. Environmental issues in integrated agriculture-aquaculture and wastewater-fed fish culture systems, p. 139-170. In R.S.V. Pullin, H.Rosenthal and J.L. Maclean (eds) Environment and aquaculture in developing countries. ICLARM Conf. Proc. 31, 359 p.

Ibrahim, Mamman A. and Paul A. Abdu. 1996. Ethno- agroveterinary Perspectives on Poultry Production in Rural Nigeria. In Ethnoveterinary Research & Development. Constance M. McCorkle *et al.* (eds.) Intermediate Technology Publications, London, U.K., pp. 103-115.

KKU-FORD,1982. An Agroecosystem Analysis of Northeast Thailand. KKU-FORD Cropping systems project, Faculty of Agriculture, Khon Kaen University, Thailand. August 1982. page 88-89.

Little, David C., Khalil and P. Takaikaew, 1992. Development of Duck-fish Integrated Systems in Northeast Thailand. Sustainable Animal Production Proceedings of the Sixth AAAP Animal Science Congress, Vol.II., pp. 93-106.

Little, David C., 1995. The Development of Small-scale Poultry-fish Integration in Northeast Thailand: Potential and constraints. In Seminar TSThe Management of Integrated Freshwater Agro-Piscicultural Ecosystems in Tropical AreasCC, Brussels, 16-19 May 1994, J. J. Symoens and J. C. Micha (eds.) Technical Centre for Agricultural and Rural Co-operation (CTA) Royal Academy of Overseas Sciences (Brussels) 00. 265-276.

Long, Duong Nhut, 1995. An Investigation into a Low Input Pig-fish System appropriate for the Maekong Delta, Vietnam. Master of Science Thesis, Asian Institute of Technology, Bangkok, Thailand. 75 p.

Maekong committee, 1992. Fisheries in the Lower Mekong Basin (Review of the Fishery Sector in the Lower Mekong Basin) Main report. Interim committee for Coordination of Investigations of the Lower Mekong Basin, May 1992. page 10.

Poudyal, Hem Raj. 1990. An on-farm study of a commercial integrated farm in Northeast Thailand. Master of Science Thesis, Asian Institute of Technology, Bangkok, Thailand. 168 p.

Ragland, John and Ladda Boonpuckdee, 1988. Soil Fertility Management in Northeast Thailand. NERADICS Technology Documentation Series, Paper No. T7, Northeast Rainfed Agricultural Development Project (NERAD), Northeast Regional Office of Agriculture, The Phra, Khon Kaen, Thailand. NERADICS PCE-4007-1031. 23 p.

Surinteraseree, P. 1996.Doing more with less: Impacts of non-farm employment on rice reduction in northeastern Thailand. PhD thesis. McGill University, 175 p.

Thomas, John., 1989. An assessment of the use of rice bran as a fish feed in four areas of Udornthani province in the Northeast Thailand. Master of Science Thesis, Asian Institute of Technology. 70 p.

Tree Mixtures within Integrated Farming Systems

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Abstract
Fodder trees have always played a significant role in feeding domestic animals. However, scientists have generally undervalued these feed resources mainly because of insufficient knowledge about their potential and the lack of initiative to develop appropriate feeding systems for their use. The conventional approach to the introduction of fodder trees into livestock systems is to exploit "single" species. The reality is that, in many parts of the tropical world, animals eat or are fed with "mixtures" of tree leaves. Cafeteria trials have been widely used to determine relative palatability differences within different plant species. Apart from showing the animal's preferences for a particular fodder species, they also show that, given the opportunity, ruminants will feed on mixtures of forages. Mixed foliage can be given as a supplement to rice straw and others crop residues or may constitute the whole ration. In Nepal and Indonesia, farmers traditionally feed a mixture of fodder tree leaves to their animals. This practice has been observed throughout developing countries, especially with small ruminants. There is negligible published information about the reasons why farmers feed mixtures and the choice of appropriate mixtures currently relies on the farmers' traditional knowledge. The great diversity of plant species used in Nepal may be explained by the improved nutritive value of a combination of species compared to single species on their own, with the underlying reasons being reduced toxic effects and increased variety and palatability of the diet. The use of mixtures ensures a more diverse supply of forages and therefore reduces the risk of dependence on a single plant species.

While the use of mixtures of species thus appears to be desirable, there is little scientific information on which to base practical recommendations. Recent results quantified the associative effects in vitro of mixtures of different species of Colombian fodder trees, identifying significant interactions. These suggest that there is considerable potential to develop feeding systems based on strategic mixtures that result in added nutritive value. This can be achieved by capitalising on the interactive processes, such as: protecting dietary protein with natural tannins in order to increase the amount of nitrogen which by-passes the rumen; diluting the effects of deleterious compounds; inducing associative effects that result in an increased voluntary intake; and inducing associative effects on digestibility between the components of the mixture. Appropriate mixtures of tree foliage can result in overall improvement in nutritive value and contribute to making more efficient use of the natural diversity of trees and shrubs in the tropics, and hence helping to sustain it. This paper reviews the literature on the subject and presents the main conclusions from the recent in vitro work.

KEY WORDS: fodder tree, shrub, foliage, mixture, forage, feed, toxicity, palatability, associative effect, interaction, tannin, by-pass protein

Introduction

In recent years, the scientific world has conceived the terms "biodiversity" and "megadiversity" to refer to the huge genetic reservoir in natural ecosystems. The tropical zone contains the greatest genetic diversity in the world, diversity which is expressed in the large number of vascular plants per unit area. However, this richness is being threatened by the pressure imposed by the increasing population. Of particular concern is the process of deforestation and its irreversible ecological effects. The major causes of deforestation are conversion of forest to agricultural land and cattle grazing, logging and demand for fuelwood. Recently, a range of environmentally beneficial farming practices seems to be emerging as a synthesis based on both old, proven ideas and a new understanding of natural nutrient cycles and ecological relationships (WRI, 1992). There are several examples of this new generation of farming systems in the tropics where multipurpose trees play a critical role in the sustainability of the system, by supplying protein for livestock, firewood, and sinks for carbon dioxide and controlling erosion (Preston and Murgueitio, 1992; Moog, 1992). A recent review of feeding systems used in warm climates (Roggero *et al.*, 1996) suggested that sustainability depends on making use of diverse local biological resources. This concept calls for wider use of the diversity of fodder tree species as providers of animal forage. Despite the fact that the list of trees and shrubs with potential use as fodder comprises more than 300 species, research has concentrated on very few. The danger of this over-dependence on so few species is illustrated by the psyllid epidemic (*Heteropsylla cubana*) in *Leucaena leucocephala*, and the disappearance of some valuable fodder species, e.g., *Terminalia avicennioides* in Niger, due to its replacement with *Gliricidia sepium* (Baumer, 1992). Given the current diversity of fodder trees, there is an urgent need to study and recommend promising species for specific agro-ecological environments and animal production systems, in terms of plant productivity, nutritional value and in helping to sustain this diversity.

The conventional approach to fodder trees is to study and exploit "single" species. The reality is that, in many parts of the tropical world, animals eat or are fed with "mixtures" of tree leaves. Mixed foliage can be given as a supplement for coarse roughage such as rice straw and other crop residues or it may constitute the whole ration, depending on the farming system. In Nepal, farmers traditionally feed leaves from a mixture of fodder tree species to their animals (Paudel and Tiwari, 1992) and Indonesian farmers have long been feeding mixed shrub and fodder tree leaves to their ruminants (Rangkuti *et al.*, 1990). This practice has also been observed in many other developing countries, applied especially, to small ruminants.

Nutritional Value of Mixtures of Tree Leaves

Information on the nutritive value of many trees and shrubs is scarce, yet there is even less information on the nutritive value of mixtures of leaves, since the conventional way of reporting nutritive value is a table of the chemical composition of individual feeds. There are, however, some studies on mixtures that indicate their potential.

Foliage from *Leucaena leucocephala, Calliandra calothyrsus* and their mixture (1:1) was used to supplement a diet of maize husks for goats. The daily weight gain of animals supplemented with the mixture *Leucaena:Calliandra* was greater than those animals supplemented with *Calliandra* only (22.6 and 19g). Daily weight gain of animals supplemented with Leucaena only was the highest of all (28.5), but dry matter intake (DMI) was also much greater (331.6g/day). There were no differences in the intake of Calliandra (315.2g/day) or the mixture (317.4g/day) (Phiri *et al.*, 1992).

Bosman *et al.*, (1995) fed West African Dwarf goats with *Gliricidia* sepium and a mixture of *Gliricidia sepium* combined with *Leucaena leucocephala*. (*Leucaena* only was not included in the experiment). Diets were offered at seven different levels in two experiments varying from 60 to 120g DM/kg 0.75/day, in increments of 10g, in experiment 1, and from 40 to 130g DM/kg 0.75/day, in increments of 15g in experiment 2. The maximum DM intake for *Gliricidia* and the mixture *Gliricidia:Leucaena* were, in experiment 1: 72.5 and 90 and, in experiment 2: 55.5 and 63.4g/kg 0.75/day, respectively. In both experiments *Gliricidia:Leucaena* mixtures were more digestible than *Gliricidia* alone, the difference in the second experiment being larger (10.3 vs. 3.6 percentage units). Maximum weight gain for Gliricidia was 2g/kg 0.75/day and for the *Gliricidia:Leucaena* mixture was 8.2g /kg 0.75/day, obtained when offered at a level of 80 and 106g DM/kg 0.75/day respectively. These studies indicate that a mixture of fodder tree leaves can be used to increase animal performance over that obtained when a single fodder trees species is used.

There is negligible published information on the reasons why farmers feed mixtures and the choice of appropriate mixtures currently relies on the farmers' traditional knowledge. A survey carried out in Nepal

(Rusten, 1989), showed that farmers classify forages as obhano (forages that tend to fill animal's stomach) and chiso (forages that not readily satisfy an animal's appetite and tend to lead to the production of watery dung). According to the survey the obhano-chiso status of a forage was not crucial to the evaluation of its worth. It was one attribute to be considered among others but its key importance laid in determining the mixture of forages fed. Farmers preferred to feed their animals with a mixture, "some chiso, and rather more obhano", as this was said to be optimal for animal health. For Suri farmers in Nepal, the value of any given fodder species is determined at least partially by the type of animal for which is intended, the mixture in which it is fed and the time of the year (Carter, 1992). From a scientific point of view, the improved nutritive value of a combination of species may be due to a dilution of potential toxic effects associated with particular feeds above a threshold level; the potential for synergy in digestion and/or an increase in palatability of the diet. This highlights thee important interactions which need to be considered when predicting the nutritive value of mixtures of fodder trees.

Deleterious Factors in Mixtures of Fodder Tree Leaves

Plants contain more than 1200 different classes of chemical compounds that are produced by secondary metabolism. Most of these compounds have storage, defence or reproductive functions in the plants. Many of them appear to be the natural result of the co-evolution of plants with herbivorous mammals, although some have probably evolved as mechanisms of protection against insect pests and plant diseases, in which case their effects on higher animals may be coincidental. About 8,000 polyphenols, 270 non-protein amino acids, 32 cyanogens, 10,000 alkaloids and several saponins have been reported to occur (Liener, 1980; Kumar, 1992). Tannins are the most common secondary plant compounds, but the implications for animal feeding are not entirely clear, with both harmful and beneficial effects possible (Rosales *et al.*, 1989; Mueller-Harvey and McAllan, 1992). A major characteristic is their propensity to form chemical complexes. Recent studies have revealed that tannins not only bind strongly with proteins but also with many other compounds like polysaccharides, nucleic acids, steroids, alkaloids and saponins (Mueller-Harvey and McAllan, 1992).

Farmers overcome and reduce toxicity problems by feeding mixtures of fodder tree leaves with and without sun drying. This process not only extends the choice of feeds available but also dilutes and reduces problems of palatability and side effects. Little is known about the optimum dietary levels of feeds from individual shrubs and trees (especially for those with deleterious principles), about how to reduce the incidence of deleterious effects, or about suitable mixtures in economic feeding systems for individual ruminants (Devendra, 1993). It has been suggested that the deleterious effect of secondary compounds can be overcome by the simple approach of feeding the toxic plant in a mixture with other plants, thus diluting the effective level of each compound. The effect of condensed tannins can be overcome by complexing them with polyethylene-glycol (PEG). Lowry (1990) suggested that natural PEG analogues (soluble, non-degradable polyhydroxy compounds) occur in plants, and there is the possibility of a positive interaction between tannin and PEG analogue when the two plants are fed together.

The concept of using mixtures of fodder plants with variable tannin levels to improve nitrogen utilization by ruminants (by reducing soluble protein degradation in the rumen) has been suggested. Because of the property of binding protein at neutral pH and releasing it at low pH, tannins could be used to reduce the extent of soluble protein degradation in the rumen and thus increase the amount of non-ammonia nitrogen flow to the small intestines. This concept is being tested by using the legumes *Cratylia argentea* (tannin-free) and *Flemingia macrophylla* (25.1g CT/kgDM) in CIAT, Colombia (Fassler, 1993). Intake, digestibility and nitrogen retention were measured in sheep fed low quality grass (*Brachiaria dictyoneura*) alone, low quality grass (60%) with *Cratylia argentea* alone (40%) or mixed with *Flemingia macrophylla* at two levels. Results showed that, as the proportion of *Flemingia macrophylla* increased in the mixture, there was a greater faecal nitrogen excretion and a reduction in dry matter and fibre digestibility. The positive effects found by a reduction in the amount of urea excreted in the urine were offset by the decline in digestibility. It was concluded that in formulating mixtures to supplement low quality forages it is important to consider not only tannin level but also the digestibility of the legumes used.

In another experiment at CIAT, Cratylia argentea replaced with 0, 25, 50 or 100% *Flemingia macrophylla* was fed as 40% of the total ration as a supplement to *Brachiaria dictyoneura* offered to African Hair sheep (Powell, *et al.*, 1995). As the intake of *Flemingia* increased, duodenal N flow (as proportion of nitrogen ingested) decreased. This was associated with decreasing rumen ammonia concentration; increasing proportion of nitrogen appearing in the urine, increasing loss of soluble condensed tannin and increasing protein-bound condensed tannins across the rumen. This suggests that N breakdown in the rumen was inhibited by the formation of undegradable protein-tannin complexes between feed protein and soluble tannins. There was an increment in the proportion of ingested nitrogen appearing in the faeces, indicating that post-ruminal digestion of nitrogen was inhibited. The authors concluded that, although there was no apparent benefit in terms of the overall nitrogen retention, tannins from one feed can affect the digestion of nitrogen from another feed.

Synergistic Effects of Mixtures of Fodder Tree Leaves

The amount of nutrients which a ruminant can extract from one feed can be modified by the type and quantity of other feeds consumed the same day. These interactive processes can have substantial consequences for intake and digestibility of feeds and for animal performance, in general. Associative effects between components of a mixed diet occur when, as a consequence of the interactive processes, the nutritional value of the mixture is not equal to the sum of its individual components. These effects can be positive (synergistic) or negative. Most studies of associative effects in terms of digestion relate to the effect of a source of rapidly fermentable carbohydrates (like barley or maize silage) on roughage digestion. There are some studies of the effect of mixtures of temperate (Cassida *et al.*, 1994; Glenn, 1989) and tropical (Brown and Pitman, 1991) grasses and legumes but until recently, none on the effects of mixtures of fodder tree leaves on digestion.

Rosales (1996) studied the nutritive value *in vitro* of mixtures of fodder tree leaves in order to understand the factors that determine their associative effects and the interactions between tannins and other feed components. The results of this study suggested that associative effects of mixtures of tree leaves are governed by the degree of synchronisation of the fermentation rates of the different components of the mixture and these, in turn, are dependent on the fermentability of their chemical constituents.

The fermentation of tree leaves (20 tropical fodder tree and shrub species) was studied with two contrasting media, with zero and high nitrogen contents, using a pressure transducer to measure the effect. This enabled the chemical constituents of fodder tree leaves that had the most effect on the fermentation, and the time at which their importance was greatest, to be identified. An initial understanding of the associative effects was achieved by studying mixtures of pure chemical entities.

Significant associative effects for mixtures (50:50) of fodder tree leaves and carbohydrates were shown to occur. Two types of response were identified: the first was exponential and characteristic of mixtures of high fermentability; the second was sigmoidal and was characteristic of mixtures of low fermentability. These two responses in associative effects were similar to those obtained with mixtures of pure carbohydrates and proteins where the synchronisation of the fermentation rates of the components occurred in the early and late stages respectively. The late availability of nitrogen was due to the nature of the protein itself or to the presence of phenolic compounds. Associative effects tended to be greater in mixtures with carbohydrates of low to medium fermentability, especially towards the end of the incubation period. The mode of action was a decrease in the fermentation rate and an increase in the lag phase. The associative effects with highly fermentable carbohydrates were higher at the beginning and decreased towards the end of the fermentation. The mode of action was an increase in the rate constant and a reduction in the lag phase.

Phenolic compounds in the leaves were shown to affect the fermentability of both carbohydrates and proteins. The effect was greater with carbohydrates of medium to low fermentability. On the other hand, they were shown to react with both soluble and insoluble protein. The effect of condensed tannins in the leaves was a depression in the fermentability of their mixtures with carbohydrates. This depression was greater in mixtures of low fermentability. Forages with phenolic compounds showed positive and negative effects. These effects were possibly due to synchrony or asynchrony in the release of protein.

Associative effects of mixtures of tree leaves themselves were shown to occur. By studying the fermentation rates, it was possible to characterise these effects in terms of the time at which the synchrony occurred and in terms of the fermentability of the components. The synchrony occurred at different times during the incubation period and was characterised by changes in the fermentation kinetics of the mixture. The response was also identified as sigmoidal or exponential in shape, the latter being more common. Associative effects were shown to vary with time and with the level of nitrogen. They were shown to be governed by a synchrony of the fermentation rates of the single components of the mixture.

Various authors have proposed that microbial growth efficiency and hence animal performance may be improved by a synchronisation of energy and nitrogen supply to the rumen. The importance of this synchrony to the associative effects of mixtures of forages has been proposed. Glenn (1989) suggested that the mode of action of the associative effects in mixtures of lucerne (*Medicago sativa*) and orchardgrass (*Dactylis glomerata*) was a synergism in rumen fermentation of NDF and N from the two species.

Findings by Rosales (1996) suggested that, although the mode of action is a synergism in the fermentation, the components involved are more than those suggested by Glenn. The main chemical components involved in the associative effects are proteins (at least two fractions in each component of the mixture), sugars, starch and cellulose. Phenolic compounds play a role by affecting fermentation rates and hence synchrony. The difficulty of predicting the associative effect from the chemical composition derives from the fact that the effect is produced by the interplay of all components. The individual fermentability of the chemical components (which varies between species) determines when the synchrony occurs and this determines the type of associative effect produced. According to Rosales (1996), the characterisation of the fermentability of individual nutrients may be more dominant in predicting associative effects than the chemical composition. Mixtures of leaves of plant material high in rapidly fermentable carbohydrates with material high in soluble and fermentable nitrogen showed the greatest effect of all. The mixtures of plant material with the highest phenolic contents and with the highest soluble and insoluble protein showed important associative effects. However, in the case of the high nitrogen conditions, when urea is increasing the fermentation rate, associative effects are more difficult to predict from the chemical composition as the synchrony depends on the fermentability of the individual components. This highlights the importance of characterising the fermentability of the chemical components in the leaves.

Sinclair *et al.* (1993) developed a "synchrony index" based on the fermentation characteristics of feeds that is calculated from the hourly release of nutrients to the rumen microbes. For example, a rapidly released unit of nitrogen could be used with a slowly released unit of carbohydrates that had been eaten by the animal some hours previously. This index has been developed using feedstuffs rich in energy and protein, like winter barley and fish meal, and the diets are formulated to take account of total DM intake, times of feeding and outflow rate of solids from the rumen. In the case of tree leaves, which are chemically more complex feedstuffs, the synchronisation of rates may be more critical than that of more homogeneous feeds. Nsahlai *et al*. (1995) calculated the synchronisation indices of the release of nutrients of twenty fodder trees accessions. They found that, from the point of view of the synchronisation of the release of soluble and insoluble nutrients (N and OM), there was generally a moderate to poor synchronisation of the fermentation of N and OM because nitrogen was released in excess. This is a disadvantage if the plant species is fed as a sole food but these indices may be useful to design or predict appropriate mixtures of tree fodders. The development of synchronisation indices for mixtures of fodder tree leaves is an important step towards the prediction of their associative effects. However, such indices are affected by the rate of passage and thus, an associative effect observed *in vitro* may not show, or it may change, in an *in vivo* situation because the synchrony did not occur due to differences in the rates of passage. Measurement of rate of passage is expensive, time-consuming and has to be conducted in vivo and thus current research at NRI is exploring the possibility of using palatability as a simple index with which to predict rate of passage (Romney, unpublished observations).

Before leaving consideration of associative effects in the rumen, consideration should be given to whether positive or negative associative effects should be actively sought. In the case of fodder tree leaves, a negative ruminal associative effect could be related to a dietary protein being protected from fermentation by tannins and thus providing bypass protein. In this case, a negative effect on digestibility can be a positive effect in terms of animal performance. The results of Rosales (1996) showed negative associative effects when tannin containing plants were mixed with plant material without tannins but high in soluble protein. Although important in magnitude, these effects were not statistically significant at the levels used. Other levels should be tested. The only case of a significant negative associative effect was found for a mixture of plant materials that there were both high in tannins. This indicates an antagonism of the two components in terms of fermentability but the effect on protein was not evaluated.

Effects on Voluntary Intake

The magnitude of the associative effects found in the in vitro study of Rosales (1996) varied from 4.4 to 18.1%, but these will only be turned into positive effects on animal performance if intake is maintained or increased. Ruminants (especially goats) when left to browse ad libitum will select a varied diet. Cafeteria trials have been used widely to determine relative palatability differences between species of shrubs and fodder trees. Apart from showing the animal's preferences for particular fodder species, they also show that given the opportunity, ruminants will consume more of a mixture of forages than of a single diet component. This was observed by Le Houerou (1991) who evaluated the intake of 9 species of native and exotic shrubs offered either alone or in a mixture to ewes in Libya. Thus, total intake of mixtures is likely to be higher, but in addition, different dietary components also offer the potential for feed sequencing and feed selection.

To give some idea of the potential impact which the feeding of mixed diets can have on animal performance, either through effects on digestibility and/or intake, Table 1 shows the results of experiments to compare increasing levels of fodder tree supplementation in different species of ruminants. These feeding trials with fodder tree leaves were designed to establish the optimum ratio of supplementation of a basal diet or to study substitution effects on intake. The data show that in all cases there was an associative effect on DM intake and that, bearing in mind the increased DM intake, there may be associative effects on DM digestibility between the basal diet and the leaves from a single fodder tree species. Further associative effects would be expected to arise from using leaves from mixtures of fodder tree species.

Implications of the Mixtures of Trees for the Farming System

Species mixtures may have benefits to the farming system over and above those for the animal component. A mixed stand of fodder tree species may have advantages over plots of single tree species in terms of greater biomass production (in strata) and a greater contribution to multiple uses. Growing mixed stands may also reduce the incidence of disease, since tree species grown as pure stands are more prone to disease. There are reports of 23 different common diseases for the Acacia genus for example without including those which are species specific. *Leucaena* species are prone to 16 common diseases, 56 in the case of *Cassia* species to mention some. In the case of *Gliricidia*, there are only 6 diseases common to the genus but *Gliricidia sepium* is prone to a total of 38 different diseases (NRI, 1994).

Designing the best species combination for a mixed stand of trees can prove difficult. As is the case for mixtures of forages for the animal, when plants grow in proximity to each other they interact in positive ways (complementarity) or negative ways (competition). Plants compete for three main elements: light, water and nutrients.

Table 1: Effect of increasing levels of forage tree legume supplementation on intake and digestibility by cattle and goats

Browse Species	Animal species	Basal Diet	Level of browse (%DM)	Voluntary Intake g/kg/day	Dietary DMD %
Leucaena leucocephala	Cattle	Grass	0	20.2	42
			20	26.1	44
			40	28.8	46
			60	28.8	44
			100	22.1	51
Leucaena leucocephala	Goats	Barley straw	0	17.9	48
			33	29.5	60
			65	30.9	57
			100	27.1	62
Albizia chinensis	Goats	Hay	0	18.9	46
			27	27.8	56
			61	27.4	49
			100	24.6	48
Sesbania sesban	Goats	Barley straw	0	17.7	48
			33	28.7	61
			66	31.7	64
			100	27.8	64

DM = Dry matter
DMD = Dry matter digestibility
Source: Norton 1994.

An appropriate mixture of species should perhaps include one species with a deep root system, complemented by another with a more extensive one; one species that needs plenty of sunlight and another which can grow under the canopy of the first one, for example. A combination of a legume with a non-legume species can be advantageous as well as including trees for human food production (fruits) or livestock consumption (pods and leaves). According to Sanchez (1995), the biophysical bottom line of agroforestry is how to manage the interaction for light, water and nutrients between the tree component and the crop and/or livestock components for the benefit of the farmer.

Examples of farming systems in which a mixture of fodder trees and shrubs plays a central role or is an integral part of the system are scarce. A good example of such a system is a multi-strata system. Nitis *et al.*, (1990) described a three-strata forage system in Bali. The system involves grasses and ground legumes (first stratum) for use during the wet season, shrub legumes (second stratum) for use during the middle of the dry season, and fodder trees (third stratum) for producing feeds during the late dry season. *Gliricidia* and *Leucaena* constitute the second stratum and *Ficus*, *Lannea* and *Hibiscus* trees constitute the third stratum. The system consists of 0.16 ha cash crop for human use and 0.09 ha pasture, 2000 shrub legumes and 42 fodder trees to produce feeds for livestock. Animals are fed on varied mixtures of forages throughout the year. Mixtures of fodder tree leaves can constitute as much as 75% of the diet during the dry season. Effects of associating grasses, legumes, shrubs and trees have been evaluated both from the agronomic and nutritional points of view. The three strata forage system increased forage and fuelwood production, live weight gain, stocking rates and reduced soil erosion when compared with a non strata system. Initial agronomic evaluations of another multi-strata system consisting of the herb *Symphytum peregrinum*, the shrub *Urera baccifera* and the trees *Trichanthera gigantea* and *Inga edulis* are being carried out by CIPAV.

Conclusions

The potential advantages of establishing mixtures of fodder tree species on farms when developing new feeding systems have been described in this paper. However, researchers still need to develop a series of principles from which recommendations can be developed. Since animal production in the tropics is facing new challenges, especially trying to balance food security and conservation goals, these principles need to relate to animal productivity, the productivity of the farming system as a whole and the maintenance of biodiversity.

The development of feeding systems based on mixtures which make better use of available resources and enable farmers to meet their objectives requires further research to address the questions listed above, preferably with the application of lateral thinking! Analysis of a mix of field observations and scientific experiment will help to establish principles and lead to recommendations which can be adapted by extension workers and farmers to a range of ecosystems and economic climates.

References

Baumer, M. 1992. Trees as browse and to support animal production. In: Legume trees and other fodder trees as protein source for livestock. FAO Animal Production and Health Paper No. 102. Edited by: A.W. Speedy and P.L. Pugliese. pp. 1-10.

Bosman, H.G; Versteegden,C.J.G.M; Odeyinka, S.M and Tolkamp, B.J. 1995. Effect of amount offered on intake, digestibility and value of *Gliricidia sepium* and *Leucaena leucocephala* for West African Dwarf goats. Small Ruminant Research, 15(3): 247-256.

Brown, W. F., and Pitman, W. D. 1991. Concentration and degradation of nitrogen and fibre fractions in selected tropical grasses and legumes. Tropical Grasslands, 25:305-312.

Carter, J. E. 1992. Tree cultivation on private land in Nepal's middle hills: an investigation into local knowledge and local needs. Oxford Forestry Institute Occasional Papers No. 40. 55 pp.

Cassida, K. A., Barton, B. A., Hough, R. L., Wiedenhoeft, M. H., and Guillard, K. 1994. Feed intake and apparent digestibility of hay-supplemented brassica diets for lambs. Journal of Animal Science, 72: 1623-1629.

Devendra, C. 1993. Sustainable animal production from small farm systems in South-East Asia. FAO Animal Production and Health Paper No.106. 143 pp.

Fassler, O. 1993. The effect of mixtures of shrub legumes on nitrogen utilization by sheep. Diploma Thesis. Institut fur Nutztierwissenschaften, Gruppe Ernahrung, Zurich. 80 pp.

Glenn, B. 1989. Ruminal fermentation of neutral detergent fibre and nitrogen in legume, grass and mixtures by growing steers. In: Teaming up for Animal Agriculture. American Dairy Science Association and American Society of Animal Science. Journal of Animal Science, Supplement 2. 67:11.

Kumar, R. 1992. Antinutritional factors. The potential risks of toxicity and the methods to alleviate them. In: Legume trees and other fodder trees as protein source for livestock. FAO Animal Production and Health Paper No. 102. Edited By A.W. Speedy and P.L. Pugliese. pp. 145-160.

Le Houerou, H.N. 1991. Feeding shrubs to sheep in the Mediterranean arid zone: intake, performance and feed value. IVth International Rangelands Congress, Montpellier, France. Cited by: Dicko, M.S and Sikena, L.K. 1992. Feeding behaviour, quantitative and qualitative intake of browse by domestic animals. In: Legume trees and other fodder trees as protein source for livestock. FAO Animal Production and Health Paper No. 102. Edited By A.W. Speedy and P.L. Pugliese. pp. 129-144.

Liener, I. 1980. Toxic constituents of the plants foodstuffs. Second Edition. Monographs of Food Sience and Technology, Academic Press, London. 502 pp.

Lowry, J. B. 1990. Toxic factors and problems: methods of alleviating them in animals. In: Shrubs and tree fodders for farm animals. Edited by: C. Devendra. Proceedings of a workshop in Denpasar, Indonesia. IDRC. pp. 76-88.

Moog, F.A. 1992. Role of fodder trees in Philippine smallholder farms. In: Legume trees and other fodder trees as protein source for livestock. FAO Animal Production and Health Paper No. 102. Edited by A.W. Speedy and P.L. Pugliese. pp. 43-56.

Mueller-Harvey and McAllan, A. B. 1992. Tannins. Their biochemistry and nutritional properties. In: Advances in plant cell biochemistry and biotechnology. Edited by: I.M. Morrison. JAI Press. Volume 1. pp. 151-217.

Natural Resources Institute (NRI). 1994. Diseases of nitrogen fixing trees in developing countries. An annotated list. Edited by Eric Boa and Jillian Lenne. Overseas Development Administration. 82 pp.

Nitis, I.M; Lana, K; Sukanten, W; Suarna, M; and Putra, S. 1990. The concept and development of the three-strata forage system. In: Shrubs and tree fodders for farm animals. Edited by: C. Devendra. Proceedings of a workshop in Denpasar, Indonesia. IDRC. pp. 92-102.

Norton, B. W. 1994. The nutritive value of tree legumes. In: Forage tree legumes in tropical agriculture. Edited by R.C. Gutteridge and H.M. Shelton. CAB International, Wallingford,Oxon. pp. 177-191.

Nsahlai, I.V., Siaw, D.E.K.A. and Umunna, N.N. 1995. Inter-relationships between chemical constituents, rumen dry matter and nitrogen degradability in fresh leaves of multipurpose trees. Journal of Science Food and Agriculture, 69:235-246.

Paudel, K. C., and Tiwari, B. N. 1992. Fodder and forage production. In: Sustainable livestock production in the mountain agro-ecosystem of Nepal. Edited by: J. B. Abington. FAO Animal Production and Health Paper No. 105. pp. 131-154.

Phiri, D.M., Coulman, B., Steppler, H.A., Kamara, C.S and Kwesiga, F. 1992. The effect of browse supplementation on maize husk utilization by goats. Agroforestry Systems, 17:153-158.

Powell, C.J., Lascano, C.E., Romney, D.L and Gill, M. 1995. The effect of supplementary mixtures of tropical shrub legumes on nitrogen utilisation in sheep fed a low quality grass. British Society of Animal Science. Winter Meeting. Abstract 71.

Preston T.R., and Murgueitio, E. 1992. Strategy for Sustainable Livestock Production in the Tropics. CIPAV-SAREC. Condrit LTD. Cali, Colombia. 89 pp.

Rangkuti, M., Siregar, M. E., and Roesyat, A. 1990. Availability and use of shrubs and tree fodders in Indonesia. In: Shrubs and tree fodders for farm animals. Edited by: C. Devendra. Proceedings of a workshop in Denpasar, Indonesia. IDRC. pp. 266-278.

Roggero, P.P., Bellon, S., and Rosales, M. 1996. Sustainable feeding systems based on the use of local resources. In: Ruminant use of fodder resources in warm climate countries. IVth International symposium on the nutrition of herbivores. Montpellier, France. 18 pp. (in press).

Rosales, M. 1996. *In vitro* assessment of the nutritive value of mixtures of leaves from tropical fodder trees. D.Phil. thesis, Department of Plant Sciences, Oxford University, Oxford, UK. 214 pp.

Rosales, M. Galindo, W. F., Murgueitio, E., and Larrahondo, J. 1989. Sustancias antinutricionales en las hojas de Guamo, Nacedero y Matarraton. Livestock Research for Rural Development, 1(1): 29,748 Bytes.

Rusten, E. 1989. An investigation of an indigenous knowledge system and management practices of fodder tree resources in the middle hills of Central Nepal. Unpublished D.Phil. thesis, Department of Forestry, Michigan State University. USA. Cited by: Carter, J. E. 1992. Tree cultivation on private land in Nepal's middle hills: an investigation into local knowledge and local needs. Oxford Forestry Institute Occasional Papers No. 40. 55 pp.

Sanchez, P. A. 1995. Science in agroforesty. Agroforesty systems 30:5-55.

Sinclair, L.A., Garnsworthy, P.C., Newbold, J.R., and Buttery, P.J. 1993. Effect of synchronizing the rate of dietary energy and nitrogen release on rumen fermentation and microbial protein synthesis in sheep. Journal of Agricultural Science, Cambridge, 120:251-263.

World Resources Institute (WRI). 1992. World Resources 1992-1993. International Institute for Environment and Development. Oxford University Press. Oxford. 385 pp.

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Landless Women And Poultry: The Brac Model in Bangladesh[1]

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Abstract

On the background of the extreme poverty, most women of rural, landless households are subjected to in Bangladesh, an outline is provided of Bangladesh Rural Advancement Committee and the evolution, which led to its present poultry development model. The model is exclusively targeted at landless women and builds on GO-NGO collaboration. It involves women in a chain of activities as vaccinators, hatchery operators, chicken rearers, feed sellers, producers of hatching eggs and as producers of eggs for the market. Credit as well as marketing are integrated into the model. A recent survey has reported considerable positive impact both in terms of income and producer household egg and meat consumption. It is concluded that poor rural women can contribute to economic development as buyers and sellers of goods and services, by contributing to improved household income, and - as important - in the process their own self esteem is heightened.

KEY WORDS: Landless women, rural poultry, poultry development, BRAC, GO-NGO collaboration, impact

Introduction: Poverty in Bangladesh

That poverty is acute in Bangladesh does not need to be told: However, a few words on poverty will be useful to set the scene in which Bangladesh Rural Advancement Committee (BRAC) operates. Bangladesh has the unfortunate label of a case of endless poverty and deprivation. The proportion of the rural population living below the poverty line in the early 1990s has been estimated to be between 38 percent (Sen, 1995a), 48 percent (BBS, 1995) and 55 percent (Hossain, 1995). These single index measures hide a wide range of variation among the poor: the household food intake is gender biased with the females' consumption levels being between 71 and 90 percent of the males' (Khondakar and Chowdhury, 1995). The per capita food intake (1980 k.cal. in 1990-91) remains below the requirement (2273 k.cal.). The literacy rate is still low at 35 percent (for females it is 29% and for males 45%) (Hamid, 1995). Another indication of poverty is the real wage rate, i.e. kg. of course rice a day's money wage will purchase in rural areas, which has declined from 3.84 in 1987 to 3.24 in 1990 (Hossain, 1995a). Land, which is the single most important resource in the rural areas, is distributed very uneven with 50 percent of the households owning none or less than 0.50 acre. At the same time, for around 60 percent of the rural households agriculture (cultivation and source of employment) is the primary source of income (Sen, 1995).

Access to credit has been identified as a major mechanism with which a household can improve its economic condition (Rahman, 1989; Khondakar and Chowdhury, 1995). The rural households in general and the landless in particular have very little access to institutional credit. In the late 1980s less than seven percent of the landless and 14 percent of all rural households had access to institutional credit including NGO programmes (Rahman, 1989). Given this, it is not surprising that the women in rural areas virtually had no access to institutional credit until the 1980s.

Since the beginning of 1980s some specialised programmes were launched to provide financial support on credit basis to women, who in their turn have proved themselves to be "bankable" (Rahman 1989; Hossain and Afsar, 1989). Along with the expansion of credit availability in rural areas and for women in particular through expansion of commercial banks and non-governmental programmes, other positive changes are worth noting. One of these is the expansion of safe drinking water to 87 percent of all households (Sen, 1995b). An important change is the improvement in the nutritional status of children under five years of age : the figures for stunting and wasting have declined from 74 % and 22 %, respectively in 1975 to 43% and 13 % in 1991 (Khondakar and Chowdhury, 1995).

BRAC: the Organisation

In 1972, following Bangladesh's War of Independence, BRAC worked on the resettlement of refuges in the Sulla area of Sylhet district (the administrative units in Bangladesh in descending order are country, division, district, sub-district or Thana and Union Porishad) in the north-eastern part of the country. It organized relief and rehabilitation for war victims whose homes, cattle, fishing boats and other means of livelihood had been destroyed. What made BRAC set out on its remarkable journey was the realization that relief-oriented activities could only serve as a stop-gap measure. From then on the new pledge was to provide sustainable measures to improve the conditions of the rural poor by developing their ability to mobilize, manage and control local and external resources by themselves. BRAC's programmes have never been determined by a rigid set of strategies. The organization's success is attributable largely to its flexibility in responding to the needs of the people (Lovell, 1992).

Another factor that has contributed to BRAC's transformation is its capacity to learn through trials and errors. In 1973, BRAC adapted in its work the basic rural development community strategy, focusing on entire village communities. It was at this point that BRAC realized that in fact, there was a community within the larger village community comprising the poor. By 1976, it therefore became apparent that the community approach would not work, as the poor who outnumbered the others in the community benefited very little from the interventions. This was because those who owned land and other productive assets were able to secure for themselves the larger share of the benefits. From here on began BRAC's

involvement with the poorest of the poor - the landless, small farmers, artisans, and vulnerable women. The time had also come to fix the organization's goals which were identified as:
A. Poverty Alleviation
B. Empowerment of the Poor

BRAC's Programmes

BRAC's definition of the poor refers to those people who own less than half an acre of land (including the homestead) and to those who earn their living by selling manual labour. Efforts to empower this group have been evaluated and adjusted many times over the years in the light of BRAC's growing capacity and the needs of the programme participants. Today , working as a development organization in the private sector, BRAC strives to attain its two goals by implementing such programmes as:

1. *Rural Development* which involves development of village organizations of the poor, credit operation, and facilitation of savings' habits. The village organizations are designed to mobilize the collective strength of the poor with a view to empowering them to be self-reliant. BRAC has a Human Rights and Legal Education Programme to further the initiatives aimed at empowering the Village Organization members. BRAC's Rural Development Programme implements these initiatives along with several income and employment generating programmes, designed particularly for the women village organization members. These women are provided with credit and training to carry out their activities. There are also some special programmes that have been introduced under the Income Generation for Vulnerable Group Development and Small Holder Livestock Development Programme initiatives. These too are implemented through Rural Development Programme.
2. *Education* initiatives in the form of the Non Formal Primary Education Programme for the children of the disadvantaged rural people.
3. *Health Programmes* addressing the health and nutritional status of women and children. These initiatives seek to develop and strengthen the capacity of communities to sustain health related activities.
4. *Administrative and Technical SupportServices* that facilitate BRAC's programme activities, e.g., training, research, monitoring, the "Aarong"

marketing outlet, publications, public affairs & communication, accounts & audit, logistics, computer service, and construction service.
5. Furthermore, in order to attain budgetary self-reliance the organization has set up its own revenue generating enterprises i.e., the BRAC Printing Press, BRAC Cold Storage and the BRAC Garments Factories.

Of the 86,038 villages of the country, BRAC's Rural Development Programme covers 35,961 with the Education Programme coverage in 16,946 and the Health and Population Programme in 12,056 villages. In certain areas these three programmes overlap.

The management system within BRAC is participatory and decentralized, and programme planning draws upon the experience and expertise of workers at all levels. Women comprise 23% of the staff. Founded by Mr. Fazle Hasan Abed in 1972, BRAC has now grown into an organization in which capacity building of the individual worker and the programme participants is given the topmost priority. BRAC also attaches the utmost importance to the institutionalization of the organization so that it may withstand and overcome the challenges of the future.

The State of the Poultry Sector in Bangladesh

The poultry and livestock sectors are integral parts of the farming systems in Bangladesh. There are about 90 million chicken and 12 million ducks in the country. About 89 percent of rural livestock households rear poultry and the average number per household is 6.8. It is an important source of cash income for the poor rural families, particularly for women. Most birds are kept in a scavenging system and are fed on household waste and crop residues. The predominant poultry breed in Bangladesh is the local. The productivity of the hen is about 40-60 eggs per year. Some other exotic breeds such as Rhode Island Red, White Leghorn, Barred Plymouth Rock, Australorp and Fyaumi are now available in the government poultry farms. There are six government hatcheries in Bangladesh which produce day old chicks, but there is no distribution system in rural areas. These exotic hatching eggs and day old chicks are now distributed to BRAC project areas to develop the local breed. There are some commercial farms in Bangladesh, where the production cost of eggs and meat is comparatively higher than of eggs and meat produced in scavenging system.

The annual growth rate in the chicken population was 6.5% between 1990-94 (Alam, 1996). The annual per capita egg consumption was only 23 although it should be 100 from a nutritional point of view. For optimal productivity, the high yielding varieties (HYV) of poultry requires improved feeding, but presently the feed which is prepared in the government farms is far less than the need and consequently balanced feed is not available in rural areas.

The prevailing poultry diseases in Bangladesh are Newcastle, Fowl Pox, Fowl Cholera, Fowl Typhoid, Coccidiosis, deficiency diseases and worm infestation, etc. Without interventions, the mortality rate of the poultry in the scavenging systems is high (35% to 80%) due to diseases and predators. In spite of 4 types of important vaccines are produced in Bangladesh, remote rural areas are not served due to lack of service delivery mechanisms. There are only four field staff and one livestock officer at sub-district level and they are responsible for about 200,000 poultry, 50,000 cattle and 20,000 sheep and goats.

Government istitutions that are responsible for the delivery of support services in the rural areas are not geared to assist BRAC's target group. There is thus a need to assist particularly the landless in their efforts to earn an income and to the extent possible, improve their long term potential for deriving income from sustainable agricultural practices. In remote areas where government services are not operative or inadequate, BRAC collaborate with the government machinery to extend the service delivery system by developing and using local manpower.

Summary of the Constraints and Major Issues in the Poultry Sector:

- High mortality of the scavenging bird.
- Low productivity of the local hen.
- Unavailability of cheap sources of HYV birds at village level.
- Supply of vaccines in remote rural areas.
- Health and veterinary care is inaccessible for the village women.
- Poor poultry rearing and management system.
- Unavailability of some feed ingredients.

- Lack of organized marketing mechanism.
- The government livestock service delivery system is inadequate and inefficient.
- The vast majority of women are left out of the formal credit system.

The Scope of Poultry Development

The possibilities for women's participation in poultry development are as follows:

1. About 70% of the rural, landless women are directly or indirectly involved in poultry rearing activities. Traditionally these women have some experience in poultry rearing, which therefore represent skills known to them.
2. BRAC has proved that homestead poultry rearing is economically viable. If the landless women are properly trained, supported with credit and other necessary inputs and made to operate under supervision of extension workers of both Government and BRAC and the Government machinery are activated to provide for the delivery of services, the poultry sector could be one of the most productive sectors.
3. Poultry rearing is suitable for widespread implementation as it is of low cost, requires little skills, is highly productive and can be incorporated into the household work.
4. There are few or no job opportunities for the landless, disadvantaged women. Poultry is the only activity in which a large number of landless women can participate.
5. In the small scale poultry units which support the landless, production per bird may be low, but distribution of benefits will be more equal and have great human development impact.
6. Poultry rearing is culturally acceptable, technically and economically viable. Moreover, the ownership of poultry is entirely in the hands of women. This is an asset over which the poor women actually have control. This activity can therefore play an important role in poverty alleviation which is the main goal of BRAC.

Development of BRAC's Poultry Programme

Evolution of the Poultry Programme

The history of BRAC's efforts to develop a poultry programme design can be divided into three phases, i.e. formative, development and replication (see for details in Mustafa *et al.*, 1993). These relate roughly to an eleven year timeframe during which the programme continuously underwent changes and fine tuning.

Formative Phase.

In the late 1970s BRAC identified poultry rearing as a source of income for the landless, particularly destitute women. A high mortality rate for poultry in Bangladesh, combined with its relevance as an income generating activity for poor women, led BRAC to carry out participatory 'action research' aimed at increasing productivity.

Initially, efforts were made to increase the productivity of local poultry by cockerel exchange, but this system with improved cockerels for crossbreeding failed since the improved birds tended to be sold and mortality remained high. In order to reduce bird mortality BRAC initiated an action research in its Manikganj project area. BRAC staff regularly vaccinated poultry birds in the five intervention villages for one year. The positive results in terms of reduction in mortality and increase in bird population led BRAC to realise that vaccination must be an integral part of any intervention to promote poultry rearing as an income earning source.

It was decided to involve women group members in vaccination work and allow them to vaccinate for a fee, using vaccines supplied free of cost from the Government.

It was observed that the pullets supplied by the government and other farms, like the cockerels also suffered high mortality in the scavenging system. It was therefore decided to buy day-old chicks from Government farms. Selected, trained and supervised by BRAC, rural women were to rear the day old chicks for two month on their homestead plots and thereafter sell them to key rearers. The advantage was that the two months old chicks released into the scavenging system survived to a much higher degree as mortality in chicks is particularly high in the two first months after hatching in the scavenging system. From BRAC's point of view it was an advantage that this arrangement did not require more BRAC staff.

Between 1978 and 1982 the poultry programme of BRAC had no model or design, it was done on an ad-hoc basis. The focus changed from 1983 to supply of improved chicks, prevention of common diseases and training in improved scavenging based rearing. The following model was developed: * One poultry worker (vaccinator) for every 1000 birds. The poultry worker is given a five day training on preventive and curative aspects as well as rearing management. * Vaccinations to take place at dawn. * 10 key rearers in each village keeping one HYV cock and ten hens, trained in the improved scavenging rearing management. * Model rearers with three cocks and 20 hens. * Chick rearing units (CRUs) at the level of a cluster of villages, each with a capacity to nurse 200 day-old chicks for two months. * Feed production centres at the level of a cluster of villages to supply feed to the programme participants who are all women. *In late 1980s, two more components were added to this early model: egg merchants to protect the producers from middlemen, and experiments are underway, from 1993, to create the supply sources of day old chicks through hatchery operators.

Development Phase

Having developed a model for rural poultry development, the District Livestock Office in Manikganj (60km from the capital Dhaka) was approached for cooperation by BRAC's project staff. Between 1983 and 1985 an informal collaboration developed in Manikganj whereby the Government officers supplied vaccines and provided technical advice on the chick nursing units. After extensive evaluation by officials from the Directorate of Livestock Services in Dhaka the BRAC model was accepted as viable and replicable. Based on this experience the model was tested further.

Between 1985 and 1987, the model was tested in 54 Area Offices of BRAC's core Rural Development Programme. The Sub-district Livestock Officers in the respective areas ensured the supply of vaccines to the participants through the Area Offices of BRAC in 32 Thanas. This produced positive results in terms of increased income for the participating women, a reduction in mortality rates and an increase in bird population. Through the intermediation of BRAC the government structure was brought closer to the people.

In 1987 BRAC integrated the experiences of poultry development collaboration and the Government food aid for destitute women, into an independent programme. The Income Generation for Vulnerable Group Development Programme was launched in August 1987, in collaboration between BRAC, the Departments of Livestock and Relief and Rehabilitation, and the World Food Programme (WFP).

In 1988, it was found that the income earned by the rearers was very low because the participants were able to buy only one or two HYV birds. This prevented development of crossbreeds and improved productivity, resulting in slow generation of income. In the late 1980s credit support for poultry rearing was introduced in BRAC.

Having incorporated the credit component, efforts were directed at *sustainability.* The range of income generation activities are being increased so that the beneficiaries can undertake additional enterprises, which need not be related to poultry. To support this the credit operation is also being scaled up. The interest earnings from financial operations and service charges to be levied for technical services, are estimated to cover the major portion of the programme costs. Furthermore, the need for technical services from BRAC is expected to decline over time as the beneficiaries become adept at using different technologies.

The Programme Framework

Through the process of "learning by doing" BRAC identified a framework for rural poultry development the aim of which is to enhance the income earning capability of very poor women.

Table 1. Programme Framework: The steps

Subject and Objective	Methods
1. Check the bird mortality in order to create a favourable environment, so that the people are interested to rear poultry	1. Selection & Training of beneficiaries 2. Develop poultry worker 3. Regular supply of vaccine & medicine 4. Motivate the people for vaccination of their birds
2. Upgrading of local breed in order to increase production and income	1. Training and development of key rearers 2. Supply of HYV birds through establishment of chick rearing unit 3. Supplementary feed supply
3. Marketing facilities in order to ensure Reasonable price of egg to key rearers	1. Develop egg collector
4. Permanent net work development in order to develop self supported programme	1. Improve management system components such as housing, feeding, rearing etc. 2. Medium scale poultry unit development such as model rearer to produce hatching eggs 3. Set up of small rice husk hatcheries 4. Service charge
5. Credit facilities in order to start the poultry enterprises just after completion of training	1. Small scale credit to the rearers
6. Involvement of Government in order to increase access to Government resources & services for the poor women	1. Delivery of input and other support service 2. Coordination meeting with Govt. staff

BRAC's Poultry Development Programme

Objectives

The programme aims to provide the women an entry point to diversify income earning and employment opportunities through training in poultry activities in order to improve their socio-economic situation.

Specific Objectives of The Programme

1. Integration of poor village women into poultry rearing activities, so that they can earn a monthly income of at least Tk.200 (US$ 5).
2. To reduce poultry mortality from 40-85% to 15%
3. To increase the poultry population.
4. To introduce crossbreeds and increase the production of eggs and meat.
5. Improve the protein intake level of the rural poor.

Methodology and Development Model

Considering the steps described earlier, BRAC designed a specific model for poultry development from the practical experience in 1983, which was accepted by the Government as a model for poultry development. The approach consists of an integrated package support to the rural women and includes the following:

Selection

BRAC through its Rural Development Programme organizes the landless women into groups. There are 45-55 members in each group out of which 30 are selected for poultry activities and provided different types of training on poultry rearing and management.

Training

(a) *Poultry Workers*: One woman group member is selected from each village and given 5 days of training on poultry rearing, management, vaccination and treatment. The poultry workers are engaged in vaccination and treatment of birds in their respective villages. Once in a month they attend one day refresher courses and they receive poultry vaccine and medicine twice a month. The workers charge Tk. 0.25-0.50 per bird attended to as a fee.

(b) *Key Rearers*: They are given three days of training on ideal methods of poultry rearing. Every key rearer must have one HYV cock and 10 hens (of which 4-5 HYVs) and a good housing system.

(c) *Chick Rearers*: Chick rearers are given 7 days of training. They rear 200 chicks from day old chicks till two months of age and sell them to the key rearers. The chick rearers are supplied with chicks from the Government farms, BRAC's own farms and the poultry hatcherers (see (f) below).

(d) *Feed Sellers*: One poultry feed sale's centre is established in each area. With the spread of HYV birds, people are gradually getting accustomed to buy balanced feed. Feed producers receive three days of practical training on feed preparation. She prepares poultry feed with ingredients from locally available sources under close supervision of BRAC.

(e) *Model Rearers*: They are given three days of advanced training on poultry rearing and management. They rear HYV 22 hens and three cocks, and produce hatching eggs which are supplied to the poultry hatcherers.

(f) *Poultry Hatcherer*: To meet the demand of day old chicken, five small hatcheries operated by the rice husk method are established in each area, the capacity is about 5000 chicken per month. The hatching eggs are purchased from model rearers through egg collectors.

Input Supply

(a) After completion of training, the poultry workers are provided with vaccination kits. There are specific dates for vaccine distribution. Vaccines are supplied by the Government and distributed twice a month to the vaccinators by the Government veterinary staff. All poultry workers come to the Union Porishad to collect their vaccines. Initially the Government field staff did the vaccination work by themselves, but now the strategy is that they are responsible for distribution of vaccine instead of doing the vaccination work. (b) Medicines are supplied by BRAC at cost price each month. Initially, medicines worth Tk. 25 are given per poultry worker as a revolving fund from where they buy and sell the medicines. (c) Day old chicken are supplied by the Government to BRAC and BRAC distributes them as per requisition. BRAC also assists in distribution of the day old chicken produced by the rice husk hatcheries. (d) The eight week old chickens are sold from the rearing units to the key rearers from BRAC or Union Porishad offices. (e) To ensure complete feed, BRAC supplies ingredients like fishmeal, sesame oil cake, vitamins etc. at cost price to the feed sellers. MARKETING There are 10-15 egg collectors for each area who are responsible for buying eggs at reasonable prices from the group members and marketing of the eggs.

Credit

To ensure proper utilization of the skills imparted during training, BRAC provides credit as initial investment capital to start poultry or chick rearing, feed selling, egg collection and hatchery activities. COORDINATION WITH GOVERNMENT To cooperate with Government and to ensure smooth implementation of the programme, BRAC has one Project Officer (livestock) for every 10 areas and one Project Assistant for each area office. BRAC's staff are responsible for initial surveys of participants, motivation, group formation, training and credit to the group members. The Government staff is responsible for training and input supplies.

Institutional Arrangements

BRAC's poultry programme is also a case study in multi-agency action between the State, the Aid Community and BRAC (Mustafa, 1993). The poultry programme was developed in close cooperation with the Directorate of Livestock Services of the Ministry of Livestock and Fisheries, Government of Bangladesh, an interaction, which began in the formative phase of programme development. Thereafter the Aid Community joined hands with Directorate of Livestock Services and BRAC, firstly the World Food Programme (WFP) and later the International Fund for Agricultural Development (IFAD) and Danida. The institutional arrangement for poultry development by BRAC has two aspects: (a) the providers' aspect, and (b) the implementation aspect. BRAC and Directorate of Livestock Services work with the aid community under different arrangements: with the WFP and the Ministry of Relief and Rehabilitation in one set, and with IFAD and Danida in another set of arrangements, for the implementation of the programme. With respect to the implementation aspect the programme is executed by three organizations:

a) BRAC implements the programme through its Rural Development Programme in the latter's permanent operational areas.

b) In collaboration with WFP, the local government (Union Porishad) and the Ministry of Relief and Rehabilitation, which is targeted specifically at the destitute women who receive food aid from the Government under Income Generation for Vulnerable Group Development.

c) BRAC is a partner in the implementation of the Smallholder Livestock Development Programme.

The last two arrangements may spatially overlap BRAC's core programme for rural development.

Rationale for Collaborative Action

A brief discussion on the reasons why the different agencies came forward to work together will contribute to a better understanding of a phenomena that was encouraged by the donors in the late 1980s. The limitations of the government structures and the comparative advantage of NGOs like BRAC in reaching the poor provided the motivation for joint action to develop.

Limitations of the Public Sector

The emergence and the proliferation of non governmental organisation (NGOs) in Bangladesh and elsewhere in South Asia, has been explained as a response to the fact that the State has had limited success in meeting the needs of the rural poor - particularly the women. A recent review of experiences of agricultural technology development in South and South-East Asia, has identified three broad trends:

- Limited public sector success in meeting the needs of the rural poor.
- The recent establishment of a large number of NGOs which claim advantages over the public sector in reaching the rural poor.
- The increasing weight attached to views that the prospects of successful change are enhanced if the poor participate in its design (Farrington and Lewis, 1993)

The Independent South Asian Commission on Poverty Alleviation (ISACPA) also pointed out the failure of the Government initiated programmes to reach the poor. The Commission identified the following among other reasons for this: "Conventional top-down development strategies, inequitable distribution of assets, inaccessibility of the poor to technological innovations and finance , the misuse of development resources and viewing the poor as a liability". These factors obviously led to the exclusion of a large number of poor from benefiting from Government initiated programmes and hence to their increasing marginalisation (SARC, 1992).

Comparative Advantages of BRAC and the State

The Government structures which extend to the sub-district level and that are relevant for BRAC's poultry programme are the Ministries of Fisheries and Livestock and of Relief and Rehabilitation. The two are briefly described below with a view to identify the weaknesses in them.

The Directorate of Livestock Services, Ministry of Fisheries and Livestock, is the sectoral Government structure whose line functions extend to the Union level. The Directorate of Livestock Services is the Government agency responsible for promoting livestock and poultry development in the country.

The Directorate of Livestock Services has several constraints of its own, particularly inadequate manpower, to cope with the magnitude of the tasks involved. The activity spectrum involves providing of development inputs, training of beneficiaries, prevention and cure of diseases of the animals and birds.

The workload of the present Thana Livestock Development Complex staff appears to be quite heavy as it includes delivering services to around

40,000 households owning over 40,000 cattle, 20,000 goats and 150,000 poultry. This is excessive by any standard of user:provider ratio. As a result, the extent of coverage has obviously been limited and confined virtually to prophylactic treatment i.e., vaccination (Samdani, 1991).

The Directorate of Relief And Rehabilitation under the ministry of the same name, is responsible for providing emergency relief at times of natural disasters, for implementing the "Food for Work" programme during the slack employment season, and for the Vulnerable Group Development (formerly Vulnerable Group Feeding) Programme throughout the year. In terms of the number of beneficiaries the Vulnerable Group Development Programme administered by the Directorate of Relief and Rehabilitation is perhaps the largest. Some 450,000 families in rural Bangladesh are recipients of a monthly income transfer ration of 31.25 kg of wheat for a period of two years. However, the programme has virtually turned into a relief and welfare programme as the target women received wheat only because of lack of adequate personnel for extension services, technical ability and other resources.

The Union Porishads are one of the mechanisms for the distribution of food relief. With one chairman and nine members, directly elected by the rural population, they are close to the recipients of food aid. Village level developmental activities, such as infrastructure construction, are organised through the Union Porishads. The representatives are also involved in health and family planning activities. For all of their developmental activities and resources they are entirely dependent on the respective governmental structures at the sub-district level.

Disfunctioning Government Structures Questions of disfunctioning arise when structures exist, but do not deliver their services to a large segment of the population. In particular, the rural poor men and women are not reached by the services provided by government structures.

In the context of agricultural technology development, a recent six-country study of NGO-State collaboration has found that NGO approaches emphasise those areas in which "Government services have either disregarded the needs of the poor or have responded to them inadequately". These areas include:

- Technologies and management practices adapted to difficult areas
- Technologies to meet the needs of the rural landless
- Technologies to meet the specific needs of women
- Approaches that "de-mystify" complex technologies and make them suitable for neglected groups
- Approaches helping to form local groups which then carry forward the technology in a sustainable fashion , linking in with input supplies and markets (Farrington and Lewis, 1993).

These general comparative advantages of NGOs in Asia, are also applicable to the concrete situation in Bangladesh and BRAC in particular. The government has traditionally concentrated on the physically favourable areas, large scale lumpy technologies, literate male farmers, emphasising the individual, and so on. Such an orientation reaches only a few and thus diverts resources away from a large number of people. On the other hand the BRAC approach considers people as active participants in development, emphasises the poorer section, particularly women and adapts existing technology to the specific condition of the poor (Mustafa, 1993).

Implementation Arrangements

At the top level the poultry development programme is led by a senior manager who is reportable to the Director of Field Operations. At the implementation level three separate organisations with different funding sources, are engaged.

BRAC implements the poultry programme on its own through its Rural Development Programme which is a multisectoral intervention that comprises group formation, social development, credit and sectoral programmes such as fisheries, agriculture and livestock. Poultry development is part of BRAC's livestock sector development programme. It is implemented through the area offices of the Rural Development Programme.

The organisation of the Income Generation for Vulnerable Group Development Programme focuses primarily on the poultry sub-sector and its beneficiaries are the destitute women who receive the two-year long wheat ration from the Ministry of Relief and Rehabilitation. A part of the food aid from the WFP is used to provide the ration and another part is monetised to establish the Revolving Loan Fund. The Revolving Loan Fund is managed by BRAC staff. The management cost is primarily borne by the Rural Development Programme's budget for 'special programmes'. The officers of the Directorate of Livestock Services provide technical supervision. The role of the local government (Union Porishad) is to select the relief recipients (whose eligibility is verified by BRAC), distribute the relief, provide space for training and motivate villagers on the need for poultry health care. Coordination committees which are comprised of representatives from the Government, the WFP and BRAC, exist at four levels i.e. national, district, sub district and Union.

In 1993 a new organisation was set up to undertake poultry development on a large scale, jointly by the Government's Directorate of Livestock Services and a number of NGOs including BRAC. The funding sources of the Smallholder Livestock Development Programme are entirely different from the two above. IFAD extends soft, long term loan to the government for training and for the Revolving Loan Fund, through Bangladesh's central bank. The Bank on-lends the fund to a) the Directorate of Livestock Services which then finances the training activities undertaken by the NGOs, b) the Bangladesh Krishi Bank which on-lends to the participating NGOs who conduct the credit operations. The social development activities such as group formation, awareness building and other human resource costs are met by Danida on a grant basis. The Smallholder Livestock Development Programme is implemented in 80 sub-districts (out of a national total of 460) of which BRAC is responsible for 66. After the expiry of the Smallholder Livestock Development Programme the groups which are formed will become part of BRAC's core programme for rural development.

Impact of the Poultry Programme

A recent evaluation of the Smallholder Livestock Development Programme (Alam, 1996) reports positive improvements for the beneficiaries. The findings of the assessment are summarised below:

Poultry and Breed

The number of poultry reared per farm in 1995 was 17 for key rearers, 11 for chick rearers, 32 for model rearers, 10 for poultry workers, 10 for feed sellers and 11 for mini hatcherers. The average number of poultry reared per farm was 16 which was much higher than the national average (of 6.8 in 1988-89).

All birds reared by different categories of beneficiary households were classified by type of breed. It was observed that 47.4% of all birds was of the improved type while 52.6% was local. The percentage of improved breed was highest for model rearers (79.2%), followed by mini hatcheries (57.0%), key rearers (44.8%), feed sellers (42.7%) and poultry workers (39.7%). In the case of chick rearers, all chicks were identified to be of improved breed. Considering the national average figure for improved breeds of chicken is at around 5%, one can safely conclude that the Smallholder Livestock Development Programme has contributed substantially to breed improvement in the areas it covers.

One of the objectives of the Smallholder Livestock Development Programme was to reduce the mortality rate of chicken in rural areas. The mortality rate of adult chicken was less than 3 percent for each category of farms and one can thus conclude that the Smallholder Livestock Development Programme has had a significant, positive impact on the mortality rate of chicken.

Income Generation

The repayment behaviour of group members suggests that the loans were properly used and that investment in Smallholder Livestock Development Programme activities was profitable. It was noted that the average net income per household from the Smallholder Livestock Development Programme activities was Taka 427 per month. The amount of income was highest (Taka 1047) for mini hatcherers followed by Taka 761 for chick rearers, Taka 757 for feed sellers, Taka 500 for model rearers, Taka 394 for key Rearers and Taka 265 for poultry workers. The average monthly benefit/cost ratio was 1.5 : 1 for all farms. The benefit/cost ratio was highest, 3.86 : 1 for key rearers and lowest 1.06 : 1 for feed sellers.

Consumption

As the economic condition of the beneficiary households improved, one would expect that the intake of food by household members would increase after the intervention of the Smallholder Livestock Development Programme. The proposition was thoroughly investigated and analysed. It appears that the consumption of all food items increased after membership. The increase in consumption was substantial in the case of eggs by 159.6% for per week and of chicken by 137% per annum. With regard to consumption of eggs within the households, children, and especially boys, were given priority.

Decision Making

All the beneficiaries of the Programme are women. The Smallholder Livestock Development Programme has ensured employment and income for them and thereby enhanced their status in the family. Their relationships with their husbands have improved and their participation in decision making has increased. Sole decision making by men has declined sharply from 21% in the pre-project period to 2% in the project period. The evidence suggests that the socio-economic status of women within the household has increased after the intervention made by the Smallholder Livestock Development Programme, whereas no change has yet been registered with regard to the beneficiaries' status in the village society.

Conclusion

The poultry programme has made a significant contribution in raising the income level of disadvantaged women, who would otherwise be left without work. They are now an active work force and even if their income is not much, it helps to augment the meagre earnings of the family as well as improving their quality of life. For many it is the sole source of income.

What is noteworthy about this programme is that poor, rural women can actively participate in the rural economy both as buyers and sellers of goods and services. Moreover, a strong linkage is developed with the Government services, which are now accessed. Another, more important aspect of the programme is the feeling of dignity, the women develop as a result of their participation.

References

Alam, I (1996). Socio-economic Impact of the Smallholder Livestock Development Programme. MFL (GOB) and Danida, Dhaka

BBS (1995). Summary Report of Household Expenditure survey 1991 - 1992. Bangladesh Bureau of statistics, GOB. Dhaka

BRAC (1995). The BRAC Annual Report -1994. BRAC, Dhaka.

Khondakar and Chowdhury (1995). Nutritional Dimension of Poverty. In: Rahman and Hossain (eds)(1995).

Farrington and Lewis (eds)(1993). Non-Governmental Organisations and the State in Asia: Rethinking Roles in Sustainable Agriculture Development. Overseas Development Institute (UK). Routledge, London.

Hamid, S (1995). Gender Dimension of Poverty. In Rahman and Hossain (eds)(1995).

Hossain, M (1995a). Structure and Distribution of Household Income and Income Dimension of Poverty. In: Rahman and Hossain (eds) (1995).

Hossain, M (1995b). Socioeconomic Characteristics of the poor. In: Rahman and Hossain(eds)(1995).

Hossain, M and Afsar, R (1989). Credit for Women's Involvement in Economic Activities in Rural Bangladesh. Research Report no. 105, Bangladesh Institute of Development Studies, Dhaka.

Lovell, K (1992). Breaking the Cycle of Poverty - The story of BRAC. Kumarian Press, New York.

Mustafa, S (1993). The State and BRAC: a case study of Joint Public Action in Bangladesh. Paper for Workshop on NGO-Local Government Collaboration in Management of Local Development in South Asian Countries. Organised by the UN Centre for Human

Settlement, Rajendrapur, (Bangladesh).

Mustafa, S, Rahman, S and Sattar, G (1993). BRAC: Backyard Poultry Development and Landless Irrigators' Programmes, in Farrington and Lewis (eds) (1993).

Rahman, A (1989). Credit for the Rural Poor, in: Institutions (compendium Volume V), Bangladesh Agriculture Sector Review, UNDP, Dhaka.

Rahman, H Z and Hossain, M (eds)(19995). Rethinking Rural Poverty: Bangladesh as a case study. UPL, Dhaka.

Samdani, G. (1991). Poultry Development in Rural Bangladesh - A case of GO & NGO collaboration. Paper presented at National Workshop on Livestock Development. Centre for Development Management, Rajendrapur.

SARC (1993). Meeting the Challenge: an Overview of the Report of the Independent South Asian Commission on Poverty Alleviation. ISACPA secretariat, Colombo.

Sen, B (1995a). Rural Poverty Trends, 1989-90. In Rahman and Hossain (eds) (1995).

Sen, B (1995b). Selected Living Standard Indicators. In Rahman and Hossain (eds) (1995).

Traditional Poultry Production Systems and the Role of Women in Parts of Western India

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Backyard poultry production is traditional in most rural and peri-urban areas of India, particularly in some communities. Until about 15 years ago, it contributed the major share of the total poultry production in India but is now reduced to 25%.

Studies were carried out in a number of clusters of villages in under-developed pockets of Western India, involving a variety of communities. Observations were gathered through repeated small group discussions and participatory exercises.

Discussions and participatory exercises were conducted with more than 1000 families to understand the poultry production system, the perceptions and priorities of women and find suggestions for improvement.

Almost 80% of rural families, from the under-privileged group and Muslim community were found to keep backyard poultry in numbers varying from 6 to 20. Seventy-five per cent of families kept 6-12 birds. In about 70% of the families, the entire operation, from feeding and management to marketing, was handled by women. Feeding and management of the birds was entirely looked after by women in more than 95% cases. The sale of eggs and birds from the household (where middlemen or individual buyers come to purchase) was by women, irrespective of socio-economic class. Selling of eggs and birds in village markets was by men in some communities and higher socio-economic groups. However, among lower socio-economic strata groups, it was common to see women selling eggs and birds in weekly markets.

There is a good demand for the products (eggs and birds) and they command higher market prices than the commercially produced equivalents. Except in summer, the backyard egg or bird gets double the price of commercial eggs and poultry. During festival seasons, it is even higher. Frizzle fowl and fighting cocks fetch very high prices in the market.

The objectives and outputs of poultry keeping are multiple and their ranking varies from area to area, community to community and between men and women. Based on the average of rankings by families from different areas of the study, the objectives and products are indicated in Table 1.

Table 1.

	Objective	Product
1.	Small cash - regular income	1. Bird
2.	Entertaining guests and festivities	2. Egg
3.	Cheap source of nutrition for the family	3. Chicks

The relative importance of birds or eggs as products for sale varies from region to region. About 20% of families were found to be involved in the production of chicks using brooding hens.

These perceptions have implications for planning interventions and extension programmes.

Almost 90% of the families were in favour of keeping coloured country fowl and the major reasons for the choice were:

1. Easy to manage
2. Low external inputs
3. Good market demand/price
4. The country fowl can protect itself well against predators
5. The adult country fowl has good resistance to disease

Feeding of backyard poultry is a good example of the recycling of household and farm wastes, and the use of naturally occurring resources. Women devise innovative ways of using waste products. Grain and grain by-products are usually offered as supplements to the birds.

A variety of poultry housing systems were observed in different regions. These ranged from crudely constructed houses, to bamboo baskets, wire mesh or bamboo cages placed in the backyard, to innovative systems of putting bamboo or wooden cages on tree tops, wooden poles or along the roof. Saving the birds from predators is the major objective of these innovations. Birds are trained to climb or fly over to the cages, placed on trees - or are manually picked up and put there.

The results of the ranking of constraints indicates the most serious problem to be losses at the chick stage, which are about 30%. However, losses among adults are only about 7%. Newcastle disease and lack of facilities for vaccination are the main reasons for losses in chicks. Nutritional deficiency and coccidiosis could be other causes of loss. These aspects need critical study. The second constraint is losses due to predation by birds and animals (also neighbours).

The suggestions made for improving productivity according to the average of ranking in different areas and groups were:

1. Control of losses of chicks due to diseases
2. Help in improving housing
3. Marketing linkage

From the development and environment viewpoint, most facets of traditional backyard poultry production are favourable. While commercial poultry has its place and contributes to growth in production, there is the risk of abuse of resources and marginalisation of small farmers. Commercial poultry is a good example of mass production and rapid growth, but should be differentiated from development and production by the masses. A comparative picture of the various facets of the two poultry production systems is presented from a rural development viewpoint in Table 2.

Table 2.

Facets of production systems	Traditional and backyard system.	Commercial system
1. External inputs	Low	High
2. Dependency on outside agencies	Low	High
3. Outputs	Low	High
4. Involvement of small farmer and women	High	Low
5. Risks	Low	High
6. Effect on environment	Positive	May be negative
7. Biodiversity	Promoted	Adversely effected
8. Competition with human food, like grains	Very low	High

There is a need for marketing linkage, extension and training for women and the development of paravet groups, which would be useful in controlling losses and improving productivity and profits. Attempts are being made to develop womens' groups in some tribal areas of Rajasthan and Gujarat and a detailed study of the nutritional status of birds is being attempted. The observations indicate the need to critically study feeding practices and available feed materials for the birds and to suggest suitable, locally available supplements.

The Role of Scavenging Poultry in Integrated Farming Systems in Ethiopia

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Abstract
This paper focuses on the role of scavenging poultry in integrated farming systems and is mainly based on previous studies and past research and development attempts to improve scavenging poultry in Ethiopia. Village poultry production is an integral part of a balanced farming system and has a unique position in the rural household economy, supplying high quality protein to the family. In this paper, the present structure, socio-economic aspects, constraints, potential and future prospects of scavenging poultry in the mixed farming systems are described, and recommendations are also made to change the present scavenging system to semi-scavenging system.

KEY WORDS: Poultry, scavenging, semi-scavenging, village, Ethiopia, mixed farming system

Introduction

Rural poultry production in Ethiopia represents a significant part of the national economy in general and the rural economy in particular, and contributes 98.5 and 99.2% of the national egg and poultry meat production, respectively (AACMC, 1984), with an annual output of 72,300 metric tonnes of meat and 78,000 metric tonnes of eggs (ILCA, 1993).

Comparatively little research and development work has been carried out on village poultry, despite the fact that they are more numerous than commercial chickens, accounting for around 99% of the total number in the country. Studies carried out at the College of Agriculture, Alemaya (Bigbee, 1965) and Wolita Agricultural Development Unit (WADU) (Kidane, 1980) and by the Ministry of Agriculture (1980) indicated that average annual egg production of the native chicken was 30-60 eggs under village conditions and that this could be improved to 80-100 eggs on-station.

A recent study at Asela Livestock Farm revealed that the average production of local birds around Arsi was 34 eggs/hen/year, with an average egg weight of 38 g (Brannang and Persson, 1990). These results look unimpressive when compared with egg-laying exotic breeds which can produce more than 250 eggs/hen/year, with an average egg weight of 60 g. They show that local birds are poor producers of small sized eggs. But smallholder poultry production using unimproved stock can be the most appropriate system in practice, with low input levels that makes the best use of locally available resources. Village poultry are important providers of eggs and meat as well as being valued in the religious and cultural life of society in general and the rural people in particular.

As pointed out by Sonaiya (1990), in recent years, rural poultry have assumed a much greater role as suppliers of animal protein for both rural and urban dwellers. This is because of the recurrent droughts, disease outbreaks (rinderpest and trypanosomiasis) and decreased grazing land, which have resulted in significantly reduced supplies of meat from cattle, sheep and goats. Poultry is the only affordable species to be slaughtered at home by resource-poor farmers, as the prices of other species are too high, and have increased substantially in recent years. Consumption of pork is not allowed for religious reasons for most Ethiopians (Orthodox Christians and Muslims) but fortunately there are no such cultural or religious taboos in relation to the consumption of poultry and poultry products.

Ten years ago, per capita consumption was about 57 eggs and about 2.85 kg of chicken meat per annum in Ethiopia (Alemu, 1987), which are very low figures by international standards. Although there are no current data on the present per capita consumption of poultry products, a similar or even declining trend is probable because the population of Ethiopia has increased by about 3% per annum over the last ten years without any marked increase in the production of poultry meat and eggs. Innovative ideas and programmes are therefore required to promote rural poultry production for the improvement of rural household incomes and nutrition.

Poultry production is an effective means of transferring wealth from the high-income urban consumers to the poor rural and peri-urban members of the community. Small scale poultry development should therefore concentrate on the rural and peri-urban areas of the country. The focus of this study was on villages in the central highlands of Ethiopia.

Present Structure of Poultry Production in Ethiopia

The total poultry population in Ethiopia is estimated to be 56.5 million (ILCA, 1993). Poultry production systems in Ethiopia show a clear distinction between traditional, low input systems on the one hand and modern production systems using relatively advanced technology on the other (Alemu, 1995). Ninety-nine per cent of the population consists of local breed types under individual farm household management (Alamargot, 1987), and the remaining 1% of birds are mainly in state-run modern production systems, with a very small proportion in private units. Of the total national egg and poultry meat production 98.5 and 99.2% respectively are contributed by local birds (AACMC, 1984), resulting in an annual output of 72,300 metric tonnes of poultry meat and 78,000 metric tonnes of eggs.

Large-scale Commercial Systems

Modern poultry production started in Ethiopia about 30 years ago, mainly in colleges and on research stations. The activities of these institutions mainly focused on the introduction of exotic breeds to the country and the distribution of these breeds to farmers, including management, feeding, housing and health care packages.

The history of poultry production in the industrialized countries may offer some basic knowledge and guidelines for poultry development in the developing countries as a whole and in Ethiopia in particular, but in view of the particular conditions in different countries and regions, specific research and development approaches are needed to determine which are the optimum production systems and development strategies.

Most of the research work is still being carried out on intensive poultry production, with modern housing and sophisticated feeding systems. However, the great majority of poultry production is based on extensive rural production systems where the results of current research are often not applicable.

Today, a number of large commercial state farms have been established and private poultry farms are starting to operate in the country. This would seem to be a positive trend in increasing the supply of animal protein for the Ethiopian people, whose primary source of protein is of plant origin, because poultry are efficient converters of by-products and grains into eggs and meat, and have a fast turnover and rapid growth rate. In spite of these advantages, including intensive poultry production in the livestock development strategy must be questioned, due to the fact that commercial poultry compete with human beings for scarce food grains. This statement is justified if we consider the composition of diets used on the industrial poultry farms, where the major ingredients are high quality cereals like maize and wheat (AACMC, 1984).

If we consider commercial poultry production under Ethiopian conditions, where there is a national shortage of grain to feed an ever-increasing human population and a negative trade balance, then allocating hard currency to import breeding stock, medicines, vitamin-mineral pre-mixes and concentrates to support intensive poultry farms will involve critical political as well as economic decisions. So, in a country like Ethiopia, the outcome will be the converting of food that resource-poor people can usually afford to buy, to smaller amounts of luxury food items that only the minority wealthy members of the society can afford.

No attempts have been recorded to evaluate the performance of exotic birds under local farmer conditions. The only serious on-station attempt carried out in Ethiopia was a comparative study of the performance of six different exotic breeds, namely: Brown Leghorn, White Leghorn, Rhode Island Red, New Hampshire, Light Sussex and Barred Rock at Debre Zeit Agricultural Research Centre. This study showed that the White Leghorn was the best performing exotic layer breed (DZARC, 1984).

Rural Poultry Production Systems

There is no generally accepted definition of rural poultry production, and various production systems have been described by a number of authors, including Huchzermeyer (1967), Aini (1990), Cumming (1992), Alemu (1995) and Tadelle and Ogle (1996a). The production systems are characterized as including small flocks, with nil or minimal inputs, low outputs and periodic devastation of the flocks by disease. Birds are owned by individual households and are maintained under a scavenging system, with little or no inputs for housing, feeding or health care. Typically the flocks are small in number with each flock containing birds from each age group, with an average of 7-10 mature birds per household, consisting of 2-4 adult hens, a male bird and a number of growers of various ages. Tadelle and Ogle (1996a), Gunaratne *et al.,.* (1992) and Cumming (1992) also described village poultry flocks in Asia as including 10-20 birds of different ages per household. According to AACMC (1984), in Ethiopia there is an average of six indigenous birds per household and, according to Sonaiya (1990), the average flock size in Africa ranges from 5-10 birds. As described by Tadelle and Ogle (1996a), the village poultry production system is characterised by minimum inputs, with birds scavenging in the backyard, and no investments beyond the cost of the foundation stock, a handful of grain each day and possibly simple night enclosures.

Past Research and Development Attempts

Comparatively little research and development work has been carried out on village chickens, despite the fact that they are usually more numerous than commercial chickens in most developing countries (Cumming, 1992) and they have been marginalized by planners and decision makers (Panda 1987), which is certainly true in Ethiopia. Few attempts have been made to increase protein supply by improving the egg and meat production potential of local birds, and upgrading and crossbreeding with exotic germplasm has been the main focus of the research and development organizations. For the last three decades, scientists and the government have promoted schemes in which cockerels from selected strains are reared up to 15 to 20 weeks of age, mainly on government poultry stations, and then exchanged for local cockerels owned by rural subsistence farmers.

The study reported by Tadelle and Ogle (1996a) in the central highlands of Ethiopia shows that there has been an introduction of exotic breeds to the three villages at various times and in different forms, as cockerels, pullets and fertile eggs, but their impact in upgrading the village chickens has been minimal. The farmers were given advice on improved feeding and housing and were asked to remove all remaining local cockerels. In addition, improved hens were introduced to boost egg production in co-operative based intensive poultry farms in rural Ethiopia, but most of these projects collapsed, mainly due to inadequate feed supply, management, medicines and discontinuation of the schemes. However these approaches led to only limited improvement, due to the high mortality rate of the modern breeds because of their lack of adaptation to the rural environment, poor management, ultimate discontinuation of the schemes and, above all, the farmers' lack of interest and awareness, because the programmes were usually planned without farmer participation and without parallel improvement in management and feeding.

Many cross-breeding projects failed because the crosses were not accepted by local people, who feared they would be vulnerable to harsh village conditions. Above all, those development strategies did not pay attention to local social and cultural aspects of poultry production. For example, farmers prefer to have double-combed cocks for sacrifice purposes, in addition to their colour preferences (Tadelle and Ogle 1996a). Local scavenging chickens, in addition to providing cash income, have nutritional, cultural and social functions which require consideration from planners, professionals and farmers, which is rarely given. However, planning and execution of research and development work on local birds could result in considerable improvement in egg production performance, and a reduction in the high chick mortality.

Tadelle and Ogle (1996) described the scavenging feed resource base (SFRB) for local birds in the central highlands of Ethiopia as variable, depending on the season and rainfall. This is in agreement with the results from three different production systems (two from Sri Lanka and one from Indonesia) (Cumming, 1992 and Roberts, 1992). So strategic supplementation of birds according to age and production status can be a suitable solution.

Generally, non-genetic factors such as poor nutrition, disease (mainly Newcastle disease) and other management practices have a much greater effect than genetics on production parameters under scavenging systems. In the results of an on-farm trial in the central highlands of Ethiopia, vaccination for Newcastle disease, improved feeding systems, regular provision of water and small night enclosures for scavenging birds were very important as a way of achieving optimum production.

Socio-economic Aspects of Rural Poultry Production

Rural poultry represent a significant part of the rural economy. This segment of production in Africa as a whole represents an asset value of US$ 5.75 billion (Sonaiya, 1990). In addition to their contribution to high quality animal protein and as a source of easily disposable income for farm households, rural poultry integrate very well and in a sustainable way into other farming activities, because they require little in the way of labour and initial investment compared to other farm activities (Tadelle and Ogle, 1996a). A number of authors, including Veluw (1987), Sonaiya (1990), and Gunaratne *et al.* (1992), have also reported that rural poultry play a significant role through their contribution to the cultural and social life of rural people.

The existence of poultry in the household does not imply necessarily that the farmers are willing and in a position to expand poultry production. Experience has shown that intensive persuasion is needed to convince them to introduce regular watering and feeding, to clean the birds' night shelter and to take care of the young chicks, before starting any research or development programme to attain the genetic potential of the local birds. The first critical step in rural poultry development is therefore the encouragement of farmers to change their attitude towards poultry keeping and the traditional system.

It is very difficult to determine the most important purpose of keeping birds in each household because it is impossible to compare the spiritual benefit of sacrifice with the financial benefit of a sale. A ranking of purposes based on the number of birds used has very little to do with the order of importance, and understanding this is a considerable challenge for development workers. For a better understanding of the role played by poultry in the lives of rural people, it is necessary to know exactly the purposes for which households keep poultry. The five major uses and benefits of poultry and eggs in rural societies in the central highlands of Ethiopia are summarized as follows: eggs for hatching (51.8%), sale (22.6%) and home consumption (20.2%), and production of birds for sale (26.6%), sacrifice (healing ceremonies) (25%), replacement (20.3%) and home consumption (19.5%). In some cases farmers give live birds (8.6%) and eggs (5.4%) as a gift to visitors and relatives, as starting capital for youths and newly married women. They also invite special guests to partake of the popular dish "doro wat", which contains both chicken meat and eggs and is considered to be one of the most exclusive national dishes (Tadelle and Ogle, 1996a), as confirmed by Veluw (1987) in Northern Ghana. Birds are also given as sacrificial offerings in traditional worship, and finally they perform a valuable sanitary function in the villages through eating discarded food and cockroaches, for example.

The feed resource base for the scavenging chicken production system described has no alternative use and, if they were not present, other scavengers, particularly dogs and crows would perform this function, with no associated benefit to the farming community.

Poultry keeping in most of the developing countries is the responsibility of women. Tadelle and Ogle (1996a), in a study of three villages, found that it is the women that look after the birds, and the earnings from the sale of eggs and chickens are often their only source of cash income. It is therefore important to actively involve women in the process of poultry improvement, a feature which has been neglected in the past. Most of the poultry extension workers, vaccinators and key poultry farmers are men. In some parts of Ethiopia, contacts between women and male extension workers are restricted by cultural and religious factors and information has to be passed indirectly through their husbands. It is important to plan poultry development projects in such a way that women participate actively as poultry advisers, extension workers, and vaccinators, as well as poultry farmers.

Input-output Relationships

Despite the fact that more than 70% of the poultry population in Africa (Table 1; Sonaiya, 1990) and 99% of the poultry population in Ethiopia (Alamargot, 1987) consists of local birds, their contribution to farm household and national income is not in proportion to the high numbers. Productivity is observed to increase in direct proportion to the level of confinement (Sonaiya, 1990) and other feeding and management factors, up to a certain level of production corresponding to the upper limits of the genetic potential of the local birds.

This system of production, although it appears primitive, can be economically efficient because, although the output from the individual birds is low, the inputs are even lower or virtually non-existent (Smith, 1990). The low output is expressed as low egg production, small sized eggs, slow growth and low survivability of chicks (Smith, 1990; Tadelle and Ogle 1996a) but small management changes, for example regular watering, night enclosures, discouraging them from getting broody, vaccination for common diseases and small energy and protein supplements can bring about significant improvements in the productivity of local birds (Tadelle and Ogle 1996c). In the central highlands of Ethiopia, indigenous birds kept under semi-intensive management conditions produced 100 eggs per annum and under this system of management ten clutches of eggs were produced per year as compared with three to four produced under normal scavenging systems (Tadelle and Ogle, 1996c). In general, with minimal additions of inputs, improving the existing management and changing the attitudes of farmers can bring about considerable improvements in terms of egg production, growth and increasing the level of survival.

Table 1. Percentage contribution of local birds in selected African and Asian countries to the poultry population.

Country	% Contribution	Reference
Sri Lanka	28	Fonseka (1987)
Zimbabwe	30	Kulube (1990)
Cameroon	65	Agbede *et al.* (1990)
Cote d'Ivoire	75	Diambra (1990)
Kenya	80	Mbugua (1990)
Gambia	90	Andrews (1990)
Malawi	90	Upindi (1990)
Nigeria	91	Adene (1990)
Ethiopia	99	Alamargot (1987)
Bangladesh	99	UNDP/ FAO (1983)

Feed Resources and Requirements

The feed resource base for rural poultry production is scavenging and consists of household waste, anything edible found in the immediate environment and small amounts of grain supplements provided by the women. As shown by Tadelle and Ogle (1996a and b), the scavenging feed resource base (SFRB) is not constant. The portion that comes as a grain supplement and from the environment varies with activities such as land preparation and sowing, harvesting, grain availability in the household and season and the life cycles of insects and other invertebrates. From the results of the same work, it is also possible to conclude that protein supply may be critical, particularly during the drier months, whereas energy may be critical during the rainy season, which agrees with the conclusions of Cumming (1992), who describes the feed resource as variable, depending on the season and rainfall. In the absence of an event which diminishes the flock biomass (number * mean live weight), such as disease or occurrence of a major festival, the village flock will normally be at the maximum biomass that can be supported by the SFRB. Any additions to the village flock which increase the biomass will result in increased survival pressure and selection against the weakest members of the flock.

According to the finding of Tadelle and Ogle (1996b), the feed resource is deficient in protein, energy and probably calcium for layer birds, and this is confirmed from the results of supplementation trial, which show that supplementation of local birds with food sources containing energy, protein and a calcium source brings a considerable increase in egg production.

Feed Requirements and Supplementation of Local Laying Hens

There is no doubt that feed supply is one of the main constraints to rural poultry production, and it has been calculated that scavenging birds are usually capable of finding feed for their maintenance needs and about 40 eggs per year, but higher levels of production require supplementary feed. The nutritional status of local laying hens from the chemical analysis of crop contents, assuming this accurately reflects the feeds consumed, indicates that the %DM (52.3 ±12.5), CP (9.1 ±2.3), Ca (0.9 ±0.4), P (0.7 ±0.3) and ME (11.9 ±0.9 KJ/g) were below the requirements for egg production, indicating the importance of supplementation.

Compound feeds are usually not available in remote areas, or are too expensive, so it is therefore necessary to use locally available materials such as household waste and cheap conventional and non-conventional feed resources such as brans and oil-seed cakes. The choice of raw materials for poultry feed is limited and it is not possible to formulate balanced diets in rural Ethiopia. Sub-optimal supplementary rations may be economically justified under rural conditions and accordingly this supplementary feeding should complement, but not replace, the feeds scavenged by the birds and must be tested and examined from an economic point of view. Special attention will need to be paid to local sources of minerals and vitamins, although scavenging birds would normally find a significant proportion of their requirements for vitamins and trace minerals, although probably not for calcium in the case of laying hens.

According to Tadelle and Ogle (1996c), it is possible to attain daily production per hen of over 30% using a supplement of 30 g/day maize and 30 g/day noug cake, 28% from 30 g maize and over 20% from 30 g per day per bird noug cake which is more than double the 13.9% from scavenging only. This result is also supported by the study of Islam *et al.* (1992) who showed that by giving a supplement that provided 30% of the daily energy and protein requirements of local birds it is possible to produce as many eggs as the un-supplemented Fayoumy breed in the villages, and that egg production from scavenging birds increased by a factor of three when they received a supplement covering 50% of their dietary needs.

Protein Requirements of Local Laying Hens

The protein requirement of high producing laying hens varies from 16-18% of the diet, to meet the needs of egg production, maintenance and growth of body tissues, and feather growth, but this also depends on the energy content of the feed. In addition to the above, the feed consumption and protein requirements are influenced by a number of factors, the most important being size of the bird, stage of production and ambient temperature.

It is possible to estimate the requirements for protein factorially. According to Nesheim *et al.* (1979), a fresh egg contains 66% water, 12% protein, 10% fat, 1% carbohydrates and 11% ash. The average weight of a local hens egg is 38 g (Sazzad, 1986; Brannang and Persson, 1990; Tadelle and Ogle, 1996c). Thus a 38 g egg contains 4.56 g protein and, at an efficiency of protein utilization of 55% (Scott *et al.*, 1982), hens must consume 8.29 g protein per egg. Harris, (1966) indicated that the endogenous nitrogen excretion is estimated to be 2.55 g per day for a bird weighing 1.14 kg. According to Scott *et al.* (1982), protein required for feather growth is 0.49g/bird/day. The sum total of calculated protein requirements for all these functions is 11.194 and 11.317 g/day for birds producing a 35g egg in phase one and a 38 g egg in phase two of lay. As described by Tadelle and Ogle (1996b), the mean crude protein (CP) in the crop contents is 9.1 ±2.3% which is below the above calculated requirement of the local laying hens. Protein deficiency was even more serious in the short rainy and dry seasons, when the CP content of the crop contents was 7.6% and 8.7%, respectively. This is confirmed by the results of the supplementation trial reported by Tadelle and Ogle (1996c), where provision of additional protein in the form of noug cake increased egg production by a factor of two as compared with scavenging birds not receiving a supplement.

Energy Requirement of Local Laying Hens

In moderate environmental temperatures, high producing White Leghorn hens require 300-320 kcal of metabolizable energy per hen per day. Local birds are low producers of small sized eggs and their live weight is lower than that of the White Leghorn. According to Scott *et al.* (1982), the net energy requirement of adult hens is NEm= 83 kcal/kg BW^0.75. Thus for a local hen weighing 1.13 kg (overall mean), the NEm is 90.97 kcal/hen/ day. Since this figure is approximately 82% of MEm value, then 90.97/0.82 = 111 kcal/hen/day, and adding 50% of this value for activity, the total requirement for a non laying hen without travelling energy will be 166.5 kcal/hen/day. However, in addition to that, local birds need more energy for travelling, and Bessie (1989) reported that a scavenging layer travelled about 4 km per day at an average environmental temperature of 20 deg C which implies a requirement of approximately 107 Kcal per day, giving a total requirement of 273.5 kcal/day. The mean true metabolizable energy of 286 ±23 Kcal from calculated values is sufficient to meet calculated requirements for a non laying hen only.

Production and Productivity of Village Birds

The production level of scavenging hens is generally low, with only 40-60 small sized eggs produced per bird per year under smallholder management conditions. According to the results of Tadelle and Ogle (1996a), the total output of scavenging birds is low, not only because of low egg production, but also due to high chick mortality as half of the eggs are hatched to replace birds that have died, and the brooding time of the mother bird is long in order to compensate for its unsuccessful brooding. Smith (1990) estimates that under scavenging conditions the reproductive cycle consists of a 10 day laying phase, a 21 day incubation phase and finally a 56 day brooding period. This implies a theoretical maximum number of 4.2 clutches per hen each year, although in reality the number is probably 2-3.

Overall the system is quite productive in relation to the very low input levels and this is underlined by McArdle (1972) who states that the net output from poultry rearing is higher in scavenging systems compared to commercial systems, and the scavenging flock is not in competition with humans for feed. This is true if we consider the input-output relation only. Chick mortality represents a major loss in scavenging village chicken production systems (Table 2), and reports from different countries show that 50-70% of chicks die between hatching and the end of brooding.

Table 2. Reported chick mortality in rural production systems in different African and Asian countries in the first 6 to 8 weeks of age.

Country	% Mortality	Reference
Sri Lanka	65	Gunaratne *et al.* (1992)
	46	Roberts (1994)
Indonesia	79	Kingston and Cresswell (1982)
	56	Hadiyanto *et al.* (1994)
Northern Ghana	80	Veluw (1987)
Ethiopia	61	Tadelle and Ogle (1996a)
Cote d'Ivoire	50	Diambra (1990)

Kingston (1980) and Kingston and Cresswell (1982) in Indonesia, Roberts (1992) in Sri Lanka and Matthewman (1977) in Nigeria calculated mortality rates of chicks as being 69%, 65% and 53%, respectively, up to 6 weeks of age. Alamargot (1987) also reports on chick mortality in Ethiopia, and during some severe epidemics, rates as high as 80% have been recorded. According to Tadelle and Ogle (1996a), the overall chick mortality was 61 ±17% (n=160) in the first two months after hatching, and is higher when there was a disease outbreak in the area. Various authors attribute these losses to different causes. For example, Roberts (1992) reported that in Indonesia losses were due to a combination of poor nutrition, predators and various disease factors and, although predators were blamed for the majority of the losses, other biological and environmental factors made significant contributions. The newly hatched chicks have access to the same feed resource base as stronger and more vigorous members of the flock but are unable to compete. In addition, the low protein and energy content of the available feed, the low hatching weight of the chicks, high ambient temperatures and other associated factors are major causes of losses, both directly, and also by increasing vulnerability to predation and susceptibility to disease.

Newcastle disease is the most important disease recognised in tropical countries in village poultry production systems (Table 3). Disease was cited as the most important problem by most of the members of the community with whom it was discussed, reducing both the number and productivity of the birds, and the problem intensified after the villagization programme in the country (1984-86). The timing of the disease outbreaks before the villagization programme was usually at the beginning of the rainy season, that is at the end of May and beginning of June, but after villagization it remains a problem throughout the year, even though it is still more serious at the beginning of the rainy season.

Sonaiya (1990), after summarising the reports from six African countries, reported that the mortality caused by Newcastle disease ranges from 50-100% per annum and that severity is higher in the dry season, whereas the disease is more widespread in the rainy season in the central highlands of Ethiopia (Tadelle and Ogle, 1996a). The farmers do not have any preventive medicine or practice for this fatal disease, and only after the start of an outbreak do they treat their birds with socially accepted medicines (Tadelle and Ogle, 1996a). However the effectiveness of these treatments is not satisfactory.

Although the local chickens are slow growing and poor layers of small sized eggs, they are however ideal mothers, good sitters and hatch their own eggs, excellent foragers, hardy and possess some degree of natural immunity against common diseases. These traits are of great importance as the farmers cannot afford to buy expensive concentrates and incubators, which at the moment are considered necessary for raising exotic birds. Brannang and Persson (1990) reported that 50% and 75% exotic blood birds did not show any signs of broodiness at the Asela

Livestock Farm. However, as reported by Panda (1987) in India, the productivity of the Kadaknath or indigenous fowl can be improved without sacrificing any of the characteristics required by village fowls. Egyptian scientists, taking a different approach, achieved significant improvements in egg production of over 21% recently by simple cross-breeding between two local strains raised in the traditional way in the near-tropical conditions of upper Egypt. This success illustrates a way of stemming the genetic erosion of local poultry breeds. Although there is a lot of evidence in the literature about genetic improvement resulting from heterosis and crossbreeding techniques with regards to egg production and growth rate, so far little research effort has been directed towards these in Ethiopia. Some information is provided by Brannang and Persson (1990), who reported average yearly egg production of 129 and 114 eggs and 48 g and 53 g mean egg weight, for birds with a 50% and 75% exotic blood levels, respectively. The only other attempt to evaluate the performance of crossbreeds with different exotic blood levels was made at Debre Zeit Agricultural Research Centre, and involved crossing local birds with White Leghorns to determine the egg production performance of the cross breeds. A preliminary analysis showed that the annual egg production of the 50% and 62.5% crosses was 146 and 193 eggs respectively (DZARC, 1991). This shows that it is possible to improve egg number and egg weight by crossing, but the results only apply to on-station conditions and no information is available for crossbred birds kept under local farmer management conditions. In any case it is not possible to substantially improve egg production if the hens incubate and rear their own chicks.

Table 3. Reported village birds mortality caused by Newcastle disease in selected African countries

Country	% Mortality	Reference
Togo	50	Aklobessi (1990)
Sudan	50	El Zubeir (1990)
Nigeria	70	Nwosu (1990) Comoros
	80	Mohammed (1990)
Ethiopia	80	Alamargot (1987)
Morocco	100	Houadfi (1990)

Conclusions

From the results of these studies it can be concluded that the scavenging system is an appropriate system for the rural areas and that it makes relatively good use of locally available resources. The requirement now is to improve these production systems in order to make the best possible use of these resources. The system is characterized by no or few inputs and a low output level. Although they appear primitive, these systems can be economically efficient because, although the output from the individual birds is low, the inputs are even lower or virtually non-existent.

The system is also characterised by huge chick mortality in the first two weeks of life, caused by different factors such as disease, predators, and the hostile environment for newly hatched chicks. The feed resource base for local birds in the villages is from scavenging and is inadequate for the production of more than around 40 eggs/birds/year. However the results from different workers show that supplementation of energy and protein in addition to other management changes can increase egg production by more than 100%.

Rural poultry production is an important part of the farming systems and needs relatively few additional resources and inputs from farmers to achieve substantial improvements in productivity and profitability by changing to semi-scavenging systems. However, because of very high mortality rates, particularly due to Newcastle disease, farmers are generally reluctant to invest in improvements in feeding, health care and housing for example. The development of a new heat tolerant vaccine that can be administered via the feed opens up the possibility of significantly reducing mortality in village poultry, which should make producers more positive towards genetically improved birds and inputs to improve feeding and housing.

Recommendations

- Village poultry production deserves greater attention from government, research and development organizations and, above all, from rural farmers.
- Preferential access to feed by the newly hatched chicks should be given through some kind of creep feeding system.
- Strategic supplementation of both protein and energy, providing small night enclosures, regular water and disturbing the broody bird results in more than 100% increase in egg production of local birds.
- Vaccination against Newcastle disease with the new heat resistant vaccine administered via the feed will substantially reduce mortality.
- It is important to focus on working with women's groups, both to use their knowledge about poultry production and to improve their incomes.
- On-farm and on-station trials on new vaccines for the prevention of Newcastle disease are needed, particularly the heat resistant vaccine which does not need cold storage and can be administered through the feed.
- Genetic improvement should be introduced only when the current systems have been improved in terms of dietary supplementation, housing, controlling Newcastle disease and regular water and management and, in due course, to change the system to semi-scavenging.

References

Adene, D. F., 1990. The management and health problems of rural poultry stock in Nigeria. CTA-Seminar proceedings on smallholder rural poultry production. 9-13 October 1990, Thessloniki, Greece, 2:175-182.

Agbede, G., Demey, F., Verhuls A. T., Bell, J. G., 1990. The impact of Newcastle disease in the traditional chicken farms of Cameroon. CTA-Seminar proceedings on smallholder rural poultry production. 9-13 October 1990, Thessloniki, Greece, 2: 49-54.

Aini, I., 1990. Indigenous chicken production in South East Asia. World's Poultry Sci. Journal, 46:51-56.

Aklobessi, K. K., 1990. Smallholder Rural Poultry production in Togo. CTA-Seminar proceedings on smallholder rural poultry production. 9-13 October 1990, Thessloniki, Greece, 2: 37-42.

Alamargot, J., 1987. Avian pathology of industrial poultry farms in Ethiopia. Proceedings of the First National Livestock Improvements Conference 11-13 February 1987, Addis Abeba, Ethiopia, pp 114-117.

Alemu, S., 1987. Small scale poultry production. Proceedings of the First National Livestock Improvements Conference 11-13 February 1987, Addis Abeba, Ethiopia, pp 100-101.

Alemu, Y., 1995. Poultry production in Ethiopia. World's Poultry Science Journal, 51: pp 197-201.

Andrews, P., 1990. Rural poultry development in The Gambia. CTA-Seminar proceedings on smallholder rural poultry production 9-13 October 1990, Thessaloniki, Greece, 2: pp 81-85.

Australian Agricultural Consulting and Management Company (AACMC), 1984. Livestock sub sector review, Volume 1, Annex 3.

Bessei, W., 1990. Experiences with rural poultry development projects. CTA-Seminar proceedings on smallholder rural poultry production 9-13 October 1990, Thessaloniki, Greece, 2: pp 53-60.

Bigbee, D. G., 1965. The management of the native chickens of Ethiopia. Miscellaneous publication, No. 5. HSIU, College of Agriculture, Alemaya.

Brannang, E. and Persson, S., 1990. Ethiopian Animal husbandry, Uppsala, Sweden, 127 pp.

Cumming, R.B., 1992. Village chicken production: Problems and potential. Spradbrow, P. B. (Editor) Proceedings of an International Workshop on Newcastle disease in village chickens, control with Thermostable Oral Vaccines 6-10 October, 1991, Kuala Lumpur, Malaysia, pp 21-24.

Debre Zeit Agricultural Research Centre (DZARC), 1991. Annual Research Report 1990/1991. Debre Zeit, Ethiopia.

Diambra, O. H., 1990. State of Smallholder Rural Poultry production in Cote d'Ivoire. CTA- Seminar proceedings on smallholder rural poultry production 9-13 October 1990, Thessaloniki, Greece, 2: pp 107-116.

El Zubeir, A., 1990. Smallholder Rural Poultry production in the Sudan. CTA-Seminar proceedings on smallholder rural poultry production 9-13 October 1990, Thessaloniki, Greece, 2: pp 217-226.

Ethiopian Mapping Agency (EMA), 1981. National atlas of Ethiopia, Addis Abeba, Ethiopia.

Feltwell, R. and Fox, S., 1978. Practical poultry feeding, Faber and Faber limited, Great Britain, pp 36-59.

Gunaratne, S. P., Chandrasiri, A. D., Mangalika Hemalatha W. A. P., and Roberts, J. A. , 1992. The Productivity and Nutrition of Village Chickens in Sri Lanka. Spradbrow, P. B. (Editor) Proceedings of an International Workshop on Newcastle disease in village chickens, control with Thermostable Oral Vaccines 6-10 October, 1991, Kuala Lumpur, Malaysia, pp 21-24.

Harris, L. E., 1966. Biological energy interrelationships and glossary of energy terms. Publ. 1411, National Academy of Sciences-National Research Council, Washington, D.C.

Houadfi, EL. M., 1990. Rapport sur la production avicole et problemes lies aux elevages traditionnels au Marco. CTA-Seminar proceedings on smallholder rural poultry production 9-13 October 1990, Thessaloniki, Greece, 2: pp 161-171.

Huchzermeyer, F. W., 1967. Some thoughts on poultry keeping in African areas of Rhodesia under subsistence economy conditions. Rhodesian Agriculture Journal, 64: 133-139.

Huque, Q.M.E. and M.J.Hossain.1991. Production potentials of ducks under scavenging system of management. Bangladesh Journal of Animal Sci., 20(1&3):119-122.

International Livestock Centre for Africa (ILCA), 1983. Research on farm and livestock productivity in the central Ethiopian highlands: Initial results, 1977-1980. ILCA research report, No. 4, Addis Abeba, Ethiopia.

International Livestock Centre for Africa (ILCA), 1993. Handbook of African Livestock Statistics. ILCA, Addis Abeba, Ethiopia

Islam, M.K., Hussain, M.A., Haque, M.F. and Paul, D.C., 1992. Performance of Fayomi Poultry Breed with Supplemental Ration Under Farmers' Management. Abidur, R., (Editor) Proceedings of the Fourth National Conference of Bangladesh Animal Husbandry Association, December 26 - 27, 1992.

Kassimo, M., 1990. Rapport sur L'Operation coqs raceurs a' anjouan Comores. CTA-Seminar proceedings on smallholder rural poultry production 9-13 October 1990, Thessloniki, Greece, 2: 55-65.

Kidane, H., 1980. Performance of F1 Crossbred Birds. Wollaita Agricultural Development unit. Animal Husbandry and Breeding. Wollaita Sodo, Ethiopia Bulletin No. 4: 38 pp.

Kingston, D. J., 1980. The productivity of scavenging chicken in some villages of West Java, Indonesia. Proceedings 1980 South Pacific Poultry Science Convention. 13-16 October 1980 Auckland, New Zealand, pp 228-237.

Kingston, D. J., and Creswell, D. C., 1982. Indigenous chickens in Indonesia: population and production characteristics in five villages in West Java. Bogor, Indonesia, Research Institute for Animal Production, Report No. 2: 3-8.

Kulube, K., 1990. Small holder rural poultry production in Zimbabwe. CTA-Seminar proceedings on smallholder rural poultry production 9-13 October 1990, Thessaloniki, Greece, 2: 263-270.

Matthewman, R., 1977. A survey of small livestock production at village level in the derived savanna and lowland forest zones of South West Nigeria (Monograph, Univ. of Reading, 1977)

Mbugua, N. P., 1990. Rural smallholder poultry production in Kenya. CTA-Seminar proceedings on smallholder rural poultry production 9-13 October 1990, Thessaloniki, Greece, 2: 119-131

McArdle, A.A., 1972. Methods of poultry production in developing area. World Animal Review. 2: 28-32.

Ministry of Agriculture (MOA), 1980. Development Strategy of Animal Breeding and Improvement: 10 year Development Strategy. Animal Breeding and Improvement Team, MOA, Addis Abeba, Ethiopia.

Nesheim, M. C., 1986. Austic, R. E., and Card, L. E., 1979. Poultry production. 57 pp.

Nwosu, C. C., 1990 The state of small holder rural poultry production in Nigeria. CTA-Seminar proceedings on smallholder rural poultry production 9-13 October 1990, Thessloniki, Greece, 2:183-194.

Panda, B., 1987. Role of poultry in socio-economic development of small farmers in India. Asian Livestock, 12: pp 145-148.

Roberts, J.A., 1992. The scavenging feed resource base in assessments of the productivity of scavenging village chickens. Spradbrow, P. B. (Editor) Proceedings of an International Workshop on Newcastle disease in village chickens, control with Thermostable Oral Vaccines 6-10 October, 1991, Kuala Lumpur, Malaysia, 29-32.

Savory, C.J., 1989. The importance of invertebrate food to chicks of gallinaceous species. Proceeding of Nutrition Society No. 48: 113-133.

Sazzad, M.H., 1986. Reproductive performance of Desi hens under scavenging and intensive systems of rearing. Proceedings of first Annual Livestock Research Workshop, Livestock Research Institute, Savar, Bangladesh.

Sazzad, M.H., S.M.H. Mamotazul and A.U. Asaduzzamn, 1988. Growth pattern of Desi and Khaki Campbell ducks under rural condition. Indian Journal of Poultry Sci. 23(2):165-166.

Scott, M. L., Nesheim M. C. and Young, R. J., 1982. Nutrition of the chicken. pp 48-92.

Smith, A .J., 1990a. Poultry-Tropical Agriculturist series. CTA, Macmillan Publishers, London. pp 179-184.

Smith, A .J., 1990b. The integration of rural production into the family food supply system. CTA-Seminar proceedings on smallholder rural poultry production 9-13 October 1990, Thessloniki, Greece, 1: 15-128.

Sonaiya, E. B., 1990 The context and prospects for development of smallholder rural poultry production in Africa.CTA-Seminar proceedings on smallholder rural poultry production 9-13 October 1990, Thessaloniki, Greece, 1: 35-52.

Tadelle, D. and Ogle, B. 1996a. A survey of village poultry production in the central highlands of Ethiopia. M.Sc Thesis, Swedish Univeristy of Agricultural Sciences, pp 22.

Tadelle, D. and Ogle, B. 1996b. Nutritional status of village poultry in the central highlands of Ethiopia as assessed by analyses of crop contents and carcase measurements. M.Sc Thesis, Swedish Univeristy of Agricultural Sciences, pp 15.

Tadelle, D. and Ogle, B. 1996c. Effect of maize (*Zea mays*) and noug (*Guizotia abyssinica*) cake supplementation on egg production performance of local birds under scavenging conditions in the central highlands of Ethiopia. M.Sc Thesis, Swedish University of Agricultural Sciences, pp 14.

Teketel, F., 1986. Studies on the meat production potential of some local strains of chickens in Ethiopia. PhD Thesis, J.L. University of Giessen, pp 210.

Upindi, B. G., 1990. Smallholder Rural Poultry production in Malawi. CTA-Seminar proceedings on smallholder rural poultry production 9-13 October 1990, Thessaloniki, Greece, 2: 141-146.

UNDP/FAO. 1983. Rural poultry improvement project of the Govt. of the People's Republic of Bangladesh. No. BGD/82/003. Project document, Dhaka, Bangladesh.

Veluw, V. K., 1987. Traditional poultry keeping in Northern Ghana. ILEIA, 3(4): 12-13.

Effect of Cropping Patterns on Egg Production of HYV Hens in a Semi-Scavenging Poultry Model in Bangladesh

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Abstract

A study was made with 1272 pullets of 6 months age under semi scavenging conditions to compare the egg production in three agro-ecological zones with different cropping patterns. The cropping patters were grain dominant in low lying 201% cropping intensity (Manikgonj), grain / fibre (Jute) in medium high land 207% cropping intensity (Jessore) and Sugarcane / grain in high land 159% cropping intensity (Rajshahi). Cropping pattern significantly influenced age of first egg and total egg production. Average age at first egg was 31, 34, 34 weeks in the grain, grain/fibre and sugarcane/grain cropping patterns respectively. The average egg production/hen/year were 157, 154 and 103 respectively and the results varied significantly. It was interesting to observe that the highest egg production and early egg laying were associated with the lowest level of supplementation by the farmers in the grain dominant cropping patterns (130Kcal and 6.4g protein/bird/day). The results indicated that HYV hens can be an efficient utilizer of grain based crop residues as scavenging feed resources and the egg productivity seems to be much higher than the existing non descriptive native chicken under same nature of management.

Introduction

The native chicken in the existing traditional scavenging system of Bangladesh produces 45 eggs per hen per year (Ahmed and Hasnath, 1983) and constitutes about 80% of country's chicken population. Some experiments have been conducted concerning introduction of exotic breeds of hen (HYV) and their crosses to determine potentials and limitations in the scavenging and semi scavenging system (Ahmed *et al.*, undated; Quader *et al.*, 1989; Hossain *et al.*, 1992; Sazzad, 1992; and Rahman *et al.*, 1995).

The Directorate of Livestock Services (DLS) and the NGO Bangladesh Rural Advance Committee (BRAC) have developed a unique semi scavenging system (BRAC, 1994) in which exotic chicken are reared in confinement during the first 8 weeks age after which the birds scavenge part time for some days and gradually shifted to the semi scavenging system of rearing.

The feed resources for small flock of birds in traditional scavenging system are agricultural crop residues in and around homestead /or after harvest near by crop fields, kitchen and dinning wastes, grazing of green grass /small plants, earthworms, insects and small amount of supplemented feed ingredient(s) offered by the flock owner. The agricultural cropping patterns of Bangladesh which varied from one region to another are said to contribute as major feed resources for scavenging chicken. This study was undertaken; 1) to know the egg production of HYV hens under semi scavenging system of rearing in three agro ecological zones with different cropping patterns, and 2) to estimate the energy and protein content of feed ingredient(s) supplemented to the birds by flock owner.

Methodology

A total of 1272 selected HYV pullets from 4 batches of 11 weeks interval were at the age of six months placed by 297 rural women farmer (key rearer - beneficiaries of BRAC) kept for a period of one year. Number of pullets per key rearer ranged from 3 to 6. The distributions of pullets/key rearer were 375/98 for grain dominant (Manikgonj), 408/98 for grain/fibre (Jessore) and 489/101 sugarcane/grain (Rajshahi) cropping areas. The experimental locations with cropping patterns are shown in table 1.

Table 1. Cropping patterns of sites during experimental period

Particulars	Grain dominant (Manikgonj)	Grain/fibre (Jessore)	Sugarcane/grain (Rajshahi)
Agro-ecological zone	Low Ganges	Medium high river flood plain	High Ganges flood plain
Seasonal flood	Yes	No	No
Cropping intensity	200.6 %	207 %	159 %
Major cropping patterns	1.Rice(B.Aman +B.Aus)-Onion (T.Aman)	1.Rice(B.Aus) /Jute-Rice	1.Sugarcane -Lentil
	2.Rice(B.Aman +B.Aus)- Mustard	2.Rice(B.Aus) /Jute-Rice (T.Aman)- Wheat/Pulse/ Oil seed	2.Sugarcane -Onion/Garlic
	3.Mustard-Rice (Boro)	3.Rice(B.Aus) -Rice(T.Aman) -Rice(Boro)	3.Rice(B.Aus)- Wheat
	4.Rice(Boro) -Rice(Local) -B.Aman (transplanted)	4.Rice(B.Aus) /Jute-Wheat/ Pulse-Oilseed/ vegetables	4.Rice(B.Aus)- Lentil/Mustard
	5.Rice(B.Aus+ B.Aman)/Jute -Khesari		5.Rice(B.Aus)- Potato
	6.Rice(B.Aus+ B.Aman)- Wheat/Potato/ Mustard		6.Rice(Boro)
	7.Rice(B.Aman) -Ground Nut		7.Rice(T.Aman) -Wheat
	8.Rice(B.Aman) -Sesame		8.Rice(T.Aman) -Vegetables

The key rearers were offered a short training on HYV chicken management before started. Birds were allowed to scavenge in and around homestead and adjacent crop fields during day time and kept in shelter at night and during unfavorable weather conditions. Feed ingredients, like wheat, wheat bran, paddy, broken rice, cooked rice, balanced diets for laying hens etc. were supplemented as single or a mixture of 2 or 3 ingredients to the birds by farmers. Birds were housed in a bamboo shelter when offered supplemented feed. There was continuous supply of drinking water in the bamboo enclosure and birds had easy access during scavenging period of the day. Laying nest was placed in night shelter areas. Birds were dewormed every two months and vaccinated against Newcastle and Fowl pox diseases according to a program. Data regarding egg production, mortality and supplemented feed were recorded twice a week. The protein and energy content of the supplemented feed were calculated on the basis of book values. Data were analyzed by the least square principle using the SAS programming package, SAS (1988).

Results and Discussions

The performance data of the hens up to 18 months of age are presented in table 2. Birds from grain dominant Manikgonj area started early egg production (31 weeks) compared to other locations (34 weeks) and the difference was significant.

The average hen day egg production / hen was highest in grain dominant area (157) followed by grain/fibre (154) and significantly lower in sugarcane/grain (103) cropping patterns. Mortality was observed very high in all the locations and the most suspected reason was bacterial diseases against under nutrition condition of the birds. The seasonal flood in grain dominant Manikgonj area and water logging condition in grain/fibre Jessore area could be the other reasons for higher significant mortality than sugarcane/grain based cropping patterns of Rajshahi. Mortality due to predator (wild animals) loss were found significantly higher in the sugarcane/grain cropping area compared to other locations and the reason was that wild animals hunt experimental birds from their sugarcane fields hideout adjacent to scavenging areas.

The energy content of supplemented feed was observed lowest in grain dominant cropping area and found significantly lower than grain/fibre area.

Table 2. Performance of experimental birds reared under semi scavenging conditions at three locations

PARAMETERS	PERFORMANCE (Least square mean)		
	Grain (Manikgonj)	Grain/fibre (Jessore)	Sugarcane/grain (Rajshahi)
Age of first egg (wk)	31a	34b	34b
Eggs/hen (hen day)*	157a	154a	103b
Mortality % (excluding predator loss)	43.9b	12.3a	19.8a
Mortality % due to predator loss	0a	0.3a	6.3b
Supplemented energy Kcal/bird/day	130a	146b	134a
Supplemented protein (g)/bird/day	6.4b	8.3c	5.6a

Figures with same letter in a row are not significantly different (P<0.05)
* Corrected for 12 months production period from first egg production

The amount of supplemented protein were found lowest in sugarcane/ grain area followed by grain dominant and grain/fibre areas and differed significantly. However, irrespective of locations the amount of supplemented protein and energy seems to be around 30 and 40% of daily requirement of commercial hens in captivity.

In grain dominant cropping pattern (201% cropping intensity) area, it was observed the highest egg production and early egg laying while the birds received the lowest amount of energy and protein supplementation. On the other hand, the egg productivity of birds in grain/fibre cropping area (207% cropping intensity) receiving higher amount of energy and protein supplementation might not come up like in the grain dominant area because of the presence of the fibre crop in the cropping patterns.

The results indicated that the HYV hens used to manage good amount of feed by scavenging various resources, especially the grain based crop residues widely scattered in and around homestead or nearby after the harvest in the crop fields. The amount of scavenged feed seems to be 60 - 70% of total feed consumed by a scavenging bird which has practically no cost involvement. The higher egg productivity over native chicken indicated that HYV hen could be an efficient utilizer of various scavenging feed resources including the grain based crop waste of Bangladesh.

References

Ahmed, A. and M. A. Hasnath, 1983. A study on the heritability estimates of body weights of indigenous chickens. Bangladesh Vet. J: 17: 19-24.

Ahmed, N.U., R. Amin, N. P. Magor, N.I. Miah, N. Islam, A. Saha , A. H. Khan and H. Ali, nd. Livestock related FSR activities of the Bangladesh Rice Research Institute, Rice Farming Research Division, Bangladesh Rice Research Institute, Gazipur, Bangladesh. pp 171.

BRAC, 1994. Poultry programme. RDP annual report. Mohakhali, Dhaka, Bangladesh. pp. 21 - 24.

Quader, M. A., M.M. Rahman, M.G. Moula and M.R. Khan,1989. A comparative study on adaptability of different exotic and local breeds of poultry under two management systems of rearing. Research Report (Rabi 1988-89). On-farm Research Division, Region II , Bangladesh Agricultural Research Institute, Jamalpur, Bangladesh.

Rahman, M.M., M. N. Islam, and N. R. Sarker, 1995. An adaptability study of three improved types of layer chicken under rural conditions at Naikhongchari FSR site. Bangladesh Journal of Livestock Research. Paper accepted for publication.

Sazzad, M.H., 1992. Comparative study on egg production and feed efficiency of different breeds of poultry under intensive and rural conditions in Bangladesh. Livestock Research for Rural Development, Vol.4 no.3: 65-69.

The Role of Scavenging Ducks, Duckweed and Fish in Integrated Farming Systems in Vietnam

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Abstract
There are some 30 million ducks raised annually in Vietnam. Most are scavengers raised seasonally in rice fields during the early growth of the crop and immediately post-harvest; and in backyards or gardens of farm households throughout the year. Duck and fish production has been expanding and contributes to increased income and improved living standards of the farmers, especially for poor farmers in the remote rural areas.

Trials on using duckweed cultivated as a partial or complete replacement of protein supplement for feeding crossbred and Muscovy ducks gave encouraging results. The practice of using scavenging ducks to control insects and weeds in the rice fields contributes to decreased investment and brings more benefits for the farmers. Duckweed grown in the integrated farming system is also a high quality feed for fish.

KEY WORDS: Ducks, local, scavenging, rice fields, duckweed, fish

Introduction

The duck industry in Vietnam is of long standing and plays a considerable role in providing meat and eggs in the diet of the people (Men *et al.*, 1991). Ducks are raised throughout the country but are concentrated in the Mekong and Red River Deltas, but also in suburban areas of the big cities.

Unlike the Northern countries, duck egg and meat consumption is expanding in Vietnam and they provide important and nutritious protein foods for people in both cities and rural areas, especially the poor farmers in the remote regions. The products are usually sold at a reasonable price that the poor can afford and they can be processed into many different traditional dishes and even special dishes in the restaurants of the big cities.

The farmers use many traditional systems for raising ducks, of which the rice-duck system is the most common. In this system rice production is enhanced due to the ability of the ducks to control insects and weeds and at the same time excrete manure which provides nutrients for the growth of the rice plants. There are also environmental benefits as chemical control of insect pests and weeds is not needed. Along with the improvement in rice, the farmers derive more profit from the ducks because they forage themselves on natural feeds and left-over rice in the fields which decreases the need for supplementary feed. Ducks are also commonly allowed to scavenge in the backyards or gardens of households in small flocks, receiving household waste or rice to supplement what they obtain by scavenging.

Today, ducks are also raised in partial confinement, either for table eggs in coastal areas where shellfish gathered from the sea are good mineral and protein sources for ducks, or in areas where they are bred for meat during the dry season in an integrated fish-duck system. Duck production makes good use of available labour in rural areas and increases the income of poor farmers, especially the landless. However, duck producers have experienced problems since the introduction of high yielding rice varieties because the time available for duck flocks to scavenge is limited. Also, the price of feeds, especially protein supplements, has greatly increased. Consequently, although consumer demand for duck products is increasing, the income for farmers is reduced by the high input costs.

Duckweed (*Lemna* spp.), which is common throughout the country, is a tiny water plant that grows very well on the surface of stagnant ponds all the year round. It can tolerate high nutrient stress and is able to survive extremely adverse conditions, and appears to be more resistant to pests and diseases than other aquatic plants in tropical areas. It has a high content of nutrients in the DM, especially protein and carotene, which are necessary for growing animals. Duckweed is popular in Vietnam as a feed for fish and poultry, so it seems a useful candidate for development as a year-round feed resource for ducks and fish within the integrated farming system.

Scavenging Ducks

Breed

Several breeds of ducks are raised in the country. The two different species are the common breed and the Muscovy duck.

The common breed is estimated at 80% of the duck population of the country (Phuoc *et al.*,1993). They consist mostly of local and improved breeds and a few exotic strains (Cherry Valley).

Of the local breeds, the first type is the "Tau" or "Co" breed (grass ducks). This is a laying type that reaches mature body weights of 1.3 - 1.5kg for females and 1.5 - 1.8kg for males. Drakes can mate at 120 days of age. The females begin to lay at 140 days old and achieve an average of 180 eggs per layer per year with egg weights in excess of 60 g. This breed tolerates hard conditions of nutrition and management, so they are well suited to egg and meat production in the remote rural areas. Also, they are very good at foraging for food such as insects, water creatures and plants. The mating ratio of males to females is 1:20-25, but this achieves highly fertile eggs (over 90%) with high hatchability in traditional hatcheries in the rural areas, even without electricity. The prices of table eggs, ducklings and duck meat from these ducks are usually lower than those of other types because of lower production costs.

The second group, called "Ta" or "Bau" ducks, is a meat type that achieves a mature live weight average of 2.5 kg. This breed is low in reproductive ability and gives low profit to the producers so the population has been decreasing.

The local Pekin has been imported for a long time and is genetically poorly defined. It has degenerated into a dual purpose breed. They achieve live weight gains and finishing weights slightly higher than the "Tau" or "Co" ducks and the number of eggs laid appears to be equivalent to the "Co" breed.

There are several crossbred types which are a combination of the local and exotic breeds. These are used for meat purposes.

The exotic Cherry Valley type has been imported from Europe and gives high meat performance but, given the conditions in which they are bred and raised, productivity and profitability has declined and the population is decreasing. At present they are raised for crossing and for meat around some cities. The Khaki Campbell breed is a laying type imported from Asian countries which achieves poor performance under the conditions in Vietnam and the yield of eggs appears to be equivalent to the local laying type (personal observation).

Muscovy ducks are estimated at some 20% of the population and numbers have expanded throughout the country. These include both local and exotic types, and their crosses. The local breed achieves mature weights from 3-3.5kg for males and 1.8-2kg for females. The female lays on average 40-60 eggs per year and hatches them herself under extensive conditions. The Muscovies are suitable for smallholders with small flocks because they are easy to manage and can consume different feeds in the farming system. Also, the ducklings or table ducks are usually sold at a higher price than common ducks.

Scavenging Ducks in the Integrated Farming System

Duck Raising Along with Growing Rice

The ducks selected for this purpose are commonly the local laying type or local Pekin breed due to their small body size. They do not harm the plants, are active and forage well when herded. In the brooding stage, after the first week of age, the ducklings are driven into the rice fields from 20 days after transplanting until the plants begin to flower. In the young rice fields, the ducklings can catch destructive insects such as white or brown hoppers, leaf insects, mosquito larvae, spiders, small shellfish and fish. During scavenging, the ducks consume weeds and stir and loosen mud around the rice roots with their beaks without harming the rice plants. In addition, they excrete manure to fertilize and stimulate the growth of the rice. Insecticide and herbicide inputs are rendered unnecessary, and labour for weeding is reduced. The reduction in chemicals is beneficial to the environment.

The ducks are supplemented with feed consisting of by-products of rice or rice grain, 3-4 times daily depending on feed availability in the rice fields.

After the rice plants start flowering, the ducks are driven from the rice fields to the canals, ditches, lakes and swamps to forage in the water. The duck raising season usually lasts for 3 months producing males for meat and females which continue to lay eggs in the post-harvest rice fields. The culled ducks are sold in the market.

Duck Raising in the Post-harvest Rice Fields

Along with laying ducks, the table ducks or ducks for meat are reared in the rice fields post-harvest. Generally farmers purchase ducklings from the hatcheries 3-4 weeks before the rice harvest. The ducks usually selected are the native meat type, local Pekin, crossbred local x Cherry Valley or Cherry Valley.

After 3 weeks of age when the ducklings can consume whole rice grains, they are permitted to enter the newly harvested rice fields. They forage the whole day on leftover or fallen rice grains, insects, shellfish, small frog and fish, and water plants. In the late afternoon, they are moved to pens or sheds on the dikes near the household until next morning. The ducks raised at this time are usually finished at 2.5-3 months of age, and achieve live weights of 1.6-2.0kg for the crossbred Cherry Valley.

Now, most varieties of high yielding rice are planted and harvested within a short period with only a limited time available for the duck flocks to scavenge, so this traditional system is becoming less feasible. In order to solve the problem, a trial was recently carried out, feeding a supplement of broken rice and crushed, dried fish (CDF) to crossbred meat ducks (Cherry Valley hybrid x local Pekin) herded in rice fields post-harvest, in order to shorten the time to finish and improve the meat quality. Three supplements of 50g/duck/day of a mixture of broken rice (80%) and CDF (20%), 50g/day broken rice or 20g/day of CDF were given each evening to the ducks, and compared with no supplementary feed. The live weights at 70 days of age were 1855, 1749, 1659 and 1592g ($P<0.001$) and daily live weight gains 34, 30, 28 and 27g, respectively (Men *et al.*1995).

The results of the trial show that supplementation with broken rice alone or a mixture of broken rice and crushed-dried fish to scavenging crossbred meat ducks significantly improved the daily gain and carcass quality, and would shorten the time to market. This trial demonstrates a strategy for improvement of the traditional method of the farmers in order to meet the increasing demands of consumers for high quality duck meat, and is consistent with today's rice cultivating conditions in the country.

Scavenging Ducks in the Backyard Or Garden

The system is common to most smallholders. Small flocks of ducks from 5-50 head, producing eggs for the table or fertile eggs for meat production or combining both, are allowed to run loose in the backyards and gardens, and are fed household wastes or rice 2-3 times per day and obtain other feeds from scavenging in the ditches, canals, ponds or part of the rice fields near the home. This system is very suitable for home consumption of the products by the poor farmers.

Duckweed (*Lemna minor*)

Duckweed is a small floating aquatic plant that grows very well on stagnant ponds and is commonly found throughout the country. It has a high content of nutrients, particularly protein and carotene, and tolerates adverse conditions such as nutrient stress and attacks by pests and diseases. Duckweed gives a high biomass yield as a result of rapid reproduction and growth. When effectively managed, yields of 10 tonnes

DM/ha/year are possible (Preston, 1995).

Duckweed can be collected daily when grown on ponds manured with effluent from biodigester systems and home waste, and produce an average of 100g (38.6% CP of DM) fresh weight per square metre (Men, 1995). Duckweed protein has a better composition of essential amino acids than most vegetable proteins and closely resembles animal protein (Culley, 1978).

Duckweed has long been used in poultry diets (Lautner, 1954). Fresh duckweed (26.3% of DM) was used to replace soya beans at levels from 19-27% in diets for fattening ducks at Cantho University in Vietnam. There were no adverse effects on health, but the reductions in growth rate and feed conversion efficiency were considerable when duckweed replaced more than 20% of soybean protein (Becera *et al.*1994).

Recently, an experiment was carry out on crossbred ducks fed roasted whole soya beans replaced by duckweed (38.6% CP in DM) at levels of 0, 30, 45, 60 and 100% in the diet (Men *et al.*, 1995). Daily gains of ducks fed duckweed were higher than those of ducks fed a conventional diet because the duckweed , which was grown and managed well, had high nutrient concentrations, especially of CP and carotene.

If duckweed is grown and collected by household farmers, the feed cost could decrease 48%. However, feed conversion ratios tended to be poorer on the diets with duckweed due to their low energy compared to the control diet. In another experiment, local Pekin were fed fresh duckweed ad libitum (40% CP in DM) in limited broken rice diets at levels 80 and 60g/day compared to *ad libitum* feeding (Men *et al.*, 1995). Results obtained showed that the ducks with live weights of 1.5-1.6 kg can consume an average of 870g fresh duckweed per day in the growing stage. The final weights and weight gains of the ducks fed 80g broken rice were slightly lower than those fed rice *ad libitum*, but the difference was not significant.

Muscovy ducks are known to like duckweed very much. In 1994, a trial was carried out on growing exotic female Muscovies at Cantho University, where 15 and 30% of the dietary protein was replaced by fresh duckweed from 28 to 70 days of age and compared to a conventional diet (Men *et al.*, 1994). At finishing, daily gains were 37, 36 and 34g (P<0.001) and feed conversion rates were 3, 3.3, 3.5, respectively. Correspondingly, the cost of feed decreased by 15 and 26% compared to the control diet.

In another trial, Men *et al.* (1995) fed local female Muscovies on duckweed *ad libitum* with a limited amount of broken rice at levels of 80 and 60g/day compared to ad libitum feeding from 28 to 70 day of age. Results achieved showed that local female Muscovies consumed fresh duckweed less than the local Pekins (325 vs 817g) and daily gains were 25, 20, 18g, respectively.

Fish in the Integrated Farming System

Fish is a common food for Vietnamese people. Wild freshwater fish are caught in many ways. At present, because of indiscriminate exploitation, environmental damage caused by overuse of agricultural chemicals and serious pollution caused by humans, the precious food source is becoming impoverished.

In order to solve the problem, many farmers raise fish profitably in ponds, even rice fields, in the integrated farming system. The main feed sources for fish continues to be based on natural aquatic creatures and plant feeds that grow and develop themselves in the pondwater. In some regions, farmers raise fish on feeds such as grass, weeds, leaves, by-products from agricultural processing or animal manure and obtained good results with fast growth of the fish. However, the feeds only contribute about 20% of the requirements of the fish (personal observation).

Duckweed As A Feed for Fish

Many trials have been carried out using duckweed as the major feed to raise fish, with good results (Journey *et al.* 1991), but, so far, this is fairly rare in Vietnam. The farmers in the Mekong and Red Deltas and around Ho Chi Minh city use duckweed as a partial or complete feed for growing fish and get excellent results. The farmers in the Mekong Delta feed duckweed to breeding fish to increase reproductive performance.

Most of the fish species living in fresh water are known to like to eat duckweed very much, especially Tilapia, carp, catfish, Mekong catfish, gourami, etc. Duckweed is convenient and fairly easy to manage because it is grown in the ponds on stored waste water. It utilises the nutrients and contributes to a clean environment. Children or women in the households can take part in managing and collecting duckweed to feed fish. The farmers can control the amount of feed to the fish easily by observation and prevent excessive growth, thus protecting the fishes' environment (personal observation).

Conclusions and Suggestions

There is no doubt about the role of scavenging ducks, fish and duckweed in the integrated farming system in Vietnam today. They produce truly sustainable economic benefits to the smallholder farmers. The results achieved in the experiments and practices show that the development is based on scientific logic under natural and social conditions that avoid damage to the living environment and improve living standards of the people, of which 80% are working in the agricultural domain.

Development of scavenging ducks and fish, based on renewable local feed resources such as duckweed in integrated farming systems, is an actual revolution and is consistent with the strategy to eliminate hunger and reduce poverty in the country. However, in order to make further progress, the detailed parameters of using scavenging ducks and their influence on the environment, soil fertility, and other effects, need to be investigated. There is also a need to look at which species of fish are most suited to feeding on duckweed.

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References

Becerra, M., Ogle, B. and Preston T. R. 1994. Effect of replacing whole boiled soybeans with duckweed (Lemna sp) in the diets of growing ducks. Livestock Research for Rural Development. Volume 7, Number 3, 44.8Kb.

Culley, D. D., Jr. and Epps, E. A. 1973. Use of duckweed for waste treatment and animal feed. Journal Water Pollution Control Federation. Vol. 45, No. 2, pp. 337-347.

Hillman, W. S., Culley, D. D. and Jr. 1978. The Use of Duckweed. American Scientist. Volume 66, pp. 442-450.

Journey, W. K., Skillicorn, P. and Spira, W. 1991. Duckweed Aquaculture - A New Aquatic Farming System for Developing Countries. The World Bank. 76pp. Washington DC.

Leng, R. A., Stambolie, J. H. and Bell, R. 1995. Duckweed - a potential high-protein feed resource for domestic animals and fish. Livestock Research for Rural Development. Volume 7 Number 1, 36 Kb

Men, B. X and Su, V. V. 1991. "A" molasses in diets for growing ducks. Livestock Research for Rural Development. Volume 2, No 3.

Men, B. X., Ogle, B. and Preston, T. R. 1995. Use of restricted broken rice in duckweed based diets for feeding growing Common and Muscovy ducks. (Unpublished data, Vietnam).

Men, B. X. and Preston, T. R. 1994. Use of duckweed as partial replacements for protein supplement in diets for feeding exotic Muscovy ducks. (Unpublished data, Vietnam).

Preston, T. R. 1995. Reserch, Extention and training for Sustainable Farming Systems in the Tropics. Livestock Research for Rural Development. Volume 7, Number 2, 84Kb.

Use of Rabbit Slaughtering Wastes as a Protein Source for Muscovy Ducks

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Abstract
The utilisation of rabbit slaughter waste (RSW) as a protein source for Muscovy ducks was studied as an example of integration within backyard systems.

Four groups of 33 Muscovy ducklings, 4 weeks old at the start, were used to compare a commercial mash with 3 other diets based on RSW given ad libitum, and corn, amounting to 25, 50, 75 % of the intake of the commercial mash (control). After a 6 week trial, the 50% and 75% corn + RSW groups showed a growth rate comparable to the control group, and only the animals receiving the lower amount of corn (25%) showed a reduced body weight in comparison to the control group (g 1841 vs. 2069). The lower growth rate occurred mainly during the first 4 weeks of the trial. Nevertheless compensatory growth was noted in the last 2 weeks.

The dressing percentages were similar to those of the control group for the 50 and 75% corn + RSW groups.

KEY WORDS: Rabbit, slaughter waste, Muscovy duck, integration.

Introduction

The complete recovery and utilisation of any kind of residue and waste is very important in backyard systems, which are the normal type of animal husbandry found in villages.

Slaughter waste from small animals is often available but unsuitable to feed to certain animal species. In backyard systems, this by-product is suitable for Muscovy ducks, which are commonly present in the villages of developing countries, and contribute to the rural economy as producers of meat and eggs.

The Muscovy duck is vigorous, resistant to common diseases, adapted to hot climates and, unlike other web-footed birds, is less demanding in terms of non-drinking water needs. It is an omnivorous species, able to graze and to utilise a wide variety of feed sources, and is known to particularly relish feeds of animal origin if given fresh.

The Muscovy duck is able to integrate with rabbit breeding for other reasons since they eat earthworms, grubs, insects and dropped feeds which they find among the rabbit droppings (Finzi and Amici, 1989). Rabbit slaughter waste (RSW) has been shown to be very profitably utilised (Gualterio *et al.*, 1988).

These considerations indicate that the use of RSW can favour the integration of rabbit and muscovy duck breeding, and contribute to improved backyard economics.

RSW is composed of gastro-intestinal tracts together with their contents. It is a by-product very rich in protein (35.4% CP in D.M.) and energy (calculated ME 4028 Kcal/Kg DM) (Leclerq and De Carville, 1978), the source of which is mainly fat (ether extract 26.3%; nitrogen-free extractive only 17.9%). It is therefore advisable to feed it together with grain, in order to balance the protein and energy. Some published data (Gualterio *et al.*, 1988), together with new results are reported here.

Materials and Methods

The experimental diets were based on corn, provided at 75, 50 and 25 percent of the consumption of a control mash fed ad libitum. The animals receiving corn were also fed ad libitum with hashed RSW.

The experimental feeds and the control commercial diet (table 1) were fed for six weeks to four groups of 33 ducklings from four weeks of age. The animals were bred in open-air enclosures of 40 m^2 with a roofed area of 3.5 m^2

Table 1 Chemical composition and energy content of feeds (% DM)

	Control	Corn	RSW
Moisture	12.0	11.5	73.3
Crude protein	19.8	11.5	35.4
Crude fibre	7.3	2.1	10.9
Ether extract	3.6	4.7	26.3
Ash	8.2	1.8	9.5
NFE	61.1	79.9	17.9
ME Mj/Kg	13.2	16.5	16.5

A slaughter trial and a meat quality control, by a panel of eight judges, were performed at the end of the experiment. The following slaughter traits were measured: dressing percentage, liver, head and feet, empty gizzard, stomach and gut, and half breast.

Results

During the first week, when the animals in the experimental groups were not yet accustomed to eating RSW, the daily body weight gains were higher in the control group (table 2).

Thereafter, the two experimental groups (50% corn + RSW and 75% corn + RSW) began to grow better than the control up to 56 days of age. In the final 14 days, daily gains of these groups decreased according to the natural growth curve. Growth was significantly lower than control ($P<0.05$) only for the 25% corn + RSW group.

The results show that RSW is a very good feed source which can easily balance a corn diet. In fact the two groups which received the highest percentage of corn (75% and 50%) achieved a final live body weight even higher than the control group (Table 2).

Table 2: Live body weight (g) at different ages (days)

	Days	28	42	56	70
Control	mean	475	846a	1474a	2069a
	sd	103.5	129.1	149.9	137.8
25 corn + RSW	mean	479	686b	1240b	1841b
	sd	127.0	143.7	207.8	198.0
50 corn + RSW	mean	498	801a	1520a	2132a
	sd	101.5	142.5	187.6	196.5
75 corn + RSW	mean	481	823a	1478a	2085a
	sd	103.8	128.3	208.0	197.7

ab- different letters in the same column indicate significant differences ($P<0.05$).

The economic advantage is obvious, since corn is much cheaper than commercial feed and it can be utilised in an amount which is only half that of the mash necessary to obtain a normal growth rate.

The performance of the 25% corn + RSW group, which showed a lower final body weight (-11%, $P<0.01$), is nevertheless interesting since this was achieved with reduced amounts of corn (25% of control feed consumption) and acceptable growth performance was obtained (table 3).

In this case, one week more was required to reach the same live weight as the other groups, but it must be stressed that, in developing countries, the saving in grain is much more important than obtaining a maximum growth rate.

In table 4, the average daily consumption of corn, RSW and commercial mash are analysed at different ages of ducklings. It must be stressed that, from day 28 to 56, corn consumption of the 75% corn + RSW group was 12-20% lower than the amount offered since RSW were strongly preferred. Feed conversion rates (DM) were very satisfactory for all the four groups (2.8, 2.9, 2.6 and 2.4 for control, RSW+75% corn, RSW+50% corn and RSW+25% corn respectively). These results indicate that diets with only two ingredients (corn and RSW) are possible. This is particularly important in developing countries where protein sources are difficult to find and commercial balanced feeds are not easily available.

Table 3: Live weight gain (g) at different ages (days)

	Days	28-42	42-56	56-70	28-70
Control	mean	26a	44ab	43	38a
	sd	7.9	8.9	7.5	6.8
25 corn + RSW	mean	15b	40b	43	32b
	sd	14.3	7.1	8.5	9.6
50 corn + RSW	mean	22a	51a	44	39a
	sd	9.8	7.9	6.5	7.2
75 corn + RSW	mean	23a	49a	43	38a
	sd	8.3	8.7	7.8	6.9

ab- different letters in the same column indicate significant differences (P<0.05).

Table 4: Average feed consumption* (g) at different ages (days)

	Days	28-42	42-56	56-70	28-70
Control	total	65	112	138	105
25 corn + RSW	corn	17	25	33	38
	total	43	88	105	79
50 corn + RSW	corn	34	58	70	54
	total	61	112	125	99
75 corn + RSW	corn	42	68	103	71
	total	66	119	153	113

* group feeding

Dressing percentages, breast muscles and other slaughter cuts were unchanged in all the groups except for breast muscles of the 25% treatment which were 30% lower, owing to the lower live body weight (table 5).

Meat quality tests, performed on roasted meats, indicated that they were all very palatable, although a lower quality score was observed for the group with higher RSW intake (25% corn); this meat was also darker.

Table 5: Average dressing composition (g) of Muscovy ducks slaughtered at 70 days of age

		Viscera	Liver	Head foots	Dress-ing %	Right breast	Empty gizzard
Control	mean	133a	50	261	1162b	100a	67a
	sd	13.2	10.6	29.4	104.4	25.1	7.0
25 corn + RSW							
	mean	127a	41	235	1003c	71b	55b
	sd	8.6	3.4	24.3	96.7	19.1	6.2
50 corn + RSW							
	mean	157b	48	273	1256a	106a	66a
	sd	18.2	6.3	29.7	100.4	26.8	6.7
75 corn + RSW							
	mean	146b	46	268	1221a	104a	71a
	sd	18.7	8.7	32.3	60.7	20.7	5.7

ab- different letters in the same column indicate significant differences (P<0.05).

Conclusions

Rabbit slaughter waste appears to be a very valuable feedstuff for Muscovy ducks bred in developing countries.

In particular, fresh RSW can effectively balance a corn diet, permitting very good growth performance in comparison with a specific commercial diet. The utilisation of the fresh by-product has the advantage of eliminating all the problems of drying and conservation, and allows a worthwhile saving in cereals. RSW utilisation is advisable mainly where and when local grain resources are poor.

The integration of rabbits and Muscovy ducks in rural backyard systems is a very simple and practical way to eliminate slaughter waste and to save on the use of corn.

These results also suggest the possibility of studying the introduction of slaughter wastes from other species in Muscovy duck feeding in backyard systems, particularly near to slaughter houses.

References

Finzi A. and Amici A. (1989). Rabbit slaughtering wastes in muscovy duckling feeding. Riv. di Agricoltura Subtrop e Trop, 83: 293-303.

Gualterio L., Finzi A. and Bagliacca M. (1988). Anatra di Barberia: possibilita di allevamento integrato nella coniglicoltura all'aperto. Avicoltura, 58 (3): 43-46.

Leclerq B. and De Carville H. (1978). Interet du rationnement du caneton male de Barbarie entre les ages de 8 et 12 semaines. Annales de Zootechnie 27:

Poultry and Fish Production - A Framework for Their Integration in Asia

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Abstract
A framework for the integration of poultry and fish production in the tropics and sub-tropics is proposed. Poultry may be integrated with fish culture in several ways and benefits extend to both. Both poultry production and processing wastes have value as nutrient inputs to fish and the water used for fish culture can be used for evaporative cooling of poultry and fertilization of crops. The conceptual basis of controlled eutrophication of fishponds using poultry manure for the production of herbivorous fish is compared to feeding of abattoir wastes to carnivorous fish. A comparison of poultry production systems in terms of their potential for integration with fish culture is made; the modern feedlot is compared and contrasted with traditional systems. The nature of poultry wastes is reviewed with respect to the effect of poultry strain/species, diet, and poultry and waste management. The impacts of the use of bedding materials, frequency of waste collection and contaminants are discussed. The use of poultry feedlot waste alone for fish culture is compared to the use of waste and additional fertilisers or feeds. The relative value of wastes from scavenging poultry alone or together with other inputs is analysed. The political economy of current poultry and fish production are considered in this article. The impacts on public health and the environment are also discussed.

KEY WORDS: aquaculture, fish nutrition, poultry, integrated systems, wastes.

Introduction

Fish raised in semi-intensive, freshwater systems provide the major proportion of farmed, global production (FAO, 1995). A high proportion of this aquaculture occurs in rapidly developing Asian countries, which are also experiencing sharply increased consumption of poultry. Semi-intensive systems are usually based on ponds fertilised with livestock manure and fed with low cost supplementary feeds. This type of integration can increase overall production intensity and economise on land, labour and water requirements for both poultry and fish. For example, one hectare of static water fish ponds can 'process' the wastes of up to 1500 poultry, producing fish in quantities of up to 10 MT/ha without other feeds or fertilisers. Also, since effluents are few, environmental impacts are minimal.

The importance of poultry wastes in aquaculture is relatively recent. In areas of traditional fish culture, ruminant and pig manure have predominated as pond fertilisers in the Indian subcontinent and China respectively. Poultry manure was not used to any extent probably because small flock size and extensive management precluded collection.

Livestock production systems, and opportunities for reuse of wastes and byproducts, are changing. Vertical integration of the poultry industry by agribusiness has been stimulated by the biology and widespread acceptability of poultry, particularly chickens. Global trends in livestock production indicate that poultry, particularly layer and broiler chickens, are increasing faster than any other (FAO, 1989, 1990, 1991, 1993). The intensive nature of modern poultry production and processing tends to concentrate high quality byproducts, and this has stimulated their reuse. A range of poultry byproducts are produced and reused in livestock feeds including feather meal, bloodmeal, poultry litter meal etc. (Muller, 1980), and poultry wastes are also used as fertilisers and soil conditioners. Economic growth is fuelling demand for both poultry and fish in many parts of the Asia Pacific region and a major question is the extent to which their integration should be promoted further here and elsewhere.

Table 1: Matrix of livestock waste qualities and suitability for use in aquaculture (* = high to * = low)**

	Factors increasing relative suitability for aquaculture				
Livestock type	Collect-ability	Accept-ability	Nutrient density	Low opp-ortunity cost	Lack of deleterious compounds
Poultry					
feedlot	***	***	***	*	***
scavenging	*	**	**	**	**
Pigs					
feedlot	***	*	**	**	***
scavenging	*	*	*	**	**
Ruminants					
feedlot	***	**	**	**	**
scavenging	*	**	*	**	*

Poultry production wastes have inherent qualities that make them particularly valuable for fish production compared to other livestock wastes (Table 1). Commercial 'feedlot' production leads to concentration of nutrient-rich waste which can be handled and transported cost-effectively. The small individual size of poultry also allows their confinement and production directly over fish ponds. Poultry manure has been used widely in both fresh and brackish water aquaculture. In the latter, penaeid shrimp, milkfish (*Channos channos*) and tilapia (*Oreochromis* sp.) have been the principle organisms raised. Inland culture systems in which poultry and fish such as the carps, tilapias and catfish are raised in commercial and subsistence systems are the focus of this review.

Poultry manure is now widely used in commercial freshwater aquaculture. In central Thailand, use of livestock wastes is the norm in the production of cheaper herbivorous fish. In other areas, intensification of culture using high quality feeds has reduced the importance of poultry waste to fish production. Predisposing factors to intensification include shortages of land or water and high product prices, but ready availability and competitively priced quality feeds are also critical. Wohlfarth and Schroeder (1979) identified the relative price of feeds and manures as being critical to determining input strategies.

Most published data concern integration of fish culture with modern poultry systems which are typically inappropriate for resource-poor farmers. Village or backyard poultry systems predominate in areas where modern breeds and systems are absent, or co-exist in competition with them. Recent research indicates that integration of such poultry and backyard fish culture can also bring benefits at little extra cost.

Waste-fed Aquaculture

A proportion of the nutrient content of feed given to poultry is voided as excretory or faecal waste. These nutrients can be used to support fish culture by their action as fertilisers that stimulate production of natural food organisms, such as phytoplankton, and detritus. A variety of carps and tilapias can grow rapidly on such natural feeds alone.

Stable and high water temperatures and sunlight ensure year-round growth of both fish and their natural feeds. The tropics, in which average water temperatures remain above 25 deg C, are ideal for culturing fish using poultry waste as inputs, although it is also practised in sub-tropical and sub-temperate climates during suitable periods of the year (>20 deg C).

Poultry wastes and byproducts can provide the feed support of aquaculture across a range of intensities. Poultry wastes may act mainly (1) indirectly or (2) directly to support fish production.

Poultry manure can be used fresh, or after processing, to enhance natural food production in sun-lit tropical ponds. Although some nutrition may be derived directly from the waste, natural feed produced on the nutrients released from the wastes is more important. Fish feeding low in the food web - the carps and tilapias benefit most from this type of management since they can utilise plankton, benthic and detrital food organisms effectively.

Several factors affect the level of waste loading and standing stock of fish that can be supported. Greater sensitivity to dissolved oxygen limits carps to standing stocks of <3 MT/ha whereas tilapias may be harvested at standing stocks of over 5 MT/ha. Water quality, particularly the level of dissolved oxygen in the early morning, therefore limit the amount of wastes that can used. Input levels in excess of 75 kg DM/ha/ day typically 'overload' the system over a typical fish culture cycle (4-8 months), causing early morning deficits of oxygen. Balancing the production of wastes from poultry and the requirement of the fishpond is a key aspect of management.

The quality of poultry wastes used in fish culture varies greatly. High levels of spilt feed, for example, increase direct feeding value. Nutrient composition may be a useful guide to value but the availability or release of nutrients to the food web may be more important.

Conventional feed ingredients have been 'replaced' with dried poultry wastes of various types, but low metabolisable energy and digestible protein levels limit their usefulness (Wohlfarth and Schroeder, 1979).

Poultry processing byproducts such as chicken bones, intestines and whole carcasses have greater value as 'direct' feeds and are normally used for higher value fish species raised more intensively. High fish standing stocks can be maintained and yields produced using this type of product and management. Processing wastes can be used fresh, or after further processing, as good quality supplementary, or complete, feeds.

Traditional Aquaculture

A lack of nutrients was a major constraint to traditional aquaculture and this remains true for much of the fish culture practised in the developing World. Yields from carp-based polycultures in China were limited until recently by the paucity of diets for pigs and grass carp (Ctenopharyngodon idella), and their manures, which provided a large portion of the nutrients entering the food web (Ruddle *et al.*, 1983; Guo and Bradshaw, 1993). Recycling and reuse of nutrients on-farm has a long tradition born of necessity in the population-dense areas of Asia. However, the high outputs of fish and other products from integrated systems reported from China and elsewhere in recent decades are related to greater inputs from off-farm (Edwards, 1993).

Lack of nutrients and sub-optimal stock management remain major constraints to the production of fish on small-scale farms, as they are for traditional livestock management generally. Greater outputs of fish necessitate more nutrient inputs to be used than are available on typical resource-poor farms. Such inputs may be either direct fish feeds or feeds for livestock that in turn produce waste used in fish culture. Both need to be purchased from off-farm to supplement better reuse of on-farm wastes.

Factors Affecting Use of Poultry Wastes in Fish Culture

The type of poultry production system can greatly influence the amount of fish produced. Poultry systems producing nutrient-rich and collectable wastes are most valuable for fish production. A broad dichotomy exists between 'modern', normally intensive poultry production and 'traditional', extensive systems and this affects potential for integration with fish culture (Little, 1995). Edwards *et al.* (1983) describing the level of integration of poultry with fish in Central Thailand found large differences between small and large producers. Flock sizes of less than 100 birds were unlikely to be cultured with fish but larger flocks (>400) were usually integrated. Modern 'feedlots' raise large flocks and are generally capital intensive, highly dependent on off-farm support and profit-orientated. Generally raised on optimal, processed feeds in 'feedlots', production cycles are rapid and all the high quality waste can be collected for use in fish culture. In contrast, Klausner (1966) observing traditional management in a Northeast Thai village said that 'the owners feel that there is not much point in taking pains and spending money in caring for chickens, when chickens seem quite capable of caring for themselves'.

Many factors appear to constrain close integration of traditional poultry and fish culture. The poor quality supplementary feeds usually given, and the fact that confinement is restricted to overnight, result in less and poorer quality manure being available for use in fish culture. Moreover, farm households may already be using the poultry waste which is collectable for other purposes such as fertilising backyard crops.

Recent analysis of current poultry production in small-scale farming households reveals a marginal but important niche.

Poultry Production Waste Characteristics

Poultry manures are nutrient-rich, but there is great variability in their quality at the time of use as fish production inputs. Although between 72-79% of the dietary nitrogen, 61-87% phosphorus and 82-92% of the potassium was present in feedlot egg-laying hens (Taiganides, 1978), the variability in terms of nutrients available (g nutrient/bird/ day) can be much greater. The impacts of the gradual improvements in food conversion efficiencies attained by modern breeds and feeds are probably overridden by other factors, especially diet. Poultry raised on a balanced ration produce a higher quality, more nutrient dense waste than those fed a supplementary feed (Table 2).

Species, size and sex of bird directly affect the quantity of manure produced. The amount of feed spilt during feeding and drinking also varies with these factors together with the nature of the feed and feeding practice. Generally, larger birds produce more waste than small birds; the waste production increases rapidly over the rearing period of modern broilers as a result. Layers produce more calcium and phosphorus-rich excreta than broilers and the waste of replacement birds fed restricted diets high in fibre is correspondingly poorer than laying birds.

In scavenging systems, manure quality is greatly affected by the quality and quantity of supplementary feeds, which in turn affects fish production. Egg-laying ducks fed paddy grain at night produced poorer quality manure than those fed rice bran. The amount of nitrogen and phosphorus in the manure was 50% and 25% respectively of that found in ducks fed relatively nutrient dense village rice bran (Table 2). Restricted feeding of rice bran during night-time confinement to Muscovy ducks (*Cairhina moschata*) scavenging during the day reduced both quantity and quality of collectable wastes. Nitrogen in wastes declined with the level of restricted feed given from 1.28 g N/duck/day, for birds fed ad libitum to 0.55 g N/duck/day for ducks restricted to 50% of *ad libitum* feeding levels. (AFE, 1992)

Table 2. Effect of feeding and management on waste characteristics of poultry.

Poultry	System		Feed		Production		Waste g/animal/day			
	Feed	Scav-eng-ing	Conc-ent-rate	Supp-lemen-tary	Daily LWG	Lay-ing	DM	N	P	Ref
Egg lay-ing duck	Yes	No	Yes	No	1.88	46-58	44.7	1.97	0.49	a
Egg lay-ing chick-ens	Yes	No	Yes	No	-	-	44	1.3	1.14	b
Broiler chicken	Yes	No	Yes	No	32	-	20	0.7	0.92	c
Egg lay-ing duck	No	Yes	No	Yes	0.38	16.3	59.9	1.16	0.69	d
Egg lay-ing duck	No	Yes	No	Yes	0.42	29.8	24.8	0.52	0.16	e
Muscovy duck	No	Yes	No	Yes	10.4-16	-	40-70	0.65-1.28	0.5-0.8	f

a) Edwards *et al.*, 1983
b) Muller, 1980
c) Hopkins & Cruz, 1982
d) AASP, 1996 (Rice bran)
e) AASP, 1996 (Paddy rice)
f) AASP, 1992

Supplementary feeds of different types drastically affect waste characteristics and their value for fish culture. In a trial in which three different supplementary feeds (village rice bran, ground maize and ground sorghum) were fed to pekin and Muscovy ducks, both waste quantity and quality was affected. The degree of wastage, related to palatability and physical attributes of the feed, was an important factor (see below) but the intake and proximate composition greatly affected the value of waste for fish culture (Niang, 1990). Manure derived from maize-fed ducks was high in nitrogen, sorghum was intermediate and rice bran low, reflecting the composition of the feeds themselves. Total nutrients in the waste tended to be higher than in the feeds, suggesting the scavenged food tended to be of higher feed value than the supplement.

Spilled feed is a loss to the poultry system but a gain to the fish because of it's direct feeding value. The method of food presentation (timing, frequency, location) affects the amount of feed available directly for fish. Feedlot ducks fed complete diets appear to waste less than birds allowed to scavenge during the day and given access to supplementary feed at night. Feed processing can reduce spillage; up to 15 % of granulated feeds may be lost compared to 10% if the same duck feed is pelletised (Barash *et al.*,1982). Feeding behaviour and the nature of different feeds may increase the amounts of feed available directly for fish. Waste feed left in the waterer comprised more than 25% of the collectable dry matter from scavenging Muscovy ducks fed a supplement of village rice bran (AASP, 1996).

Poultry species, strain and environment affect the normal conditions of poultry management in tropical environments and these interact to determine the final characteristics of wastes available for fish culture. The density of birds in a given system and their method of confinement -in small cages or batteries (such as for chicken layers) or in pens with bedding material (litter) affects the management of both the poultry and their waste. Confinement directly over fish ponds is used for both broiler and layer chickens but pens that give access to ponds stocked with fish for drinking and/or bathing are generally used only for ducks and geese.

Poultry house litter (PHL), which can be broiler, replacement or layer bird waste is produced from poultry raised in houses with bedding materials of various types. The type and management of these materials can affect nutrient content and availability for fish culture. Fermentation can result in losses of nitrogen, volatilised as ammonia, or becoming refractory and unavailable. Some vitamins may increase (vitamin B12) and some antibiotics (e.g. Chlortetracycline) decrease with duration of storage (Muller, 1980).

Table 3. Check list of factors affecting characteristics of poultry waste and its use for aquaculture (modified after Muller, 1980)

- used fresh or collected, stored and transported
- nature of bedding materials (bulk density, particle size, moisture retention capacity, compressibility, penetrability, hygroscopicity, biodegradability)
- type of bird (size, growth rate, efficiency, sex)
- housing (open, closed)
- litter management (regular/irregular removal)
- nature of ingredients in poultry ration (digestibility, nutrient density and composition)
- type of storage (aerobic, anaerobic, exposure to temperature, rain, wind)
- quantity of bedding materials per surface unit (nutrient dilution, microorganism activity)

Action of Wastes in the Pond

The rate of nitrogen and phosphorus release, particularly in the most available forms, (dissolved inorganic nitrogen, DIN; soluble reactive phosphorus, SRP) has been used as an indicator of wastes value for fertilisation of fish ponds. Laboratory leaching experiments indicated that DIN was rapidly released as ammonia-N, levelling off at 6 mg NH4-N/g DM chicken manure after 4-5 days (Knud-Hansen *et al.*, 1991). Storage of duck wastes under aerobic conditions for a period of 4 weeks reduced both total nitrogen in the waste and the amount released subsequently as ammonia (Ullah, 1989).

The type of ingredients fed to poultry can affect the subsequent manure quality and release of nutrients for pond fertilisation. Substitution of a mixture of cassava leaf and root meal for village rice bran in complete diets of broiler Muscovy ducks resulted in a more nitrogen-rich manure but a similar cumulative release of nitrogen (5.5-6.7 mg/g DM). Release of DIN varied between 20-74% of the total in the waste. A greater proportion of phosphorus was released as SRP in all the wastes and the amount was inversely related to the level of cassava in the diet (AIT data).

Manure obtained from scavenging Muscovy ducks fed variable levels of a rice bran supplement (100, 75 and 50% of ad libitum) had different release characteristics. Significantly more DIN was released by ducks fed less supplementary rice bran suggesting that the protein in the natural feeds ingested during scavenging were less refractory than the nitrogen contained in village rice bran. SRP showed the inverse trend, with ducks fed ad libitum producing manure richer in phosphorus, of which more was released in the available form (AIT data).

Manures release other factors apart from nutrients that may have adverse effects on water quality and inevitably, fish production. Shevgoor *et al.*(1994) found that tannins and flavonoids were a major factor in the poor water quality observed in ruminant manure-fed systems. Substitution of cassava leaf for rice bran in complete diets for Muscovy ducks correlated with increased levels of tannin released from manure (AIT data).

The value of manures, including poultry manure, as a source of detritus and the role of detritus in the direct nutrition of fish has been much debated (Schroeder, 1978; Colman and Edwards, 1987). The stimulation of bacterial production, both in the water column and sediments is known to be stimulated by addition of poultry waste (Moriarty, 1987). Animals that filter feed or graze on bacteria attached to detritus directly, or consume the grazers, are therefore likely to benefit directly through this mechanism. Both feed and dissolved oxygen are required to maintain high fish yields and phytoplankton, both alive and as detritus, is the most important source of both in fertilised ponds (Colman and Edwards, 1987, Knud-Hansen *et al*, 1993).

Classification of Poultry-fish Systems

A framework for poultry-fish systems is given in Table 4. Feedlot and scavenging poultry represent two ends of a continuum of systems (Little and Edwards, 1994). The type of producer and characteristics of the production system and waste collection methods are distinct. In both cases however, poultry wastes may be part of a range of inputs used to produce fish. The use of poultry processing wastes is distinct and considered separately, although this strategy is linked closely to feedlot broiler production.

Van der Lingen described the concept of increased carrying capacity and fish yields if more nutritional inputs are complemented with higher stocking densities (Edwards, 1986). Yields from fertilisation alone may be increased with the use of supplementary feeds. Further increases in density and yield rely on improvements in feed quality and quantity so that they become the primary source of nutrition to the fish. Poultry wastes are used across a range of intensities, and for different purposes. Poultry wastes, inorganic fertilisers and feeds are to some extent substitutable. Poultry waste can be used in place of inorganics or feeds, inorganics in place of manures or feeds, and feeds in place of either type of fertiliser. Thus if manures are in short supply, inorganics can be used to optimise nutrient loadings and feeds to further increase yields. Feed may be substituted, to some extent, with fertilisers.

Table 4 Input and output of poultry-waste-fed-aquaculture

SYSTEM	INPUTS ($g/m^2/day$)						Ref
	POULTRY WASTE			OTHER			
	DM	N	P	DM	N	P	
FEEDLOT							
Egg-laying ducks	6.71	0.3	0.07	-	-	-	a
Broiler chickens	10.0	0.4	0.46	-	-	-	b
Layer chicken	14.3	0.4	0.3	-	-	-	c
Layer chicken	1.07	0.03	0.018	-	0.47	0.23	d
SCAVENGING							
Muscovy duck	9.7	0.15	0.10	-	-	-	e
Egg-laying duck	3.0	0.23	0.03	-	0.17	-	f
Egg-laying duck	1.24	0.20	0.01	-	0.17	-	g

SYSTEM	Fish	OUTPUT ($g/fish/m^2/day$)	System	Ref
FEEDLOT				
Egg-laying a ducks	Tilapia	2.82	$200m^2$ ponds, 6 months	
Broiler chickens	Tilapia, common carp	2.87	$400m^2$ ponds, 3 months	b
Layer chicken	Tilapia	1.33	$1000m^2$ ponds, 5 months	c
Layer chicken	Tilapia	2.75	$220m^2$ ponds, 5 months	d

Table 4 (Continued)

SCAVENGING				
Muscovy duck	Tilapia	1.38	$5m^2$ tanks, 3 months; duck fed 75% ad libitum	e
Egg-laying duck	Tilapia	1.21	$200m^2$ ponds, 4 months	f
Egg-laying duck	Tilapia	1.21	$200m^2$ ponds, 4 months	g

a) Edwards *et al.*, 1983
b) Hopkins & Cruz, 1982
c) Green *et al.*, 1994
d) Knud-Hansen *et al.*, 1991
e) AFE, 1992
f) AASP, 1996 (Rice bran)
g) AASP, 1996 (Paddy rice)

Feedlot Systems

Most of the poultry-fish systems described in the literature use waste from feedlots. Modern breeds of poultry raised on balanced feeds give the most nutrient-rich waste and produce the most fish, but systems are frequently sub-optimal, resulting in inefficient waste or space usage. Poultry manure is used either directly on-site, through the siting of poultry houses over ponds, or after collection, storage and transport to the site of fish culture.

Construction of the poultry house over the pond allows waste to drop directly in, saving labour costs. Also, in the peri-urban, flood-prone land often used, the cost to fill land for poultry housing, and the opportunity cost of land itself, are reduced. Confining poultry next to, or over, water can also improve their productivity under tropical conditions. Evaporative cooling can reduce heat stress in broilers (Theimsiri, 1992) and access to water improves feather quality of ducks, although growth may suffer (Edwards, 1986). Ducks free ranging over ponds in large numbers can damage dykes and cause water quality problems, restriction of the ducks to the water and pen prevents this problem (Edwards *et al.*, 1983). However, evidence from on-station research and farmers suggests that access to complete feeds and some degree of scavenging optimises egg production in Khaki-Campbell ducks (AIT, 1986).

Fish species is a critical factor in determining loading rates of poultry waste since there is a range of sensitivity to dissolved oxygen among the commonly cultured fish species. Air-breathing fish, such as clarias catfish and the silver-striped catfish (Pangasius hypothalmus), can tolerate the highest input levels and, at the high stocking densities normally raised, also require extra feed to sustain growth. These fish species are also probably inefficient at using the phytoplankton-dominated food web. In contrast, the microphagous Nile tilapia is more sensitive to low dissolved oxygen in the early morning but thrives at numbers of poultry between 1000 and 1500 egg-laying ducks/ha without other inputs. Using poultry manure alone, net extrapolated yields of up to 12 MT, or standing stocks of 5-6 MT/ha, appear possible in monocultures of tilapia.

Polycultures of carps are often considered most efficient in waste-fed ponds but greater sensitivity to dissolved oxygen necessitates lower input levels. Hopkins and Cruz (1982) found a poor survival of the more sensitive common carp in a tilapia-dominated polyculture, and Yakupitiyage *et al.* (1991) recorded poor survival of large silver barb (Puntius gonionotus) under similar circumstances. Research using more sensitive Indian Major carps has normally been undertaken at lower loading rates (<100-500 poultry/ha; Jhingran and Sharma, 1978, 1980).

Temperature regime affects the level of wastes that can be used in ponds and this is reflected in the lower stocking densities in eastern Europe (Edwards, 1986). Low temperatures reduce the amount of waste that can be processed by a given area of fish ponds. The fish kills reported in Hong Kong (Sin, 1980) are related to a continued build up of waste during the cool season, causing a subsequent bacterial and plankton boom as temperatures rise. This phenomenon, equivalent to a massive overloading, quickly removes oxygen from the water.

The dynamics of poultry flocks can make management of the waste for fish culture problematic. Direct use of egg-laying poultry for instance, in which the birds are of constant weight and produce fairly constant levels of waste, are easier to manage than broilers in which waste availability is cyclical (Hopkins and Cruz, 1982). The timely availability of replacement stock, veterinary support and market demand may be critical to maintaining both poultry and their waste production.

Higher loadings of waste necessitate water exchange or mechanical aeration to maintain dissolved oxygen. Green *et al.* (1994) significantly improved yields of Nile tilapia at high loading rates of chicken manure (1000 kg DM/ha/week) using mechanical aeration to ensure a high survival rate of fish. Additional aeration at levels of 10% saturation were sufficient to improve yields by 20% over unaerated ponds. Regular exchange of water to reduce phytoplankton biomass can alleviate water quality problems from overloading. In a well designed system, this would be avoided as effluents reflect inefficient nutrient reuse and negative impacts on surrounding environment.

Overloading of poultry waste can also be avoided by housing poultry over concrete or earthen floors, rather than directly over ponds, and regular manual or mechanical addition. This option may reduce construction costs considerably and also enables farmers to sell manure surplus to their requirements.

Supplementation of Feedlot Wastes

Various factors may limit the size of a poultry flock that a farmer can manage and integrate with fish culture, reducing wastes to levels below optimum. Edwards *et al.*(1983) found that problems of marketing duck egg, and high feed costs constrained small-scale farmers from maintaining even 30 ducks over small ponds (200m^2) as feedlots. Farmers with limited numbers of poultry for their pond area need additional nutrient inputs to optimise productivity.

Inorganic fertilisers may be a cheaper form of nitrogen and phosphorus than purchased poultry manure in many situations (Table 5), and highest yields may be achieved with relatively low loadings of poultry manure. The optimal level of poultry manure in ponds fertilised with high levels of inorganic fertilisers (5 kg N/ha/d) was found to be around 75 kg/ha/week for a monoculture of Nile tilapia in Thailand (Knud-Hansen *et al.*,1991). These low levels reflect the subtle balance of dissolved oxygen and food production in a highly eutrophic pond. Green *et al*. (1994) recorded similarly high yields (>20 kg/ha/day) of Nile tilapia using higher levels of chicken manure in combination with inorganic fertilisers. There are indicators however that, compared to tilapia, carps raised at lower nutrient loading rates perform better when fertilised with organic manures in addition to inorganics (AASP, 1996). Also, high levels of inorganics may be constrained by their availability or opportunity cost.

Supplementing the use of poultry manure with cheap and available direct feeding of fish is an alternative strategy. The impact of supplementary feed on yields of fish in ponds fertilised with poultry waste is affected by many factors. The level of natural feed to some extent affects the effectiveness of the supplementary feed; more natural feed allows greater feeding of a high-energy supplement to 'spare' the protein requirements and support the growth of more fish. The optimal levels for feeding supplementary feeds are complicated by the variable levels of waste poultry feed mixed with the manure.

Strategic use of additional feeds such as rice bran can boost yields of a Nile tilapia monoculture receiving egg-laying duck manure by between 10-150% (AIT, 1986), but their use may not be cost effective. One trial clearly demonstrated the 'law of diminishing returns' when a low feeding rate (1% body weight/ day) increased yields profitably by between 28-40%, depending on duck manure level, but a further doubling (2% body weight /day) increased yields further by a mere 4% or reduced them by 16% respectively (Yakupitiyage *et al.* 1991).

This suggests that overall dry matter loadings into ponds receiving both feeds and fertilisers should be considered. The variable response of different fish species within the polyculture also illustrates that supplementary feeding should be strategic. Although manure level and rice bran acted independently to boost overall yields, Nile tilapia responded most to duck density and silver barb only to feeding rate, indicating the role of supplementary feeding in polycultures of fish with different feeding niches.

Table 5. Economic comparison of different fertilizers with respect to available nitrogen (N), phosphorus (P), and carbon (US$ = 25 Baht), (Knud-Hansen, 1993)

Fertilizer	Cost (baht/50g)	Available N (baht/kg)	Available P (baht/kg)	Available C (baht/kg)
Chicken manure	20/a	76/b	194/c	7/d
Urea	240	10	-	24
TSP	450	-	45	-
$NaHCO_3$	1000	-	-	140

a/Wet weight
b/Assumes 40 % dry weight of total N is available (Knud-Hansen *et al.* 1991).
c/Assumes 10 % dry weight of total P is available (Knud-Hansen *et al.* 1993).
d/Assumes 50 % dry weight of organic C oxidizes to DIC.

Supplementary feeding of fertilised ponds is only necessary if the carrying capacity is exceeded. Green *et al.* (1994) found no benefits to yields in poultry-manure fertilised ponds also receiving high quality pelleted feed, probably because, at the low fish stocking densities ($2/m^2$) used, growth could be supported by natural feed alone. Yields may also be constrained by other factors such as seasonally low temperature and dissolved oxygen levels. The relatively low yields reported in Hong Kong (1.5-4.7 MT/ha/year; Sin, 1980), despite supplementary feeding of carp polycultures fertilised with duck manure, appear to be related to such water quality factors. Green *et al.* (1994) also reported poorer yields in supplementary-fed, poultry waste-fertilised ponds during cooler periods.

The reduction in feeding costs of more intensive systems by fertilising ponds with poultry manure is another strategy that has attracted attention by farmers and researchers alike. Clearly, the fish species raised need to be suitable for culture in plankton-rich, waste-fed systems. Green *et al.* (1994) found that the tambaqui (*Colossoma macropomum*), in contrast to the Nile tilapia, grew poorly in fertilised systems without supplementary feed.

Liao and Chen (1983) reported that Nile tilapia in Taiwan are raised in duck manure-fed, mechanically aerated ponds and also fed pelleted feed; yields of up to 18 MT/ha are the norm. Hepher and Pruginin's (1981) description of commercial polycultures in Israel indicates that fertilisation is an essential component of their high-yielding, semi-intensive systems.

Feed costs may also be reduced by feeding only in the later stages of the culture period, when the nutritional needs of the fish exceed the level supported by natural feed alone. Green *et al.* (1994) found that, at densities of 1 fish/m^2, tilapia could be raised on poultry waste alone for the first 3 months of an 137 day production without any differences in final yield.

Scavenging Systems

The use of scavenging poultry wastes in aquaculture is rare; few systems have been described in the literature in anything but qualitative terms. The variability of such systems must be expected to be greater than conventional poultry-fish systems; the production function between waste level and fish production, for example, is far more variable. The relationship between number of poultry and fishpond area is less clear cut when the wastes from scavenging birds are used. Waste collection is normally limited to overnight to allow enough time for the poultry to obtain natural foods, but absolute amounts of waste collected may still be high (Table 2). If feeds are given ad libitum and all wastes are used for fish culture (see above), dry matter levels/bird may be higher than those produced in feedlot systems. Overloading of these wastes can have clear negative impacts on water quality and fish yields.

Developing fish culture based solely or partly on the wastes of current poultry production requires an understanding of feed constraints. In north-east Thailand, the main supplementary feeds, village rice bran and unmilled paddy rice, are available only in limited quantities. Feeding restricted amounts of feeds to a larger flock of poultry can result in more poultry and fish from the same amount of rice bran (AASP, 1996).

The quality of the scavenging environment might be expected to affect the requirement for supplementary feed and the final quality of wastes produced. Natural forage is frequently seasonal and crop harvests may produce short-lived abundances of residues (dropped paddy, spilt maize) that will affect waste composition.

The relatively low nutrient density of wastes from scavenging poultry fed supplementary feeds explains the rationale for using them as partial inputs into fish culture. Farmers understand this limitation; in a study of farmer practice in Udorn Thani, farmers tended to use a variety of inputs in addition to poultry manure including plant leaves, ruminant manure and rice bran (AASP, 1996).

The quality and quantity of supplementary feed is the key factor in waste characteristics (see above) and subsequent fish yield. Feeds high in cassava products generally depressed fish yields, possibly due to the levels of tannins and unavailability of nutrients. Rice bran, corn and sorghum-fed ducks produced highly dissimilar wastes and subsequent fish yields based on similar numbers of ducks were very variable (Naing, 1990). Egg-laying ducks allowed to scavenge and fed either supplementary rice bran or paddy rice at night showed that tradeoffs may be involved. Egg yields were higher,(Table 2) but fish yields barely half that from ponds in which ducks were fed rice bran (Table 4; AASP, 1996).

Inorganic fertilisation can have a major impact on yields (up to 100%) of microphagous fish such as Nile tilapia in ponds receiving scavenging poultry wastes. In small ponds, the relative amounts required are also affordable, given the value of the fish produced (Edwards *et al*, 1996).

Poultry Processing Wastes

Boneless chicken meat is now an international commodity that resource-rich developing countries, with vertically integrated poultry industries, compete to produce and market. Low labour and feed costs and good infrastructure are necessary preconditions to develop the business that can produce large amounts of high quality byproducts suitable for intensive fish culture.

Poultry slaughterhouse wastes are in great demand for feeding hybrid clarias catfish (Clarias macrocephalus x Clarias garipinus) in Thailand.

Heads, viscera and thigh bones are the main byproducts fed fresh after simple on-farm grinding and mixing with a binder. Food conversion ratios of 4-5 (wet:wet basis) are attained under farm conditions (Little *et al.*, 1994), similar to levels reported by Prinsloo and Schoonbee (1987) for the use of chicken offal and dead whole chickens fed to Clarias gariepinus.

Benefits - the Political Economy of Poultry-fish Systems

Modern agribusiness control over production and marketing of poultry products is in great contrast to the fish component of integrated farming. Agribusiness companies control the breeds, the feeds and the marketing of broiler chickens in central Thailand and for hen eggs in Northeast Thailand (Engle and Skaldany, 1992). In contrast, the fish stocked are purchased from local entrepreneur breeders (Little *et al.*, 1987), fed on poultry and other wastes and marketed directly or through local middlemen and markets. Farmers are willing to contract-grow broiler chickens over their fishponds for minimal return in order to gain the benefits of high cultured fish yields. This has resulted in long term declines in the price of both chicken and freshwater fish over the past decade.

Changes in production and demand for poultry and fish stimulate new opportunities for their integration. Increasing proportions of chicken consumed and exported as boneless products has spurred the use of slaughterhouse wastes as feeds in Thailand, principally for a recently developed hybrid catfish which thrives under such culture conditions (Little *et al.*, 1994). These forms of production however are concentrated in the hands of relatively few, richer farmers and entrepreneurs. Urban consumers benefit from lower prices for poultry and freshwater fish but rural small-scale production may be constrained through a lack of feeds and markets.

Environmental and Public Health Aspects

The concentration of nutrients that feedlot agriculture encourages can lead to pollution of surface waters. The controlled eutrophication of static water ponds stocked with herbivorous fish can act as on-site treatment and, providing water exchange is avoided, impacts on surface waters are minimal. Nutrient budgets indicate that, although only 15-20% of input nitrogen and 8-12% of phosphorus are recovered as fish, most of the nutrients accumulate in the sediments (Edwards, 1993). Loss of nutrients with drainage water (<10% of both N and P) and seepage are minimal (Boyd, 1985). Waste-fed aquaculture is therefore more likely to alleviate pollution from livestock production than cause it, although more intensive use of wastes and porous soils could increase nutrient losses to surface and ground water resources.

Public health concerns have been raised about the integration of poultry and fish production on several levels. The risks of direct pathogen transfer to humans in fishponds fertilised with manures, whether consumers, producers or intermediaries, have been most assessed (e.g. AIT, 1986; Buras, 1993). Although faecal bacteria and viruses are present in poultry manures, rapid attenuation of pathogens occurs in most stable, waste-fed ponds (Edwards, 1986, 1993). Clearly, the control of Salmonella and enteric bacteria capable of causing human disease is important and their maintenance in fish culture water below threshold levels that can lead to infection (Buras, 1993). The control of poultry disease, however, leads to the concern that poultry feeds containing prophylactic antimicrobials can encourages the emergence of antibiotic resistant strains of bacteria. The relative risks are likely to be insignificant compared to other causes such as direct human abuse (Dalsgaard, 1993: personal communication) or chemotherapy of fish themselves (Austin, 1993).

There has also been implicit connections made between integrated livestock-fish systems and influenza pandemics (Scholtissek and Naylor, 1988); this disturbing theory has led to widespread comment and discussion of the desirability and impacts of integrated farming (Edwards *et al.*, 1988; Morse,1990; Skladany,1992). The theory maintains that integrated aquaculture encourages the raising of pigs and poultry together to provide manure for fish and that this in turn increases the risks of new forms of influenza developing. Pigs may indeed act as 'mixing vessels' for avian viruses that can transfer to forms more virulent to humans but fishponds have had little role in bringing pigs and poultry together on farms. Indeed, pigs, poultry and fish together are rare on both large and small-scale farms in Asia. Intensified poultry-fish systems are more likely to separate poultry from pigs and other livestock than traditional farms (Edwards, 1991).

The purposeful eutrophication of water, leading to blooms of toxic blue green algae, has also been raised as an issue (Maclean, 1993). The poisoning of mammals drinking water containing toxic strains of Microcystis aeruginosa is established in temperate climates and research has indicated that the Nile tilapia avoids ingesting toxic strains (Beveridge, 1993). Under practical conditions however, such fish grow fastest in ponds dominated by this same species of algae (Colman and Edwards, 1987). Although the possibility of poisoning of fish and mammals from poultry-waste fertilised water exists, their controlled use in fish ponds reduces the likelihood of pollution to other water bodies.

References

AFE, Agricultural and Food Engineering, 1992. Final Report-Muscovy Duck Project : The development of economic feeding systems for Muscovy ducks (*Cairhina moschata*) in duck/fish integration in Thailand (15 May 1988 - 31 December 1991). Agricultural and Food Engineering, Asian Institute of Technology, 36 pages.

AASP, Agricultural and Aquatic Systems Program, 1996. Final Technical Report-IDRC: The development of feeding systems for fish and an integrated duck-fish system (30 December 1991 - 31 April 1996). Agricultural and Aquatic Systems Program, School of Environment, Resources and Development, Asian Institute of Technology. 41 pages.

AIT, 1986. Buffalo/fish and duck/fish integrated systems for small-scale farmers at the family level. Agricultural and Food Engineering Division, Asian Institute of Technology. 138 p.

Austin, B. 1993. Environmental issues in the control of bacterial diseases of farmed fish. p.237-251 In R.S.V.Pullin, H. Rosenthal and J.L.MacClean (eds) Environment and aquaculture in developing countries. ICLARM conf. Proc. 31, 359p.

Barash, H, I. Plavnik and R. Moav, R.1982.Integration of duck and fish farming: experimental results. Aquaculture 27, 129-140.

Beveridge, M.C..M. and M.J.Phillips, 1993. Environmental impact of tropical inland aquaculture. p.213-236 In R.S.V.Pullin, H. Rosenthal and J.L.MacClean (eds) Environment and aquaculture in developing countries. ICLARM conf Proc. 31, 359p.

Beveridge, M.C. M., Baird, D.J., Rahmatullah, S.M., Lawton, L.A., Beattie, K.A., Codd, G.A., 1993. Grazing Rates on Toxic and Non-Toxic Strains of Cyanobacteria by *Hypophthalmichthys molitrix* and *Oreochromis niloticus*. Journal of Fish Biology 43:6, 901-907.

Boyd, C. 1985. Chemical budgets for channel catfish ponds. Trans.Am.Fish.Soc.114:291-298

Buras, N. 1993. Microbial safety of produce from wastewater-fed aquaculture.p.285-295. In R.S.V.Pullin, H. Rosenthal and J.L.MacClean (eds) Environment and aquaculture in developing countries. ICLARM conf. Proc. 31, 359 p.

Colman, J. and P.Edwards.1987. Feeding pathways and environmental constraints in waste-fed aquaculture:balance and optimization, p.240-281. In D.J.W. Moriarty and R.S.V. Pullin (eds). Detritus and microbial ecology in aquaculturee. ICLARM Conference Proceedings 14, 420 p. International Center for Living Aquatic Resources Management, Manila, Philippines.

Edwards, P., K.E Weber, E.W. McCoy, C.Chantachaeng, C. Pacharaprakiti, K. Kaewpaitoon,and S. Nitsmer. 1983. Small-scale fishery project in Pathum Thani Province, Central Thailand: a socioeconomic and technological assessment of status and potential. AIT Research Report No. 158, AIT, Bangkok, 256 p

Edwards,P. 1986. Duck/Fish Integrated Farming Systems. p 267-291. In D.J Farrell and P Stapleton (eds). Duck Production Science and World Practice.430 p

Edwards, P., C. Kwei Lin; K.Leong Wee; D.Little and N.L.Innes-Taylor., 1988. Nature. 333:505-506

Edwards,P. 1991. Integrated farming and influenza pandemics. World Aquaculture 22(3) 2-6

Edwards, 1993. Environmental issues in integrated agriculture-aquaculture and wastewater-fed fish culture systems, p.139-170. In R.S.V.Pullin, H. Rosenthal and J.L.MacClean (eds) Environment and aquaculture in developing countries. ICLARM conf Proc. 31, 359 p.

Edwards, P, H. Demaine, N. Innes Taylor and D. Turongruang. 1996. Suataianble aquaculture for small-scale farmers: Need for a balanced Model. Outlook on Agriculture Vol.25, No.1, 19-26 p.

Engle, C.R., Skladany, M., 1992. The Economic Benefit of chicken Manure Utilization in Fish Production in Thailand. CRSP Research Reports 92-45,Program Management Office, Pond Dynamics/Aquaculture Collaborative Research Support Program, USA. 8 pages.

FAO,1989. FAO yearbook: Production Vol.42:1988. FAO Statistics Series No.88. Food and Agriculture Organization of the United Nations Rome, page 241-252, 266-268.

FAO,1990. FAO yearbook: Production Vol.43:1989. FAO Statistics Series No.94. Food and Agriculture Organization of the United Nations Rome, page 241-251, 265-267.

FAO,1991. FAO yearbook: Production Vol.44:1990. FAO Statistics Series No.99. Food and Agriculture Organization of the United Nations Rome, page 189-198, 212-214.

FAO,1993. FAO yearbook: Production Vol.46:1992. FAO Statistics Series No.112. Food and Agriculture Organization of the United Nations Rome, page 189-198, 202-214.

FAO Inland Water Resources and Aquaculture Service, Fishery Resources Division. 1995. Review of the state of world fishery resources:aquaculture. FAO Fisheries Circular, No.886. Rome, FAO. 127 p

Green, B.W., D.R. Teichert-Coddington and T.R Hanson. 1994. Development of semi-intensive aquaculture technologies in Honduras. International Center for Aquaculture and Aquatic Environments Research and development Series Number 39, Auburn University, Alabama, USA, 48 p

Guo, J.Y and A.D. Bradshaw. 1993. The flow of nutrients and energy though a Chinese farming system. Journal of Applied Ecology,30,86-94

Hepher, B. and Pruginin, Y., 1981. Commercial Fish Farming, with special reference to fish culture in Israel. John Wiley & Sons, New York. 261 p.

Hopkins, K.D. and E. M. Cruz, 1982. The ICLARM-CLSU, integrated animal-fish farming project: final report. Vol. ICLARM Technical Reports 5. Freshwater Aquaculture Center-central Luzon State University and International Center for Living Aquatic Resources Management, Nueva Ecija, Philippines. 96 p.

Jhingran, V.G. and Sharma, B.K., 1978. Operational research on aquaculture in West Bengal. Central Inland Fisheries Research Institute, Barrackpore, West Bengal, Bulletin No.27. Mimeograph.

Jhingran, V.G. and Sharma, B.K. , 1980. Integrated livestock-fish farming in India. (edited by R.S.V. Pullin and Z.H. Shehadeh) Proceedings of the ICLARM-SEARCA Conference on Integrated Agriculture-Aquaculture Farming Systems, ICLARM Conference Proceedings 4, Manila, August 1979, pp. 135-142, ICLARM-SEARCA, Manila, Philippines.

Klausner, W.J.1966. Reflections on Thai culture. Suksit Siam. Bangkok. 332 p

Knud-Hansen, C.F., Batterson, T.R., McNabb, C.D. and Kitjar Jaiyen, 1991. Yield of Nile Tilapia (*Orechromis niloticus*) in fish ponds in Thailand using chicken manure supplemented with Nitrogen and Phosphorus. In Eighth Annual Administrative Report (1 September 1989 to 31 August 1990). (Eds: Hillary S. Egna, Jim Bowman, and Marion McNamara) Pond Dynamics/Aquaculture CRSP, Oregon, USA, 54-62 p.

Knud-Hansen, C. F., Batterson, T.R., McNabb, C.D., Harahat, I.S., Sumantadinata, K. and Eidman, H.M., 1991. Nitrogen input, primary productivity and fish yield in fertilized freshwater ponds in Indonesia. Aquaculture, 94:49-63.

Knud-Hansen, C. F., Batterson, T.R., McNabb, C.D., 1993. The role of chicken manure in the production of Nile Tilapia (*Orechromis niloticus*). Aquaculture and Fisheries Management,24:483-493.

Liao, I. C. and Chen,T. P., 1983. Status and Prospects of Tilapia Culture in Taiwan. In International Sysmposium on Tilapia in Aquaculture, Proceedings. (EDS: Fishelson, L., Yaron, Z.) Tel Aviv University, Tel Aviv, Israel, page 588-598.

Little, D.C., M. Skladany and R. Rode. 1987. Small-scale hatcheries in north-east Thailand. Aquaculture and Fisheries Management, 18:15-31.

Little, D.C., K. Kaewpaitoon and T. Haitook. 1994. The commerical use of chicken processing wastes to raise hybrid catfish (*Clarias gariepinus x Clarias macrocephalus*) in Thailand. Naga, The ICLARM Quarterly. 25-27

Little, D.C. and P.Edwards. 1994. Alternative strategies for livestock-fish integration with an emphasis on Asia. Paper presneted at the International Workshop on Integrated Fish farming, 11-15th October 1994, Wu-Xi, China

Little, D.C. 1995. The development of small-scale poultry fish integration in Northeast Thailand:Potential and Constraints. In J.J. Symoens and J.C. Micha (eds) Proceedings of a seminar "The management of integrtaed freshwater agro-piscicultural ecosystems in tropical areas", Brussels, 16-19 May 1994.

Maclean, J.L., 1993. Developing-Country Aquaculture and Harmful Algal Booms. In Pullin, R.S.V., Rosenthal, H., Maclean, J.L., 1993. Environment and Aquaculture in Developing countries. ICLARM Conf. Proc. 31. 252-284 p.

Morse, S.S.,1990. Stirring up Trouble, Environmental Disruption Can Divert Animal Viruses into people. The Sciences Sept./Oct. page 16-21.

Muller, Z.O., 1980. Feed from animal wastes: state of knowledge. FAO animal production and health paper, Food and Agriculture Organization of the United nations, Rome. 190 p.

Naing, T. 1990. Potential of rice bran, corn and sorghum as supplements for scavenging meat ducks. MSc thesis. Asian Institute of Technology. 71 p

Prinsloo, J.F.and H.J.Schoonbee. 1987. Utilization of chicken offal in the production of the African sharptooth catfish *Clarias gariepinus* in the Transkei. Water SA 13(2), 129-132

Ruddle, K, J.L Furtado, G.F.Zhong and H.Z. Deng. 1983. The mulberry dike-carp pond resource system of the Zhujiang Delta, People's republic of China :I Environmental context and system overview. Applied Geography, 3:45-62.

Scholtissek, C. and Naylor, E., 1988. Fish Farming and Influenza Pandemics. Nature Vol.331 (21 January 1988). Page 215.

Skladany, M. 1992. People, Poultry, Pig, Fish and Social Viruses : The Integrated Aquaculture-Human Influenza Pandemic Controversy or "Give me a Fish Pond and I'll Either Feed or Infect the whole World". In Paper presented at the 8th World Congress for Rural Sociology, The Pennsylvania State University, Pennsylvania, U.S.A. 19 pages.

Shevgoor, L., Knud-Hansen, C. F., Edwards, P., 1994. An assessment of the role of buffalo manure for pond culture of tilapia. III, limiting factors. Aquaculture 126: 107-118.

Schroeder, G.L., 1978. Autotrophic and Hetrotrophic production of micro-organisms in intensely manured fish ponds, and related fish yields. Aquaculture 14:303-325.

Sin, A. W-C. 1980. Integrated Animal-Fish Husbandry Systems in Hong Kong with Special Case Studies on Duck-Fish and Goose-Fish Systems. In Proceedings of the ICLARM-SEARCA Conference on Integrated Agriculture-Aquaculture Farming systems, Manila Philippines, 6-9 Aug, 1979. (Eds: Pullin, R.S.V., Shehadeh, Z.H.) International Center for Living Aquatic Resources Management, Manila, and the Southeast Asian Center for Graduate Study and Research in Agriculture, College, Los Banos, Laguna, Philippines. page 113-123.

Taiganides, E. P., 1979. Wastes are resources out of place. Agricultural Wastes,1:1-9.

Theimsiri, S.1992. New concept on poultry breeder management in tropical countries 65-71. In Proceedings of Luang Suwan International Poultry Symmposium, the Sixth Animal Science Congress of AAAP, 27-28 November, 1992, Bangkok.129 p.

Ullah, M.D. 1989. Nutrient release characteristics of duck manure for Nile tilapia production. MSc. thesis. AIT. 67 p

Wohlfarth and Schroeder, 1979. Use of manure in fish farming-a review. Agricultural Wastes 1:279-299

Yakupitiyage, A., P. Edwards and K.L. Wee. 1991. Supplementary feeding of fish in a duck-fish integrated system.I. The effect of rice-bran, p. 143-157. In S.S. De Silva (ed.) Fish nutrition research in Asia. Proceedings of the Fourth Asian Fish Nutrition Workshop. Asian Fish. Soc. Spec. Publ. 5, 205 p. Asian Fisheries Society, Manila, Philippines.

The Use of Leguminous Leaves as Fish Pond Inputs

The following was the executive summary of a final report to USAID on a research project 'Use of leguminous leaves as fish pond inputs'. The authors of the report were David Little, Amararatne Yakupitiyage, Alma Castanares and Peter Edwards of AIT, and Leonard Lovshin of Auburn University.

The use of the leaves of four perennial leguminous tree species: *Cajanus cajan* (pigeon pea), *Gliricidia sepium, Leucaena leucocephala* and *Sesbania grandiflora* were studied for their value in aquaculture. A series of trials was designed to determine how such leaves could be used as on-farm inputs for fish ponds in the tropics where other inputs are unavailable or expensive. A series of experiments tested strategies to use the leaves directly as feeds or indirectly as fertilisers to enhance pond productivity. Their use as green manures or ruminant feeds, with subsequent use of ruminant excreta as pond inputs, was tested.

As fresh feed, the leaves were found to have negligible feeding value to four herbivorous fish species: Nile tilapia (*Oreochromis niloticus* L.), silver barb (*Puntius gonionotus*), grass carp (*Ctenopharyngodon idella*) and giant gourami (*Osphronemus gourami*). The presence of anti-nutritional factors was suspected to reduce palatability and intake but further research, after removal of the major anti-nutritional factors, suggested that poor digestibility was also a major factor.

The leaves may have some potential for use as green manure, although the labour requirements for leaf harvest will be a major constraint under many circumstances. Measurement of the amount and release rate of major nutrients (total nitrogen and phosphorus) in water indicated that 50% of nitrogen was released after a 25 day period. The relatively low nutrient density (high C:N) however, mean that the leaves cannot be used as a sole source of nitrogen in pond systems receiving optimum nitrogen levels (3 kg N/ha/d) as the dry matter loading required leads to high oxygen demand and increased levels of tannic acid which decreases water transparency, fish survival and fish growth. Fish production comparable to inorganic fertilisation alone was achieved using legume leaf nitrogen to supply 50% of nutrients in both tank (*Oreochromis niloticus*) and earthen pond (*Oreochromis niloticus* and *Cirrhinus mrigala*) experiments. Potential exists for their seasonal use in multiple, lower input, carp-based polycultures.

The limited applicability of legume leaves as conventional feeds or green manures in ponds led to the study of the value of their nutrients after 'treatment' via a ruminant. Improvement of smallholder ruminant production in the tropics often involves upgrading the diet with legume leaves and its acceptability to farmers is proven. Previous research had demonstrated that faecal wastes are poor fertilisers but the current study showed that 100% of inorganic fertiliser-derived nitrogen can be substituted by goat liquid waste (urine plus floor washing). The main constraints to adoption are likely to be the relatively large numbers of ruminants and fodder required to provide significant inputs to the typical-sized fish pond. Up to 14 goats, and considerable labour and land, are required to provide optimal nitrogen levels for a single 200 m2 pond for example. This approach will have most value in situations where the ruminant system has been intensified, waste re-use is sub-optimal and fish ponds are located close by. Smallholder dairy production is expanding in many parts of developing Asia and fish culture may be an ideal integrated activity.

Whole farm analysis compared scenarios for inclusion of legume leaves into a food production system including fish and suggested that the wood fuel value of legume twigs derived from leaf production may be an important product. Fuelwood typically constituted as much to simulated incomes of the systems as fish production.

Legume leaves could have a subsidiary role in increasing nutrient inputs and fish outputs from smallholder ponds, particularly if intensified ruminant production has already been adopted. A high demand for fish, a lack of alternative pond inputs and a scarcity of on-farm fuel would encourage the production of legume leaves and their use for ruminant-fish systems.

An Investigation into a Low-Input Pig-Fish System Appropriate for the Mekong Delta, Vietnam

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The use of pig manure as an input to freshwater fish culture is a well established system in parts of Asia. The pig production wastes, which may include urine and waste food in addition to faeces, may be used to provide nutrients for stimulating the growth of natural food organisms such as phytoplankton, zooplankton and detrital-bacterial aggregate. These feeds, present in both the water column and sediments of ponds, are consumed by suitable herbivorous and omnivorous fish species.

Research into integration between pigs and fish to date has been based on the wastes from modern pig production systems utilising nutritionally balanced feeds. Fish yields are related to the level and quality of nutrients in waste; the data from high input pig production therefore cannot be extrapolated to backyard, small-scale systems. These tend to utilise local feeds which are typically nutritionally inferior and produce wastes that are also less nutrient rich. The choice of fish species also has impacts on yields since phytophagous fish such as Nile tilapia (*Oreochomis niloticus*) are likely to optimise yields in eutrophic water. Their tendency to breed in the system may be either a benefit, if progeny can be marketed locally as 'seed', or a problem if their recruitment is uncontrolled leading to stunting of stocked fish. The use of suitable predatory fish to control excess progeny may therefore improve performance.

An experiment in which all the production wastes from fattening pigs fed a diet available to Vietnamese farmers was used to fertilise a monoculture of Nile tilapia or a polyculture of the same species with hybrid clarias catfish (*Clarias macrocephalus* x *Clarias gariepinus*). All the wastes from pigs housed in stalls were loaded daily into a series of six earthen ponds (200m^2) over a period of 90 days. A ratio of 50 pigs/ha pond area was used, based on the normal numbers of pigs fattened per household and typical fishpond size in the target area. No other inputs were used except for an initial basal fertilisation of 75 kg/ha urea and 90kg/ha triple superphosphate during pond preparation.

Pigs (hybrid Large White x Landrace x Duroc) were fed a cooked mixture of rice bran, obtained from village rice mills in north-east Thailand, and chopped water hyacinth (*Eichhornia crassipes*) twice daily. Rice bran and water hyacinth were fed on a basis of 5% and 4% (wet weight) of the live weight of the pigs, adjusted monthly. The pigs used were modern hybrids obtained from a commercial farm at a mean size of 55.3 kg and raised over a period of 3 months, reaching a average marketable size of 88.9 ± 3.2 kg.

Net yields of the monoculture and polyculture of fish were not significantly different at 14-16 kg fish/pond (extrapolated yields of 2.9 and 3.3 MT/ha/year respectively). Stocking hybrid catfish as a predator to control tilapia breeding was ineffective. Large numbers of tilapia fry were harvested from both systems, although the polyculture had significantly less.

The simulated value of the harvest varied with local market opportunities for tilapia fingerlings or hybrid catfish. The use of the tilapia fingerlings as a supplementary pig feed is a potential option; yields of small fish (total length=<10 cm) varied between 5-8 kg per pond over the three month trial.

The energy requirements to prepare the pig feed were also accounted within a framework of woody biomass produced from *Leucaena leucocephala* in which the leaf was fed to small ruminants. Rotational cutting of a boundary fence (178m long, 1m wide) would satisfy the energy needs to produce feed for one fattening pig throughout the experimental period.

Opuntia-based Ruminant Feeding Systems in Mexico

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Abstract
In Mexico, the arid and semi-arid regions occupy around 50% of the total area. One of the plant resources with a wide range of distribution and uses by man and animals is nopal (*Opuntia*).

The use of nopal as forage in Mexico depends mostly on the utilization of wild nopal communities and less on the cultivated forage, fruit or vegetable plantations.

The *Opuntia* species utilized are numerous and they are used to feed cattle (milk and meat), goats (meat and milk), sheep (meat and wool), horses (transportation and draft), and wildlife. The volumes fed to cattle are around 30-40 kg per day and to goats and sheep around 6-8 kg.

The utilization of the nopal is carried out by large, medium and small rangeland ranches, and in medium and small stables. The methods used by the farmers are reviewed. The comparative advantages of nopal are highlighted and recommendations are given for further research and extension programmes.

KEY WORDS: *Opuntia*, prickly pear, nopal, Mexico, feed, ruminant

Introduction
Opuntia cactus (prickly pear or nopal) is a group comprising plants belonging to different species of the genera *Opuntia* and *Nopalea*, both of the Cactaceae family. Its origin is the American Continent and it can be found from Canada (59 deg. north latitude) to Argentina (52 deg. south latitude), and from sea level to an altitude as high as 5100 m in

Peru (Bravo & Sheinvar, 1995).

The Cactaceae family includes approximately 130 genera and 1500 species. Of these, the *Opuntia* and *Nopalea* genera are the most important due to their usefulness to man. In America, there are two centres of diversification of the Cactaceae family, one in the northern part of the continent and the other in the south. Most of its genera are in one of the two centres; an exception is the *Opuntia* genus, which is found on both sites. There are 258 recognized species of *Opuntia* and 100 are found in Mexico, while the genus Nopalea has only ten reported species (Bravo, 1978).

Cactaceae are plants resistant to arid and semi-arid conditions. These conditions in Mexico are characterized by scarce and erratic precipitation, high diurnal thermic oscillation, high annual thermic oscillation and rainfall only in the summer (Flores and Aguirre, 1992).

The arid and semi-arid regions of Mexico cover more than 95 million ha, where annual precipitation ranges from 150 to 600 mm, and the average annual temperature is around 15-25 deg C, with more than seven dry months. Vegetation is composed of grasslands and scrublands, and the plant cover is less than 70% (Jaramillo, 1994).

History and Present-day Importance of Nopal in Mexico

Three main nopal production systems have been identified: wild cactus communities, family orchards and intensive commercial plantations. Although intensive commercial plantations are recent, they were started only 50 years ago, they produce the greatest amount of fruit and vegetable nopal which supplies the domestic and international markets (Flores, 1993). Period in use, products and the total area cultivated per system at present is shown in Table 1.

The use of nopal in Mexico goes back to its first inhabitants. At present, nopal is used in many ways; to name but a few: it is eaten as a vegetable and fruit; it is used for forage, fuel and fences, as well as in medicines, cosmetics and in ceremonies; it produces grana, a natural dye; and it helps to control erosion. The use of nopal as forage for livestock began with the colonization of the north of Mexico by the Spaniards in the 16th century.

Table 1: Period in use, products and total area cultivated under each nopal production system at present in Mexico

Production system	Period in use	Products	Area (ha)
Wild communities	20,000 BC to present	Forage Fruit Vegetable	3,000,000
Family orchards	3,000 BC to present	Fruit Vegetable Forage	unknown
Intensive commercial plantations	1945 to present	Vegetable Fruit Forage Grana	10,400 56,856 150,000 100

Source: Flores, 1993

Nopal-based Ruminant Feeding Systems in Mexico

Extensive (grazing) animal production systems

Nopal is found naturally on 3 million ha of rangelands in northern Mexico which have, even now, a good plant population density. Another 150,000 ha of nopal were planted by ranchers and small producers with government support.

The livestock fed with nopal are mainly cattle, goats and sheep. But fighting bulls and oxen are also fed with nopal. The two main products of cattle production are calves for export and meat. The goats are used to produce meat and milk, and the sheep to produce meat and wool.

The cattle have a certain amount of blood from breeds such as the Hereford, Charolais, Aberdeen Angus and Beef Master. When the quality of the rangelands is lower, crosses are made with Brahman, Indobrasil, etc.

In goats there has been a more limited degree of cross-breeding with breeds such as the Nubian, Granadina, Murciana, Alpino Francesa and Sannen. While in sheep, the situation has been similar with limited cross-breeding with Rambouillet, Suffolk and Corridale.

Feeding cattle is based on grazing on rangeland grasses such as Bouteloua, Eragrostis, Buchloe, Hilaria, and the introduced Pennisetum. All of these are reduced markedly during the dry years. There are also shrubs on which cattle forage like Prosopis, Acacia, Celtis, Flourencia, etc., and a great variety of cactus (nopal) (Table 2).

Table 2: Main *Opuntia* species used as forage on the rangelands of northern Mexico

SCIENTIFIC NAME	COMMON NAME
O. streptacantha	Cardon
O. leucotricha	Durasnillo
O. robusta	Tapon
O. cantabrigiensis	Cuijo
O. rastrera	Rastrero
O. microdasys	Cegador
O. lindheimeri	Cacanapo
O. engelmannis	Rastrero
O. azurea	Coyotillo
O. stenopetala	Serrano
O. imbricata	Cardenche
O. fulgida	Choya
O. choya	Choya
O. macrocentra	Chivero
O. chrysacantha	Espina amarilla
O. lucens	Penca redonda
O. duranguensis	
O. tenuispina	

Nopal is fed to livestock using the following methods:
a) Direct consumption, even though thorns and glochids are present in all these varieties.
b) For consumption by goats and sheep, mainly on the edge of the nopal, where the concentration of thorns is greatest, and they are cut off.
c) The whole nopal plant is burned by piling dry brush at the base and burning it in order to eliminate the thorns. However, this method has the disadvantage of causing severe damage to the plant making its recovery difficult.
d) Utilizing a gas or kerosene burner to burn off the thorns of selected nopal pads without damaging the whole plant.
e) The best method is cutting off the nopal pads, placing them on the ground, and then burning the thorns off.

The livestock on this kind of rangeland should be given supplements of at least calcium and phosphorus, which can be supplied through the addition of bone meal or blocks with phosphorus and limestone, among other nutrients. Also, it is common to use a mineral premix with salt. In some rangelands during dry seasons, a supplement with protein concentrates (i.e., cotton seed meal, oil seed meals, etc.) is commonly given to livestock. On good rangelands (with leguminous forage plants) the supplements are sources of energy (i.e., maize, sorghum, cane molasses, etc.).

In general, nopal is used during the dry season of the year. However, because there has been a continuous drought in northern Mexico during the last four years, it has been used throughout the year, resulting in deterioration of the nopal communities and a depletion of the resource (Flores and Aranda, 1996). The drought, however, did serve to underline the benefits of using nopal as a feed for livestock on the rangelands. In the last three years, 650,000 head of cattle died in northern Mexico as a consequence of the drought. In general, the ranchers with nopal did not suffer great losses compared with those who did not have or ran out of nopal. Moreover, reproduction rates and levels of production of cattle, sheep and goats are superior when the ranchers supplement the normal diet of the livestock with nopal during the dry season.

Confined livestock

For this system, the nopal is obtained from the rangelands of northern Mexico (3 million ha), from the plantations of forage nopal (150,000 ha), from the plantations of nopal for fruit (cladodes from pruning) in the central region (50,000 ha), and from the plantations of nopal for vegetable (cladodes from pruning) also in the central region (10,500 ha).

Holstein is the most common breed for milk production on small farms of the central and northern regions. Furthermore, small feedlots use nopal to grow and fatten cattle. In this case, the breeds used are the same as those mentioned for the rangelands.

The feeding of the confined dairy cattle consists of nopal supplemented with commercial concentrates and other forages like oats, alfalfa, maize silage and sorghum straw, with additions of premix and common salt.

The species of nopal utilized in these conditions are the same as those used under rangeland conditions. Additionally, *O. lindheimerii*, *O. engelmannii* and *O. rastrera* are used on forage plantations. *O. robusta* and *O. streptacantha* is used in family orchards, and *O. amyclaea*, *O. ficus-indica* and *Nopalea cochillinifera* in plantations for fruit or vegetable (nopalito).

Methods used by the farmers to prepare nopal for livestock:

a) Cutting the nopal. This is done using a knife attached to a bar or tube with a pair of hooks on the opposite end. The hooks are used to lift the cut claddodes and place them on a truck. The main problem here is the level where the nopal is cut, because most of the time the nopal is cut from the root, limiting the possibility of the plant's recovery.

b) Transporting the nopal. The cut claddodes are transported in large or small sized trucks, or even on carts pulled by animals when the distances are not so great. Unfortunately, with wild species, the sites where nopal can be found and cut have become increasingly further away (100-150 km).

c) Burning the nopal. When the nopal arrives from the field it is piled up in the yard. As it is needed, it is first spread out and then burned in order to remove the thorns (on both sides of the pad). This can be done with a gas (propane) or kerosene burner. The main problem here is the time that

the nopal can be kept in piles (no more than 10 days). On the other hand, the use of burners is expensive and, in the case of kerosene, drops of fuel are left on the nopal, so the cattle refuse to eat it.
d) Chopping the nopal. Once the nopal is free of thorns, it is chopped and then given to the cattle. The process can be done manually or by cutting machines (usually on farms with more than 50 head). In some cases, the nopal is chopped without burning off the spines and this causes some animals to have problems in their digestive tract.
e) Feeding the cattle. The nopal is carried on wheelbarrows to the feeder stall, and usually it is supplied twice a day. The amount used to feed cattle is around 30 to 40 kg of fresh nopal per day and 6 to 8 kg per day to feed sheep and goats. It has been found that different amounts of nopal are used in different parts of the country. For example, in Saltillo, Coah., 200 tons per day are used, while in Monterrey, N.L., the amount is around 600 tons. There are no data available for other regions.

The results obtained when cattle are fed with nopal have been shown to reduce the total milk or meat production per animal. However, the cost per unit of production is less. Thus, the utilization of nopal offers a good alternative for feeding cattle during the dry season and for lowering milk production costs.

Conclusions

In general, the technical-scientific knowledge on the use of nopal as livestock feed is good. However, knowledge on the sustainable utilization of the wild nopal communities and cultivated forage nopal plantations is limited and only just beginning to be studied.

Planting nopal on the rangelands of the central and northern regions may be the easiest way to improve the vegetation, conserve soil, stop the desertification process, increase the stocking rate, and improve productivity and incomes, and thus the living conditions of the producers of these regions.

The utilization of nopal has been compared with that of fresh alfalfa or alfalfa hay, and/or maize silage, among others. Although lower levels of production have been found using nopal, the costs per unit of production (milk and/or meat) are lower. Therefore, the nopal has been, is, and will be, an important source of forage for livestock in the central and northern regions of Mexico.

In recent extension work, nopal for forage has been planted in the Mixteca region (Puebla) and in northeastern Mexico (Coahuila, Nuevo Leon, Tamaulipas), as a first stage in a programme that includes: fencing and exclusion, sowing forage shrubs (*Prosopis, Acacia, Atriplex, Agave*, etc.), sowing grasses (*Bouteloua, Pennisetum*, etc.) and probably eliminating undesirable species (*Larrea*, etc.).

References

Bravo H.H. 1978. Las cactaceas de Mexico. Universidad Autonoma de Mexico. Mexico, D.F. Vol. I. 743 pp.

Bravo H.H. y L. Sheinvar. 1995. El interesante mundo de las cactaceas. CONACYT y Fondo de Cultura Economica. Mexico. 233 pp.

Flores V., C.A. y R. Aguirre R. 1992. El nopal como forraje. CIESTAAM-UACH. Chapingo, Mexico. 80 pp.

Flores V., C.A. 1993. "Historia del uso del nopal en Mexico y el mundo." In: Agricultura y Agronomia en Mexico. 500 anos. De la Fuente,J.; Ortega R.; Samano, M.(Eds.) Universidad Autonoma Chapingo. Chapingo, Mexico. pp.155-160.

Flores V., C.A. y G. Aranda O.1996. Uso del nopal como forraje en el mundo. Taller internacional sobre conocimiento y aprovechamiento del nopal y mezquite. FAO. U. de G., CINVESTAV-IPN. Irapuato, Guanajuato.14 p.

Jaramillo, V.V.1994. Revegetacion y reforestacion en las areas ganaderas en las zonas áridas y semiaridas de Mexico. COTECOCA. SARH. Mexico. 48 p.

The Integration of Fodder Shrubs and Cactus in the Feeding of Small Ruminants in the Arid Zones of North Africa

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Abstract
In the arid and semi-arid zones of North Africa, animal feed resources are fluctuating and insufficient. Small ruminants are basically fed on rangelands. During the last three decades, the contribution of rangelands to the needs of livestock decreased from 80 to 30%. Therefore, to reduce the increasing deficit of feed resources and to preserve the rangelands, large scale plantations of spineless cactus (*Opuntia ficus indica*, var. *inermis*), *Acacia* (*Acacia cyanophylla*, Lindl.) and *Atriplex* (*Atriplex nummularia* and *A. halimus*) were established recently (400,000 hectares in Tunisia).

The benefits of these species include high biomass yield, evergreen character, drought resistance, tolerance to salinity and soil adaptability.

These plantations were first established mainly on communal lands but recently more and more were established on mixed crop/livestock farms and private land.

Opuntia and shrubs are planted in wide rows allowing cereal cropping (mainly barley) in between. Animals may therefore graze the increased herbaceous biomass between the rows during spring, and stubbles during the summer time. The seasonal supply of feed is then better adjusted to the animals' needs, and livestock feeding is based more on farm resources than on commercial feeds. Indeed livestock farmers, and especially small herd owners, face dramatic difficulties during the frequent drought seasons. They are often forced to sell a large number of their flock in

order to buy either rarely available expensive straw and hay or imported cereal-based feeds.

Nutritionally, the above mentioned species complement each other. *Opuntia*, rich in water and carbohydrates, gives sufficient energy, *Atriplex* provides protein and *Acacia* is a fibre source.

Nutritional characteristics of these species and their use in combination with other farm resources such as treated straw will be discussed.

Opuntia pads have low crude protein (20 to 50 g/kg DM) and crude fibre (80 to 150g/kg DM) contents. However, they have high contents of water (800 to 900 g/kg fresh weight) and ash (150 to 250 g/kg DM). Cactus helps to meet the animals' water requirement. In addition, cactus pads are rich in vitamin A (almost the only source under harsh conditions) and in readily available carbohydrates. However, they need to be supplemented with nitrogen. On the other hand, poor quality diets may be correctly supplemented with cactus. Our work showed that the intake of straw increased significantly with the amount of cactus in the diet. Moreover, cactus is a good supplement to ammonia- or urea-treated straw because it provides the carbohydrates needed for the efficient use of non-protein nitrogen. Other trials clearly demonstrated that energy and nitrogen requirements of sheep may be met using cactus-based diets supplemented with *Atriplex* sp. Indeed, it is possible to get good performances by feeding animals cactus and *Atriplex* ad libitum with limited amounts of hay and barley. Such diets are recommended during drought years in arid and semi-arid zones.

Diets based on limited amounts of straw (17%) and various amounts of *Atriplex nummularia* (24 to 59%) and spineless cactus (21 to 56%) can cover 165 to 180%, and 165 to 230% of the sheep's maintenance requirements, in energy and digestible crude protein terms, respectively. Such diets, using low inputs of cereal grains and forage crops, are recommended to cope with the feed deficiency prevailing in the North African arid and semi arid areas.

Acacia cyanophylla Lindl. is a leguminous fodder tree that is widespread in North Africa. *Acacia* leaves are high in crude protein (14% DM), lignin (ADL, 16% DM) and condensed tannins (4,5% DM catechin

equivalent). Their nitrogen is poorly digested by the animal because of the condensed tannins. Air drying or polyethylene glycol (PEG 4000) treatment help to overcome this problem. PEG may be added in drinking water or included in feed blocks in order to efficiently increase the performance of animals fed *Acacia* leaves.

Trials were carried out with sheep to investigate the effect of air-drying and polyethylene glycol (PEG) treatment of *Acacia* leaves on intake, digestibility and growth. A decrease in condensed tannin content was observed when Acacia leaves were air-dried or treated with PEG. Drying and PEG treatment significantly increased nitrogen utilization. Crude protein digestibility of *Acacia* averaged 18.6, 17.2 and 68.8% for fresh, air-dried and PEG-treated leaves, respectively. The beneficial effect of PEG treatment was also supported by growth trials.

KEY WORDS: *Opuntia*, prickly pear, nopal, *Acacia cyanophylla*, *Atriplex*, PEG, North Africa, feed, small ruminant

Introduction

The North African climate is characterized by an extreme irregularity both in space and time (succession of rainy and dry years, high thermal amplitude, long dry season, etc.). Drought is a frequent phenomenon that must be coped with it.

The key problem of the arid and semi-arid zones in North Africa may be summarized as follows (Oram, 1995):

i. The increasing degradation of rangelands in the steppe zones and the consequent decline in feed supply for ruminants.
ii. The continuing increase in the number of small ruminants, especially sheep, despite widespread indications of declining productivity of the natural grazing.
iii. Uncertainties about the rights to graze animals on the range, arising from changes in the traditional tribal regulation mechanisms consequent on privatization of the range and settling of migratory peoples.

iv. Demographic changes and increasing population pressure on natural resources, both directly through competition of people for land and water and indirectly through rising demand for meat and other animal products.
v. The limited availability of technology for improving sustainable range productivity. This is because of the lack of support for range research, inexperience of management of range flora, and a "reservation-type" rather than a participatory approach by government officials to establishing and utilizing forage shrub plantations.

Fodder Shrubs: An Attractive Alternative for Rangeland Improvement

Experience with fodder shrubs started in the early 60's and even earlier in some countries (Tunisia), with various degrees of failure and limited success. Their impact is difficult to assess, since monitoring and evaluation processes are lacking most of the time.

In Tunisia, for example, according to a recent survey, rangelands cover some 5,413,000 ha distributed in forest and forest pasture (970,000 ha), *Stipa tenacissima*-based steppe (743,000 ha), communal and state rangelands (2,500,000 ha), and private rangelands (1,200,000 ha).

National strategies for rangeland rehabilitation were initiated in most countries. The most important components of these strategies are plantations of shrubs. The main species used are spineless cactus (*Opuntia ficus indica* var. *inermis*), *Atriplex* sp. (mainly *A. nummularia* and *A. halimus*), *Acacia cyanophylla* and *Medicago arborea*. Species or varieties of shrubs were not selected for each particular environment and production system.

The cost of establishment is often high. For Tunisia, the approximate cost of establishment (including the maintenance and subsidies to farmers during the first 3 years) is about 750 US$/ha for cactus and 1000 US$/ha for other shrubs .

Current Management of Shrub Plantations

Since the beginning, shrub plantations were established on communal lands under the supervision of forestry departments. Most plantations are kept ungrazed by forestry people, who are more interested in soil conservation, or exposed to uncontrolled communal grazing which frequently leads to their degradation. Thus, several constraints appear rapidly and are due to poor management.

Numerous questions arise when considering the use of introduced shrubs:

i. How should introduced shrubs be used by the animals (cut-and-carry vs. grazing)?
ii. How frequently can they be grazed?
iii. What stocking rate can shrublands support?
iv. For how long can shrublands be grazed without permanent damage?
v. Should plants be completely defoliated or would they recover better if only partly defoliated? etc.

In the absence of a well-defined management strategy, continuous grazing is the prevailing management system. Lands are permanently exploited to their maximum potential with no compensatory input.

Unfortunately, little effort has been devoted to defining convenient strategies for the management of introduced shrubs. Once planted on communal, state or private rangelands, shrubs have to be maintained for at least three years before their use by animals. Subsidies, as feed (concentrate, hay, alfalfa pellets), are given to farmers to replace outputs of the improved rangelands during the maintenance period (first three years). After three years, introduced shrubs are supposed to be properly used as recommended. Under Tunisian climatic conditions, shrubs are used from two to five years following their establishment, depending on the zones (north or south regions) and on rainfall. In Tunisia, the use of shrubs is based on field experience of farmers and technicians. No adequate seasonal or annual calendars have yet been recommended to farmers.

Acacia cyanophylla trees are used by animals every two years. Plants are grazed one year and browsed the following year. Leftover branches and leaves are cut and distributed to the animals.

Cactus plantations are never grazed directly. The cut-and-carry technique is the common practice. Using such techniques, the loss of feed is virtually nil and the risk of over-utilisation is considerably reduced. The cut-and-carry technique is, however, costly in labour and the grazing layer of herbage remains unavailable to the stock.

Saltbushes (*Atriplex* spp.) are grazed during the summer season. Plants are rarely cut for regeneration.

Meanwhile, shrubs are used in different ways depending on the users' preferences. On private rangelands, shrubs are well managed and properly used. Their use is confined to the farmers' needs to fulfill seasonal animal feed demands according to technical advice. Nevertheless, these shrubs are subject to over-use during dry years and, consequently, plants hardly survive. On communal land and on rangelands under forestry department control, the use of established plants is dictated by the forestry technicians. Plants can be used shortly after their establishment (but not before three years). However, the use of rangelands (either rehabilitated with shrubs or not) by farmers' flocks is allowed only during dry years. To use improved and/or protected rangelands, farmers have to pay a fixed fee which varies between 0.3 and 0.4 US$ per animal. Meanwhile, most protected forest and communal rangelands are often not used by animals for many years. Such practice leads to early aging of shrub plants which become woody and less productive in terms of browsing. Their periodic cutting will favour the growth of new shoots and leaves and results in an increase in the production of fodder.

Better Adoption and Better Management of Shrubs on Private Lands

Within the WANA region, Tunisia may be considered as a leader in promoting the establishment of shrubs on private farms and their integration into the current feeding calendar.

From 1990 to 1995, the Rangeland and Livestock Office (OEP) initiated the establishment of some 50,000 ha of cactus and 7,400 ha of various shrubs (*Acacia, Atriplex, Medicago arborea*) on 20,000 private farms. Most of these plantations were located in central Tunisia (arid zones) where there is a permanent feed shortage (table 1).

Table 1: Area of shrubs established by the Pasture and Livestock Office on private farms during the last five years (1990-1995) Zones

	Spineless cactus (ha)	Other fodder shrubs (ha)*
North-east	1669	1623
North-west	2772	1449
East central	9674	1495
West central	33099	528
South	2712	2265
Total	49926	7360

*Main shrub species are: *Acacia cyanophylla* Lindl., *Atriplex nummularia* and *Medicago arborea*.

It can be noted from Table 2 that spineless cactus is the main species used for rangeland rehabilitation. The largest areas of cactus plantations are located in the west central region of Tunisia (governorates of Sidi Bouzid, Gafsa and Kasserine). Using cactus pads for feeding animals has been a common practice for a long time. Cactus, a low protein, bulk foodstuff, is regarded as an emergency feed and is cultivated as such in Tunisia as part of the drought evasion strategies for livestock. Moreover, cactus feeding considerably reduces the drinking water requirement as it contains 80 to 90% of water (Ben Salem *et al.*, 1996).

In contrast to the other fodder shrubs, cactus establishment is accepted without problems by the farmers since they are familiar with this species. At the farmer level, cactus may serve as a fodder resource and also for human consumption of the fruits. However, the benefit expected from the other fodder shrubs is limited and the absence of a strategy for their management is the main constraint to their acceptance by the farmer as a tool for rangeland rehabilitation. In addition, it should be stated that the number of shrubs used for rangeland rehabilitation in the national strategy is too small to allow for better selection of species adapted to the micro-climate of each region.

Integration of Shrubs in the Production System - Some Promising Results

Spineless Cactus : A Strategic Fodder for Arid Zones

The benefit of integrated use of cactus is discussed in the following examples and case studies.

EXAMPLE 1: Nutritive value of diets based on spineless cactus (*Opuntia ficus indica* var *inermis*) and *Atriplex* (*Atriplex nummularia*) (Nefzaoui and Ben Salem, 1996).

Barbarine wethers were randomly allotted to 3 equal groups and fed diets based on cactus (*Opuntia ficus indica* var. *inermis*) and *Atriplex* (*Atriplex nummularia*) (80% of the diet). Restricted amounts of wheat straw (180 g/d) and commercial mineral and vitamins supplement (30 g/d) were distributed.

Dry matter intakes (DMI) were similar for all the groups (930 to 983 g DM/d or 70 to 73 g DM per kg $LW^{0.75}$). The relative intakes of Atriplex and cactus in the diets were 59 and 21%, 41 and 38%, and 25 and 56%, respectively for diet 1, diet 2, and diet 3. Digestibility coefficients of organic matter (OMD) and crude protein (CPD) of the 3 diets were relatively high, averaging 68 to 74%, and 75%, respectively. In contrast, fibre digestibility was low, probably because of the soluble carbohydrate content of cactus which depressed rumen cellulolytic activity. Nitrogen retentions were 4.1, 3.9, and 4.1 g. nitrogen per day for diet 1, diet 2, and diet 3, respectively (table 2).

The diets provided about 170% of the sheep's energy and digestible CP (DCP) requirements. Diet 1 provided 1.65 and 2.3 times the energy and DCP requirements of the sheep, respectively. Thus, it has an excess of nitrogen and may be supplemented with an energy source like barley grain. Diet 2 is relatively well balanced in both energy and nitrogen, while diet 3 has an excess of energy and needs to be supplemented with a nitrogen source (non protein nitrogen, like urea).

Voluntary intake of cactus was high (6.8 kg/d or ~550 g DM/d). No digestive disturbance was observed on any of the diets. Organic matter (OMD) and crude protein (CPD) digestibilities of the 3 diets were high.

Nitrogen retention was positive for the 3 diets and may indicate the relative good quality of nitrogen supplied by *Atriplex*.

In conclusion, cactus is a good source of energy and *Atriplex* a good source of nitrogen. Energy and nitrogen requirements may be matched by using diets based on these two feeds. The level of cactus in the diet may reach 55% on a DM basis, without digestive disturbances. A small amount of fibrous feed (straw, hay) has to be fed to the animals before feeding cactus. More efficient use of the diets could be achieved if the mineral balance is improved.

Table 2: Nutritive value of diets

Diets	D1	D2	D3
Total intake g DM/d*	941(70)	930(72)	983(73)
Cactus intake	197	353	550
Atriplex intake	554	391	236
Straw intake	160	159	167
Diet OMD, %	67.7	69.3	74.4
Diet DCP, %	74.5	76.6	75.5
Retained N, g/d			

* the values ( ) correspond to intakes stated in g of DM per kg of $LW^{0.75}$

EXAMPLE 2: Nitrogen supplementation of cactus-based diets fed to Barbarine yearlings (Nefzaoui *et al*., 1996).

The objective of this research was to investigate the effect of a nitrogen supplement (urea, soya bean meal, *Atriplex halimus* or *Atriplex nummularia*) on voluntary intake and growth of Barbarine yearlings fed cactus-based diets.

Four isonitrogenous and isoenergetic diets (D1 to D4) were offered each to 6 Barbarine yearlings for 60 days (summer 1995). On all diets, freshly cut cactus was fed ad libitum in addition to a limited amount of hay (170 g/d). Diets were supplemented respectively with 8 g/d urea (D1), 770 g/d *Atriplex halimus* (D2), 740 g/d *Atriplex nummularia*

(D3), and 65 g/d soya bean meal (D4).

The relatively low intake of cactus and the poor nitrogen content of *Atriplex* sp. was due to the drought during the year of the experiments.

Results showed that cactus-based diets may be supplemented efficiently with *Atriplex nummularia*. Urea and *A. halimus* lead to low growth rates in comparison to soya bean meal or *A. nummularia* supplemented diets.

The voluntary intakes were 694, 844, 858 and 674 g DM per day for diets D1, D2, D3, and D4, respectively. The average daily live weight gains were 55, 58, 74 and 70 for D1, D2, D3 and D4 respectively (table 3).

Such diets, using low inputs of cereals (28% of the diet) and forage (17% of the diet), are recommended to cope with the feed deficiency in arid and semi-arid areas prevailing in North Africa.

Table 3: Feed intake and live weight gains

Diets	D1	D2	D3	D4
Feed intake (g DM/day):				
Cactus	241	252	241	228
Atriplex halimus	0	224.2	0	0
Atriplex nummularia	0	0	225.8	0
Soybean meal	0	0	0	57.6
Barley	308.8	243.6	243.6	243.6
Hay	149.0	142.9	147.5	150.6
Urea	8	0	0	0
Total intake	706.8	862.7	857.9	679.8
Average daily gains (g/day)	55	58	74	70

Spineless Cactus and Acacia

In this example, the widely introduced shrub *Acacia cyanophylla* was used to supplement cactus-based diets. Indeed, *Acacia* is rich in crude protein (about 13% in DM). For this purpose, 4 Barbarine sheep groups were fed various diets (R00, R21, R22, R23) (table 4). Hay, a scarce and expensive feed, was distributed in a restricted and limited amount.

The intake of *Acacia* was low (250 g DM/day) because of its high content of condensed tannins (7% DM). These tannins are also responsible for the low digestibility of the *Acacia* crude protein.

Table 4: Diets nutritive value

Diets	R00	R21	R22	R23
Feed intake, g DM/day				
Cactus	0	167	246	267
Acacia	241	373	211	177
Diet digestibility, %				
OM	67.7	76.5	73.9	74.6
CP	45.8	49.4	34.8	16.9
CF	62.8	80.5	77.4	79.9
Retained N., g/day	2.77	2.73	0.46	-1.07

With such diets, the energy requirement for maintenance is matched but a large nitrogen deficit remains and they need to be supplemented with an appropriate source of nitrogen.

Integration of Shrubs and Cereal Crop Residues

EXAMPLE 1: Effect of straw supplementation on intake and browsing of *Atriplex nummularia* (old man saltbush) by 'Segurena' ewes, under pen feeding and free grazing conditions (Correal and Sotomayor, 1996)

This example is taken from experiments conducted in Southern Spain (Murcia) where agro-climatic conditions are very similar to those in North Africa.

In the first autumn experiment under pen feeding conditions, dry Seurena ewes were fed for 6 weeks with two *ad libitum* diets (a) old man saltbush browse (mixture of leaves and young twigs) and (b) saltbush browse and barley straw. At the end of the experiment, the ewes from both feedlots ended up with higher live weights (LW) and better body condition (BC), which suggests that both diets more than met the sheep's maintenance requirements. In the case of the saltbush/straw diet, ewes consumed about 2/3 saltbush and 1/3 straw. Average total intake was higher for the saltbush/straw diet than for the old man saltbush diet (102 and 88 g DM/kg metabolic weight respectively).

A second winter experiment was run with free grazing in a fenced old man saltbush plantation divided into two halves; in one half, a group of ewes had free access to straw and, in the other half, ewes were fed only on old man saltbush shrubs. The experiment finished when the shrubs were completely defoliated. In both subplots, ewes maintained BC and improved LW, but the straw supplement increased by about one-third the number of grazing days obtained from the saltbush/straw subplot compared to those on the saltbush subplot. The straw supplement also reduced by 33% the average diameter of the twigs browsed by ewes. In conclusion, the use of a barley straw supplement can improve the feeding value of old man saltbush plantations.

EXAMPLE 2: Effect of straw supplementation on the *Atriplex halimus* (saltbush) diet consumed by 'Segurena' ewes (Sotomayor and Correal, 1996)

Dry Segurena ewes were fed in pens for 4 weeks in summer with ad libitum amounts of three different diets: (a) saltbush browse (*Atriplex halimus* leaves and young twigs), (b) saltbush browse and barley straw, and (c) barley straw. Leaf and twig intake was measured daily (by difference between the offered and refused saltbush diets), and sheep live weight (LW) and body condition (BC) weekly. Ewes consuming a mixed diet of saltbush and straw ended up with higher LW and better BC, but those consuming only saltbush, increased LW and lost BC; finally, ewes fed with straw, lost LW and BC.

Saltbush leaves contained about three times more crude protein (18.5% CP) and minerals (29.7%) than stems (6.4% CP and 8.7% ash), and stems contained about four times more crude fibre (53.2%) than leaves (13.9% CF). The average leaf:stem ratio was 1.24 for the saltbush diet, and 2.23 for the saltbush/ straw diet; hence, with the straw supplement, ewes consumed more leaves (richer in CP) than without it and, in the absence of straw, ewes consumed more stems - probably in search of more fibre in an energy deficient diet. In conclusion, the combination of saltbush browse plus barley straw met the sheep's maintenance requirement during summer.

EXAMPLE 3: Spineless cactus (*Opuntia ficus indica*, var. *inermis*) as a supplement for treated straw (Nefzaoui *et al*., 1993)

Research was performed to study the opportunity to use large amounts of cactus (*Opuntia ficus indica*, var. *inermis*) and also to assess the use of non-protein nitrogen from ammonia or urea-treated straw. Six groups of six Barbarine wethers were submitted to diets including cactus ad libitum and two levels (300 and 600 g) of untreated, urea- or ammonia-treated straw.

Cactus voluntary intakes were high (450 g DM) and were not affected when the amount of straw was increased from 300 to 600 g. Diets containing 64% of cactus were well eaten without any digestive disturbance (table 5). Data indicate that it is possible to provide the sheep maintenance requirements for energy from diets based on cactus given ad libitum with 300 g of straw per day. With a high level of straw (600 g/day), it is possible to achieve 1.7 to 1.9 times energy requirements. To cover nitrogen maintenance requirements, straw should be treated. Cacti may be used as a major component of diets containing cereal straws. Non-ammonia nitrogen provided by the treatment of straw is well demonstrated. However, it is necessary to add appropriate supplements in order to overcome the nitrogen deficiency and to give the fibre needed for normal rumen function.

Table 5: Straw supplementation with spineless cactus (Nefzaoui *et al.*, 1993)

Level of straw	300 g/day			600 g/day		
	US	ATS	UTS	US	ATS	UTS
DM INTAKE, g						
Opuntia	445	447	425	432	462	439
Straw	254	242	249	494	466	486
IN VIVO DIGESTIBILITY,%						
OM	67.9	64.0	63.3	66.5	69.8	72.6
CP	41.1	48.0	43.3	45.9	61.0	77.1
CF	37.5	30.5	29.2	46.5	49.2	52.7
N RETAINED	-0.2	-0.2	-0.6	0.8	2.8	3.9

EXAMPLE 4: Supplementation of straw by *Acacia cyanophylla* (Ben Salem and Nefzaoui, 1993)

Previous studies showed that *Acacia* foliage had a relative high crude protein content. Taking into account this characteristic, it was thought that Acacia may be a suitable protein supplement for poor quality diets (straw, natural range lands, etc.). Ben Salem and Nefzaoui (1993) tested the effect of supplementing straw-based diets with graded levels of air-dried *Acacia cyanophylla* Lindl. foliage on digestion in sheep. Results obtained in this study, which are summarised in table 6., failed to support the above suggestion since there was no positive changes in the nutritive value of straw-based diets supplied by *Acacia.* Data on the crude protein digestibility of diets and the levels of ammonia nitrogen in the rumen fluid of sheep were indicative of an inhibition of rumen digestion. The presence of high levels of condensed tannins, which form insoluble complexes with *Acacia* proteins, seems to be the causative factor. Therefore, it was concluded that *Acacia* is less suitable as a protein supplement for poor quality roughages than might be expected from its high content of crude protein. Research is being carried out in our laboratory to dissociate the tannin-protein complexes of *Acacia* and preliminary results seem to indicate that polyethylene glycol (PEG 4000) had an affinity for Acacia tannins and thus improved the nutritive value (intake, digestibility, rumen fermentation and growth) of Acacia foliage.

Table 6: Effect of Acacia cyanophylla Lindl. foliage supply on intake, digestibility and rumen fermentation parameters in sheep offered straw-based diets (Ben Salem and Nefzaoui, 1993)

	Level of *Acacia* supply (g DM/day)			
	0	75	150	225
Dry matter intake (g/day)				
straw	425b	431b	687a	350b
straw + *Acacia*	425b	506b	837a	515b
Total diet digestibility (%)				
Organic matter	51.6a	40.7b	48.7a	46.1a
Crude protein	-114.1b	5.1a	-4.0a	5.3a
NDF	60.1a	44.8c	56.7a	49.8b
Ruminal fermentation parameters				
NH3-N (mg l-1)	2.74	0.57	2.97	1.17
Total VFA (mmo-1)	60.5c	67.8b	74.2a	65.0bc

a,b,c: Data in the same line with different superscripts differ ($P<0.05$)

Conclusions

We discussed several examples showing that, in arid and semi-arid zones, shrubs, and especially cactus, play a significant role in providing valuable nutrients to small ruminants. In each example, conventional feeds (concentrates, hay or straw) are used in limited amounts because they are scarce and expensive.

Moreover, we recommend the following ideas:
(i) Encourage shrub plantations on private farms instead of communal rangelands. In other words, shrubs must be considered as a part of the production system and as a permanent fodder resource instead of a 'strategic' or 'reserve' fodder to be used only during drought. This option will facilitate the management of shrubs in a sustainable way.
(ii) Avoid planting a single shrub species. This will promote the availability of feeds during all seasons and will help to provide better balanced diets. Cactus can be used all year around and *Acacia* is mainly used during autumn and winter, while *Atriplex* can be exploited during the winter and summer seasons.
(iii) Plantations should be established in alley cropping where barley (the main cereal sown in arid zones) is planted between lines of shrubs. This will help to give better barley yields and will help to make better use of cereal crops. In fact, barley stubble may be grazed directly and supplemented with Atriplex (a protein source) or cactus (energy source).

References

Ben Salem, H. and Nefzaoui, A. 1993. Effect of increasing levels of *Acacia cyanophylla* on intake, digestibility and ruminal digestion on sheep fed straw-based diets. 7th Meeting of the FAO Sub-Network on Mediterranean Pastures and fodder crops. Greece (Chania), April 21-23, 1993. p 118-121.

Nefzaoui, A., Chermiti, A. and Ben Salem, H. 1993. Spineless cactus (*Opuntia* ficus indica var. inermis) as a supplement for treated straw. 7th Meeting of the FAO Sub-Network on Mediterranean Pastures and fodder crops. Greece (Chania), April 21-23, 1993. p130-133.

Ben Salem, H., A. Nefzaoui, H. Abdouli, L. Ben Salem; 1995. Tannins in *Acacia cyanophylla* Lindl. leaves : their effect on digestion by sheep fed alfalfa hay-based diets. IVth International Symposium on the Nutrition of Herbivores - Ann. Zootech., 44, Suppl. 228

Ben Salem, H., A. Nefzaoui, H. Abdouli, L. Ben Salem; 1995. Energy or nitrogen supply to sheep fed *Acacia cyanophylla* Lindl. leaves based-diets : effect on intake and digestion. IVth International Symposium on the Nutrition of Herbivores - Ann. Zootech., 44, Suppl. 76

Nefzaoui, A., H. Ben Salem, L. Ben Salem; 1995. Ewe-lambs feeding with cactus-based diets. Effect of the type of nitrogen supplement. IVth International Symposium on the Nutrition of Herbivores - Satellite "Ruminant use of fodder resources in warm climate countries" Montpellier (France), 7-9 September 1995.

Nefzaoui, A.; 1995. Nutritive value of spineless cactus (*Opuntia ficus indica* var. *inermis*) and *Atriplex nummalria* based-diets. IVth International Symposium on the Nutrition of Herbivores - Satellite "Ruminant use of fodder resources in warm climate countries" Montpellier (France), 7-9 September 1995.

Ben Salem, H., Nefzaoui, A., Abdouli and H., E.R. Orskov. 1996. Effect of increasing level of spineless cactus (*Opuntia ficus indica* var. *inermis*) on intake and digestion by sheep given straw-based diets. Animal Science, 62 : 293-299.

Nefzaoui, A. and H. Ben Salem; 1996. Nutritive value of diets based on spineless cactus (*Opuntia ficus indica* var *inermis*) and atriplex (*Atriplex nummularia*). In : "Native and Exotic Fodder Shrubs in Arid and Semi-Arid Zones, Regional Training Workshop, Tunisia, 27 October - 2 November 1996"

Ben Salem, H., A. Nefzaoui, Lamia Ben Salem and H. Abdouli; 1996. Improvement of the nutritive value of tannin rich fodder trees: Effect of air-drying and polyethylene glycol treatment of *Acacia cyanophylla* Lindl. foliage on intake, digestibility and growth by sheep. In : "Native and Exotic Fodder Shrubs in Arid and Semi-Arid Zones, Regional Training Workshop, Tunisia, 27 October - 2 November 1996"

Correal, E. and Sotomayor, ;1996. Effect of straw supplementation on intake and browsing of *Atriplex nummularia* (Old man saltbush) by "Segurena" ewes, under pen feeding and free grazing conditions In : "Native and Exotic Fodder Shrubs in Arid and Semi-Arid Zones, Regional Training Workshop, Tunisia, 27 October - 2 November 1996"

Sotomayor and Correal, E.; 1996. Effect of straw supplementation on the *Atriplex halimus* (Saltbush) diet consumed by "Segurena" ewes In : "Native and Exotic Fodder Shrubs in Arid and Semi-Arid Zones, Regional Training Workshop, Tunisia, 27 October - 2 November 1996"

Crop-Livestock Production Systems in Some Rain Fed Areas of Western India

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Abstract
In India, like many other south and south-east Asian countries, crop-livestock mixed farming is traditional. BAIF is an NGO which has been implementing a large livestock development programme for about three decades and spread over six states in India. Its experience indicates that most of the traditional systems are highly efficient and self-sufficient, and thus are sustainable. The combination of livestock with crop production is an effective risk aversion mechanism, developed out of generations of experience of farmers in rainfed areas. The system is a very good example of recycling of all the products of the farming operations, local material, household waste, etc., with little dependence on outside resources. This is an appropriate and sustainable approach for remote rural areas, where accessibility to outside resources or services is difficult. The system illustrates very well how rural families can match production with resources and available (or unavailable) services and linkages.

The paper discusses a few examples of crop-livestock integrated systems from semi-arid and tribal pockets of western India. The studies were carried out in order to understand production systems and to assess the need, priorities and scope for development interventions. In semi-arid regions, the combination of trees, cereal crops, leguminous pulses and oilseeds along with a mix of livestock (cows, buffalo and goats) is common. Each of these is adopted with a multi-purpose objective. Trees

provide fruit, fodder and fuel, and some trees improve the soil or serve as a wind break. Crops provide food, fodder and fuel, and leguminous crops improve the soil. Most preferred fodder crops are leguminous species grown in the winter and rotated with cereal crops; thus they provide a much needed protein source for the animals. Livestock are a source of food, fuel, manure, draught power, ready cash in emergency, a movable asset and an investment but with social value. Thus each has multipurpose value but they are usually assessed with a singular approach. In tribal areas, the combinations generally seen are trees, cereal-legume mixed cropping, cows and/or goats and poultry.

The paper briefly discusses the outcome of a few studies on farming systems and perceptions of men and women farmers, tribals and agro-pastoralists, carried out in western India. The results indicate that the majority of landowners, irrespective of the community to which they belong, and about half of the landless, own some animals or poultry. During the years when rains fail or in semi-arid/arid areas, income from livestock accounts for about 60% of the farm income. In semi-arid and tribal areas, there is a shift towards small ruminants. In better rainfall areas, there is shift towards buffalo. The majority of tribal families and the underprivileged community in general own poultry which are managed in the traditional backyard system. These families (women) prefer coloured country fowl for specific and logical reasons. Unfortunately there are hardly any development schemes to improve the productivity of small ruminants or country fowl. Support services do not reach many rural areas.

The paper cites some examples of indigenous knowledge of farming men and women, gained through generations of experience, in the utilisation of local resources. The farmers prefer varieties of crops which are appropriate for local conditions and provide better quality crop residues. They choose trees which provide leaves as well as flowers and pods for feeding animals. They have identified bushes which have protein-rich leaves. They are aware of aquatic plants, mangroves, salt bushes and weeds which can be fed to different type of animals with beneficial results.

In the end, a challenge to scientists is indicated: to develop technologies and recommendations which will improve productivity (not just production of one sub-system) in a sustainable, environment-enriching and energy efficient manner but without competing for human food and, at the same time, benefiting small, underprivileged farmers. Some caution is required: the benefit is not always a straightforward equation of rupees in and rupees out.

KEY WORDS: India, integrated systems, livestock, indigenous knowledge, small farmers, arid, semi-arid

Introduction

Keeping livestock is traditional and closely linked to rural culture, indicative of the fact that rural families have always realised the importance of livestock and clear evidence is available in literature, art and ancient epics dating back to 4000 B.C. or maybe even earlier (Rangnekar 1995, Dolberg 1982).

The BAIF, a non-governmental, voluntary organisation, established in 1967, has been involved in livestock-based integrated rural development activities since 1969. The small cattle development project in western Maharashtra and south Gujarat regions of western India has grown into a large integrated livestock development programme covering more than 1.25 million livestock and involves 500,000 families in six states of the country.

Livestock development was taken up as the first major activity, considering the role of livestock in rural systems which extends from economic activity, supporting agricultural production, as an energy source and food for the family, to socio-cultural aspects, as a risk aversion mechanism and meeting needs during emergencies. Thus not much has changed in respect of the role of livestock since 4000 B.C., but we still do not have a clear understanding of the various crop-livestock systems that have emerged through generations of experience. The farmers have made appropriate changes in the mixes (crop-livestock) according to changing agro-ecological conditions and markets. The systems are more complex in rain-fed areas where the farmer has to cope with the vagaries of the monsoon and unfavourable soil conditions.

Almost three-quarters of the area of western India is rain-fed and a large part of it is semi-arid. Studies indicate that much of the area has not shown persistent improvement in crop production (Abrol 1992). According to Kanwar (1991), dryland and rain-fed agriculture are practised on 73% of the cultivated area and contribute to more than 40% of total food grain, 75% of oil seeds, 90% of pulses, 70% cotton and almost the entire quantity of coarse grain. Some of the best indigenous breeds of livestock originate from the rainfed semi-arid areas. Walker and Rajan (1990) and Kanwar (1991) have emphasised the appropriateness of livestock-crop integrated systems for rainfed areas. They recommended the re-orientation of research and extension workers towards such systems, since it is felt that the risks and economic factors of rainfed areas are probably not well appreciated.

Methodology

In the BAIF project areas, studies were undertaken within the prevailing production systems; the livestock sub-system was studied in more detail. The methodology and approach adopted for such studies and some of the initial results were reported earlier by Rangnekar *et al.* (1991) and Rangnekar (1993). The studies were conducted by combining area and family surveys, field recording and a variety of participatory exercises, including group discussions. A clear understanding of farmer perceptions, priorities and suggestions is as important as the study of different crop-livestock combinations and their productivity and interactions. Equally important was an understanding of social and gender issues which influence the systems profoundly (Crotty 1980, Dolberg 1982, Rangnekar (1992 A & B). A few examples of different crop-livestock integrations, as seen in different agro-ecological and social situations in Gujarat and Rajasthan states, are discussed in this paper. The studies relate to smallholder farmers from rainfed, semi-arid tribal and non-tribal areas of Rajasthan, and north Gujarat, and irrigated areas of south Gujarat. The contribution of livestock to whole farm productivity and family income is discussed. In the case of Rajasthan, the usefulness of livestock in sustaining livelihood during periods of drought is described.

Results and Discussions

For ease of description, findings are grouped according to social and agro-ecological considerations.

1. Smallholder non-tribal farmers of rain fed Central Rajasthan (district Bhilwara)

Rajasthan is located in the north-western part of the country and about 60% of the area is desert or semi-desert. Much of the state falls in agro-ecological zone 14 of the country which is typically arid. The south eastern part of the state is in zone 8 and is hilly and rainfed. Livestock play an important role in the rural economy of Rajasthan and contribute about a quarter of the net domestic income. The contribution is more in arid areas compared to other areas. Small ruminants dominate the livestock population and their numbers are increasing fast, while the large ruminant population is static. The state has peculiar variations in agro-ecological conditions and social groups. The north-western arid region is dominated by pastoralists, central Rajasthan has a mixed population, while south Rajasthan is dominated by tribals. The social-cultural background has a bearing on agriculture production systems apart from the agro-ecological conditions. Distinct differences are observed between the production systems of the pastoralists, agro-pastoralists, non-tribal farmers and tribal farmers. Differences are observed in respect of major crops and livestock maintained by these social groups.

In central Rajasthan, the main crops are maize, wheat or pearl millet, along with pulses. The dominant livestock species are cattle and goats. The average land holding is about 1.5 hectares, and the facility for irrigation is very limited. However, even with limited availability of water for irrigation, farmers reserve a small plot for the cultivation of lucerne (alfalfa), along with wheat in winter. Lucerne is the crop of choice for fodder production and farmers are not interested in producing green fodder in the rainy season. The farmers give preference to food crops in the rainy season and, due to the small land holdings, they cannot spare land for fodder. Moreover, they feel that cattle can get some green material while grazing. In winter, they do spare some land for lucerne and the choice appears logical (Rangnekar 1996). The area has experienced repeated spells of drought during the last 15 years and thus crop production has not been very reliable.

The BAIF became involved in livestock development in the district of Bhilwara in central Rajasthan 15 years ago. The programme involves breed improvement, health control, feed and fodder resource development, and farmer training. A system of continuous feedback has been developed through field recording, farmer participatory exercises, etc. The BAIF has a network of 20 centres for implementing the programme through which the majority of the villages are covered; the programme involves cows, buffalo and goats.

The experience of the last decade indicates growing interest in livestock production, since crop production is unreliable due to the uncertainty of timely and adequate rains, and lack of irrigation potential. Cows, buffalo and goats are the most popular and preferred animals. Dairy production has developed very fast in the last decade in this district and adoption of cross-bred cows is very good. There are several villages in the district where 80-90% of farmers keep cross-breds. There is growing interest in selling surplus cross-bred animals, besides milk. The animal market has developed in the district along with the milk collection network of the farmers' cooperatives.

The crops of choice are maize, sorghum, pearl millet, wheat, pulses and groundnut which are good sources of fodder and well-suited to rainfed farming. The farmers, especially the women, collect the crop residues and store them meticulously. Special care is taken in the collection and storage of crop residues from pulses and groundnut crops. During winter, it is a common practice to mix small quantities of green lucerne with cereal straws. While in summer, the cereal straws are supplemented with the leaves and pods of pulses, groundnut leaves and Acacia pods. These practices are good examples of strategic supplementation. It was found that the farmers (particularly women) were aware of the value of these crops and by-products.

Table 1: Contributions to income of rural families (%) in parts of central Rajasthan

Sources of Income	Percentage contribution before 1983 (under normal conditions)	Percentage contribution after 1985	
		Normal conditions	Drought Conditions
Crops	65	45	6
Sale of milk	15	41	38
Sale of livestock	-	8	36
Off-farm labour	20	6	20

Observations gathered for more than a decade on sources of income of the farming families from a few clusters of villages provided interesting information. The results, summarised in Table 1, indicate that the contribution from livestock towards total income has increased appreciably. The increase was mainly due to the increased sale of milk, as well as of cross-bred cattle. The contribution from livestock has increased, from a meagre 10%, to 45% and an important aspect is the decrease in human labour. The latter is indicative of the employment generated by the improved dairy animals. Even more interesting was the situation during the drought years when the crops failed and their income contribution decreased to 5%. It is noteworthy that the total contribution from livestock increased. Milk production was not as adversely affected by drought as crop production, an observation also reported by Gupta (1993). Many farmers sold off unproductive animals and growing heifers during drought conditions and the sale of the animals added to the income from livestock. It was also observed that, during subsequent good years after the drought, the milk production per family and the breeding performance improved substantially, probably due to the retention of better animals by the farmers. A study on the nutritional status of the dairy animals owned by the farmers was carried out to study nutritional status. Initial results indicate that the most limiting factor is protein for the majority of the cross-bred cows (averaging between 2000 to 3000 litres/lactation), taking the whole year into consideration. Both energy and protein become limiting factors for higher yielding crossbreds (3000 litres/lactation) and during the summer months for medium producers (2000 to 3000 litres/lactation). Farmers have not shown much interest in improving milk yield or reducing age at first calving which is about 30 months. This aspect will be discussed later as it is common perception in many areas.

2. Tree-crop-livestock based system of tribal areas of Gujarat and Rajasthan states.

The tribals are generally referred to in India as "Sons of the Forest" which aptly describes their way of life and habitat. In western India, they inhabit the Aravally hill ranges along with the border between north Rajasthan, Madhya Pradesh and Gujarat states, extending up to Maharashtra state. A tract of over 1500 km. The tribals were essentially gatherers and the dense forest in this hill range provided them adequate shelter, food and fuel. With the changing conditions, dwindling of forests due to population pressure, encroachment, poaching, etc., they found it difficult to make a living out of the forest. In many districts of these states, the tribals have adopted farming. The keeping of livestock and poultry has been traditional in the tribal families and they have an intimate relationship with the trees. The common crops in the tribal area are the minor millets, their traditional staple food. Cattle, goats and backyard poultry are maintained by the majority of the tribal families. Very few tribal families keep buffalo. The average land holding in the tribal area is about 1.5 hectares, the land is undulating with low productivity and there is very little irrigation.

Amongst the tribal families the production of milk has never been a traditional vocation and is a relatively new introduction to India, as a result of development interventions by the government and non-governmental agencies. Milk is not a major part of their diet and the main objective of keeping cattle was for draught purposes or as source of fuel and manure. Livestock density in the tribal districts of Gujarat is highest in the western Region (1737 per 1000 hectares) with the majority of livestock being nondescript.

The common livestock feeding practices in the tribal region include grazing in the forest and the use of crop residues supplemented with the leaves, flowers and pods of forest trees. Better producing animals are given concentrates which are generally home-made using farm produce like grains, by-products of pulses, tree pods, flowers, etc.. Studies carried out by Rangnekar (1992 & 1993) indicate that the tribal women assume the major burden of livestock production and have very good knowledge of local feed resources. The farmer men and women have identified a variety of plants (trees, bushes and creepers) as beneficial to livestock and these are used to supplement livestock feed. The tree fodder is mainly used during dry months. Various plant species, identified as good feed resources, are shown in Table 2 and the different months in which they are used for feeding livestock are indicated along with the benefits reported.

Table 2

Name of feed material	Season of availability	Nutritional characteristics
Mahuva flower	April/May	Rich in energy
Pods of *Acacia* & *Prosopis*	March/April	Rich in energy & protein
Leaves of *Ziziphus*	April/May	Rich in protein
Leaves of *Prosopis cinereria*	March-May	Rich in protein & minerals
Leaves and pod	October/	Rich in protein & minerals
Covers of pulses and oilseed crops	March/April	

Studies conducted in some tribal pockets on nutritional status of dairy animals indicated that protein availability is a major limiting factor. It is likely that the high protein content of leaves of some of the tree species is responsible for the beneficial effect observed by the tribal farmers (Rangnekar 1991). Based on these observations, a programme of promoting cultivation of these plants has been instigated in the livestock projects and is well accepted by the tribal families.

A study comparing the contributions to income from crops and livestock among tribal and non-tribal farmers in some districts of Gujarat was carried out (Patil *et al.* 1997). It is reported that livestock contribute about 33% to the income of the tribal families, as compared to a 20% contribution in non-tribal families. The contribution to income includes directly measurable products like milk and the indirect contribution in the form of energy (for crop production or transport). The study indicates that, in view of the small land holdings and limited irrigation, the only way tribal farmers can improve whole farm production is through the integration of food crops, horticulture and livestock production. Dairy production has better scope in states like Maharashtra and Gujarat because of the developing network of farmer cooperatives in tribal areas.

The systems in these rainfed, under-developed tribal areas are complex, with tribal farmers preferring "assured subsistence" to risky high production. The systems are fully self-sufficient with each commodity having multi-purpose objectives. Thus the need is to suitably modify the development approach and to consider improving whole farm production with mixed livestock (large ruminant, small ruminant and poultry) and mixed crops (cereal, pulses, vegetable and multipurpose tree species for fodder, fuel and fruits). Considerable thrust is given to the improved utilisation of local resources, re-cycling of residues, wastes and by-products. An equally important aspect is the establishment of linkages (forward and backward), or strengthening them according to need. The development of farmer groups and para-extension workers, through appropriate training, is another important activity.

Detailed studies are in progress to evaluate local feed sources like tree fodders, pods and various feed mixtures used by the tribals for feeding ruminants. The technology of urea-treatment of cereal straws has been tried in locations where it is most likely to be useful and the response from farmers has been very positive (as they notice an improvement in productivity). Improvement in feed mixtures for dairy animals is attempted through the use of urea and local feed resources like Acacia pods and the flowers of trees like Madhuca indica which are traditionally used by tribal farmers. The use of mineral supplements is also felt necessary. More data and analysis is needed to refine the recommendations for improving the feeding practices. Small projects to study feeding practices, evaluate local feed resources, test technologies and modify home-made feed mixtures are in progress. The studies adopt a participatory approach involving farmers (men as well as women) at all stages, so as to get their perceptions duly incorporated, and subjectivity or bias is minimised.

Some Issues and Challenges Facing Livestock Development

The lack of participatory and systems approaches to livestock development and research.

In most cases livestock development is considered in isolation, without giving due cognizance to the total rural system. Such an approach has resulted in adverse effects in some cases and, in other cases, very limited benefit to the rural community. Recent studies and reviews arranged by the Government of India for framing livestock policy for the future clearly indicated that there is a need for serious thought to change the approach to livestock research. The research has to be directly related to the situations faced by the farming community and conducted with a systems and participatory approach, previously lacking in animal science. In crop science, some change has already occurred and on-farm research with participation of the farmer has been introduced in several projects by many agriculture universities. In a country like India where a variety of production systems and considerable variation in social and ecological conditions exist, it is necessary to evolve appropriate approaches, with a clear understanding of the different niches.

Livestock extension is another area which is neglected and considerable effort is needed to strengthen extension which is the backbone of the development. However, here again there is a need to develop the participatory approach and ensure that appropriate recommendations are made by the extension system. The involvement of women in a major way in livestock management makes livestock extension difficult. Gender sensitisation is grossly lacking amongst those concerned with planning and coordinating development and research. There are hardly any women extension officers in livestock departments. Most of the female veterinary/animal science graduates are confined to laboratories or offices.

A development strategy for rainfed, semi-arid and arid areas is a challenge facing all those involved in planning and implementation. For such areas, the scope for increasing production from crops is limited and the contribution of livestock to total production and as source of employment is high. However, livestock are regarded as a threat to the environment and a cause of desertification. There is lack of a clear strategy for a balanced approach to sustainable development. A major constraint in the rainfed, semi-arid and arid areas is the lack of strong linkages (forward and backward). The centralised system of extension services has very limited penetration in these areas, where the population is well spread out and communication is difficult. A different approach involving the rural families is called for. The inadequacy of feed resources is also a major constraint to high productivity, more so when the major thrust in livestock development is for milk production.

Related to the above aspect is lack of research on production systems under unfavourable ecological conditions and in areas which are less well endowed with natural resources. One of the dilemmas is whether keeping fewer high producing animals is desirable or keeping more low producing animals is appropriate (to cover the risks). There is always criticism against keeping a larger number of animals, but higher producing animals need better quality feed and a more favourable environment, which a small farmer in an arid area may not be able to offer. There is precious little research on ways of augmenting feed and fodder resources in arid and semi-arid areas or areas with problematic soils (saline and alkaline soils with brackish water). There is not much research on traditional systems and indigenous knowledge of the farmers, which enabled them to survive under unfavourable conditions. The interesting part of the story is that some of best Indian breeds of livestock were developed in semi-arid and arid areas. In some cases, we are ignoring their potential and the crucial characteristics of these breeds. However, there is some resurgence, awakening and development of interest in these indigenous breeds and hopefully efforts will be made to make best use of their potential.

References

Abrol I.P. (1992). Towards a mission oriented research agenda - in Farming systems research in India - strategies for implementation. Ed. Raman K.V & T. Balguru. Pub. National Academy of Agriculture research management, Rajendranagar, Hyderabad and Ford Foundation, New Delhi. pp. 8-13.

Crotty R. (1980) Cattle economics and development. Pub. Oxford and IBH Publishing Co., New Delhi & Bombay.

Dolberg F. 1982 - Livestock strategies in India Pub. Institute of Political Science, University of Aarhus, Denmark.

Gupta A. (1993). Integration of livestock with agroclimatic zone based land use planning. Draft report on consultation (unpublished), Indian Institute of Management, Ahmedabad.

Kanwar J.S. (1991). Extension strategy for minimising risk in rainfed agriculture in - Technologies for minimising risk in rainfed agriculture. Ed. Singh S.P. 7 C. Prasad - Pub. jointly by Indian Society of Extension Education, IFAD and the Indian Council for Agriculture research New Delhi. pp. 1-24.

Patil B.R., Rangnekar D.V. and Udo H.M.J.(1997). Livestock contribution to house hold income in tribal and non-tribal areas in Gujarat, India (Paper under publication).

Rangnekar S.D (1992 - A). Women in livestock production in rural India Proceedings of 6th AAAP Animal Science Congress - 23-28 November 1992 - Bangkok, Thailand.

Rangnekar D.V (1992 - B). Study of traditional livestock production systems of the pastoralist and their perceptions about Production system and attitude to change. Proceedings of workshop on Transhumant pastoralism in Gujarat - July 24-25, 1992 at Institute of Rural Management, Anand, Gujarat.

Rangnekar S.D. (1993) Studies on knowledge of rural women of local feed resources for livestock and the feeding systems developed. Proceedings of International Conference on Increasing Livestock Production through Utilization of local resources - Oct.18-22 '93, CECAT, China.

Rangnekar D.V (1995) Research methodology for crop animal systems in semi arid regions of India. Crop-Animal Interaction, IRRI discussion paper series No.6. Ed. Devendra C, Sevilla C. pp. 405-420.

Rangnekar D.V. 1996. Experience of an NGO in fodder production. Presented to Indo-UK. Workshop on Transfer of Forage Production Technologies 2-4 Dec. 1996 organised by Indian Grassland and Fodder Research Institute, Jhansi

Walker T.S. and J.G. Rajan (1990). Village and household economic in Indias semi arid tropics, John Hopkins University Press Bulletin, Maryland.

Constraints to the Promotion of Integrated Farming Systems in Small Island States

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Abstract
Over the last 50 years when agricultural modernisation was attempted, farmers were encouraged to forsake mixed farming for monoculture systems aimed at achieving high technical efficiency and with the expectation of increased income. In the highly "monetised" though small economies of the islands, this was taken as being a valid approach for agricultural development. Integrated farming, the traditional agriculture of both larger and smaller farmers, was not encouraged.

The new systems resulted in increased production and improved quality of product. Being based on imported feed, the devaluations which occurred in the value of local currencies, with consequent increase in prices of imported inputs, have resulted in higher costs to the producer and ultimately higher prices to the consumer. The options seemingly available have been to seek high technical efficiency of production, seek alternative feed inputs from local sources, or to get out of production.

Some smaller farmers are increasingly dependent on production methods based on a mixture of new and traditional practices. These include utilising local natural feeds, recycling waste, integrating their livestock with cropping activities, limited aquaculture production, etc. The technical parameters are not as high, but the economic returns are satisfactory and the systems are apparently more sustainable. The more "commercial", medium-sized farmers are attempting to purchase only essential inputs, while growing and utilising what they can create or obtain as feed from their holdings.

The climate is such that some islands experience relatively low rainfall, 1,100 mm in Antigua and Barbuda with drier year-round conditions, while some at the other extreme have levels as high as three times this. This influences the growth, availability and quality of the forages, products and by-products useful for feeding. But these are problems that could be solved technically.

The limit of land availability dictates that integrated, intensive methods of production with recycling of effluent to soils, most of which have been heavily exploited, eroded and denuded from centuries of commercial export agriculture, must be preferred. Systems will have to be based on the economic and social environment in which agriculture operates. This presentation hopefully raises some of the issues beyond those that are only technical.

KEY WORDS: Integrated Farming System, island, Caribbean, modernisation, extension, imported feed, local feed, feeding system, sustainability

Introduction

Over the centuries, agriculture in the small island states of the Caribbean has been dominated by export crops such as cocoa, cotton, coconut, coffee, citrus, bananas, nutmeg, etc. Up to the middle of this century, "agriculture" was therefore taken to mean "export crop" agriculture. Crops such as bananas and sugar are still very important at the present time in specific countries. Bananas are important in Dominica, Jamaica, St. Vincent, St. Lucia and Grenada; sugarcane in Barbados, Jamaica, St. Kitts and Trinidad; cocoa and nutmeg in Grenada; coconuts in Dominica, Jamaica, St. Lucia, and Trinidad; and, citrus in Dominica, Jamaica and Trinidad.

While these commodities were exported, the territories imported much of their food needs. Yet food was produced for local consumption. There was dichotomy in agriculture as mainly small farmers, landless peasants and estate workers were engaged in such production. Food crops were allowed on the estates as long as they did not interfere with or reduce resources allocated to the "main" crops. Production of local food was not given recognition in terms of statistics on agriculture, so that it would have been difficult to assess levels of poultry or eggs, mutton or root crop production. There were however integrated systems of production, crops with animals as shown below:

(i) Prior to the widespread use of inorganic fertilizers, inter-planted crops of cocoa, nutmeg, citrus and bananas were fertilised mainly with manure from pens of zero-grazed cattle. Animals were tied to stakes in the fields and fed legumes such Leucaena, Glyricidia, Spondias spp., and grasses such as Brachiaria mutica, Pennisetum spp. and guinea grass, and crop or agro-processing wastes. The organic matter, after a period of curing, was used on the crops.

(ii) Sugarcane cultivation was carried out on both estates and small farms with animals - water buffalo, zebu or creole cattle - providing traction/haulage and also, manure, meat and milk. Animals utilised molasses, cane tops, grasses and legumes as the main feeds.

(iii) Coconut plantations had either estate or worker/peasant- owned cattle, small ruminants and pigs tethered between the trees. These controlled the under-storey vegetation at low cost, allowing a more complete harvest of fallen nuts. On larger estates, herds of cattle were (and are still) kept. Often, the importance of the coconuts was diminished as trees aged, with little replanting or maintenance. This has been due to competition from soya bean oil with the coconut oil. Soya bean is imported and processed in the region.

(iv) The small landholder, squatter or landless peasant practised mixed farming on small holdings, growing mixtures of fruit trees, annual plants, vegetables, etc., and rearing free-range poultry for eggs and meat, and tethered pigs, sheep, goats or cattle on roadsides or open lands. Pigs were also fed mainly on household wastes, sometimes collected from neighbours or institutions.

This general situation of integrated farming practices has been mainly reversed and there are at least three aspects to this:

- the search for modernisation of agriculture;
- pressures of the wider economy on agriculture and resource use; and
- the failure to recognise and deal with agriculture for local consumption.

Modernisation of Agriculture

The plans of the larger Caribbean states in the 1960's were to encourage economic development with modernisation and industrialisation of agriculture. These involved "improved technology". There were some influential factors:

(a) Being situated close to North America and its agriculture with yields based on high levels of technology, equipment, pesticides, irrigation, etc., this model was adopted.

(b) Even though the islands had limited land with small and fragmented agricultural holdings, "economies of scale" parameters were promoted. Poultry, pigs, milk and, to a lesser extent, beef production were encouraged as monoculture operations. (State assisted farms were forbidden to engage in any secondary enterprises).

Imported feed ingredients - corn and soya bean meal - were fed to imported, ill-adapted breeds of cattle. Backyard poultry and pigs were deemed unacceptable. The new feeding systems ignored traditional mixed crops/livestock farming.

(d) The replacement of animals with tractor power started in the 1950's and spread to even the smaller farmers. Today, livestock production by the sugar companies is separated almost entirely from the cultivation of the crop.

(e) "Modern" agricultural education reinforced the above developments. Technical efficiency became the goal with efficiency of general resource use and sustainability ignored. Monoculture economic models of production were promoted and accepted.

Pressures of the National Economy

A national economy is made up of several sectors with agriculture being one and livestock production as a sub-sector of agriculture. The other sectors heavily influence agriculture from many points of view such as return on investment, labour status, alternative land and resource use (opportunity cost), etc. In all these, agriculture comes out second best. Labour is attracted to public works, light industry, hotels and tourism, and the service sector, i.e. to virtually any non-agricultural activity.

This either leaves land idle or it makes the farmer a part timer with crop production abandoned and animals kept on systems such as "uncontrolled grazing". Animals are let out in the morning to forage where they wish and return to the owner's holding in the late afternoon to be secured. Milk production is no longer promoted (too time-consuming) and there is only occasional slaughter and sale of meat. Manure use declines. There may be some element of forage harvesting by the owner of the animals for night feeding or, especially in the dry season, on his way home from work.

In the drier areas of the islands and particularly on the coast, the "natural" land for livestock is being diverted into housing, hotels and related facilities (golf courses, etc.). The value of land earmarked for such purposes far exceeds its value for agriculture, so more and more land is lost in the absence of land utilisation plans or laws or, where they may exist, enforcement.

Dealing with Local Consumption

It has been noted that production for local use, with the notable exception in recent decades of vegetables and root crops, has been largely ignored and under reported. That was the case for meat and milk but change has come about with the attempted modernisation in pig, poultry and dairy farming. Even in these cases, the official statistics still ignore production that does not officially enter into processing. For example, Trinidad and Tobago milk production statistics are generally given as the milk intake of the single large milk processor. Yet this is variously estimated to be 1/2 to 2/3 of actual national production.

Feed Production, Cost and Feeding Systems

Feed manufacturing developed rapidly in response to the livestock development thrust. Most mills had working relations with or parent companies in the USA or Canada. In Trinidad and Tobago, there were as many as 15 mills by 1980. Initially, feed provided to the farmer was heavily subsidised by the national government to encourage farm production and "development". Subsidies were removed and, with successive devaluations of local currency and increase in international commodity prices, the quantity of feed manufactured there has declined markedly. Between 1985 and 1994, prices of dairy, pig and poultry feed to the farmer have doubled, tripled and doubled, respectively (Table 1). Manufactured feed use has likewise decreased. The efficiency of feed use has increased on the fewer, larger, more capital-intensive units that remain in production. The other farm units, mainly the middle-sized pig units, small poultry units and dairy large units, have dropped out of production. Some information on these trends is provided below.

Table 1 :Production of dairy, pig and poultry feed in Trinidad and Tobago ('000 tonnes) and unit cost per 45 kg bag ($TT) 1985 to 1994

FEED	DAIRY		PIG		POULTRY	
YEAR	Tonnage	Cost	Tonnage	Cost	Tonnage	Cost
1985	48.8	25.6	27.6	27.2	168.3	37.8
1988	28.3	28.9	23.8	34.9	148.5	43.8
1991	18.9	37.1	20.4	49.1	139.3	58.0
1994	10.2	50.7	5.7	72.4	107.6	81.6

Source: CSO

Dairy:

Annual production of milk as reflected by sales to the major processor has been approximately 10 million litres annually between 1985 to 1994, in spite of increasing feed prices. Increasingly this milk is attributed to production from smaller, mixed farms using more forage and by-products with little manufactured feed.

The bigger producers, with over 100 head, went out of production by the early 1980's. Even the 266 specialised 10- hectare pasture grazing units are now either more integrated farms, with mixed cultivation, or a few are very specialised but high cost producers, or the farms are out of production altogether. The smaller, integrated, zero-grazing farms with cross-bred stock (some are probably ill-advisedly upgrading their cattle with North American semen) are now producing more milk than the 10 hectare units.

A look at two dairy farms known to the author reveals the following:

FARM RESOURCE	FARM A	FARM B
1. Size (ha)	10	10
2. Grasses	Improved + off-farm cut grass	Partially improved, no cut grass
3. Water Resources	No pond	Pond
4. No of milk cows (yield-litres)	30 (15 - 18)	25 (10 - 13)
5. Other Products:		
a)	Heifers/bulls	Heifers/bulls
b)	-	Fish (Cascadura)
c)	-	Pumpkin/Melons
d)	-	Pigs
e)	-	Ducks
f)	-	Common fowl/eggs: (home use or sold)
g)	-	Manure (sold)
h)	-	Dahee
I)	-	Fruit (home use)

RESULTS FARM A	RESULTS FARM B
a) Higher milk income	a) Mixed income
b) Higher cash outflow for feed, medication, etc.	b) Lower milk income
c) More "dependence", lower sustainability	c) Lower cash outflow
	d) Smoother cash inflow
	e) More sustainable

Pigs:
Pig sales increased from 50,000 head to 79,000 head between 1988 and 1989, but returned to the former level by 1993 (CSO, 1994). While, in mid-1988, a total of 17,000 pigs were on farms of 21 to 500 head, by 1994 the number in this size range was 5,263. Farms with less than 20

and more than 500 head increased their population, indicative of the dichotomy in the industry. The smaller farms use less purchased feed, the larger are vertically integrated. The few large units have integrated feed manufacture, pig production, processing and marketing (and export) for high technical efficiency. Small pig farmers have reverted to farm by-products, household waste, waste from agro-industrial processing, forages, offal from poultry slaughter, etc.

Broilers:
The broiler production statistics are also of interest. Table 2 shows that, while total liveweight production of chicken has remained steady, the percentage produced by "contract farmers" who are part of the integrated feed miller/hatchery/ producer/processor/sales complex, as compared to that of "independent" non-contract farmers, rose from 55.5 to 89.3% between 1988 and 1994. Efficiency of feed use and marketing of products are important factors in this development. The small, independent poultry producers with integrated farm operation and limited use of manufactured feed (but using forages, waste grains, etc.) is making a come-back (with some free range production).

Table 2: Broiler production in Trinidad and Tobago by contract and non-contract farmers 1988 to 1994 ('000 tonnes).

Year	Total	Contract farms	Non-contract	Contract % of total
1988	25.6	14.2	11.4	55.5
1990	28.5	18.0	10.5	63.2
1992	24.3	19.6	4.7	81.4
1994	26.3	23.5	2.8	89.3

Source: CSO 1994

These indications are still not readily accepted by "officialdom" for reasons given in earlier sections. There is admittedly more recent interest in integrated farming and its validity is gradually being accepted and recognised by traditionally trained economists.

The Problem

The Caribbean region should be seeking to improve its agriculture and particularly its livestock production. A few reasons include:

- the need to provide for some measure of "food security";
- the need to use the resources of soils, climate, etc. to provide employment and economic activity;
- the need to increase inland fish production, given the water resources available and static world fish output and that the rapidly developing sub-sectors of the economy (e.g. tourism) are not only fragile but can ultimately be self-destructive if not carefully handled and also dramatically increase food importation;
- with the new world trade situation of reduced farm and export subsidies, the cost of imported food (and feed) is rising; and
- developed, "modern" agriculture is not necessarily energy-efficient agriculture.

With all the modernisation Trinidad & Tobago imports approximately TT$ 1.5 billion worth of food ($1US = $6TT) for a population of 1.2 million persons. In islands with "well-developed" tourist industries, the situation is even more dramatic.

Grenada, with less than 100,000 total population but tourist arrivals of over 200,000 persons, imported EC$ 21 million ($1US = $2.70 EC) of milk products in 1995. For Trinidad and Tobago, a development economist has noted that the index of food imported (1973 = 100) rose to over 470 by 1983 and in 1990 was 247 (Ifill, 1993). Food imports as a percentage of total imports rose from 10.3% in 1973 to 20.4% in 1990.

The macro-economic policy of devaluation and later the open liberalised economy are appearing not to work for the development of agriculture. In fact the liberalised agricultural regime is expected to have negative output and reduced employment implications. Countries of the region are, however, committed to such policies.

References

Central Statistical Office (CSO) (1994) Quarterly Agricultural Reports, Government of Trinidad and Tobago.

Ifill, M. (1993): "How the country got on the devaluation ladder and why we are likely to stay there"

Livestock in Integrated Farming Systems

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In an earlier paper in this conference (Rodriguez and Preston 1996), we stressed the advantages of indigenous breeds of livestock when multi-purpose "recycling + upgrading" replace "specialized feed conversion" as the major role of animals in natural resource management. There are many opportunities to be investigated. Certainly the animal provides the most efficient pre-treatment of high-moisture biomass to convert it to a substrate suitable for biodigestion. Equally the "animal-biodigester" sub-system is a more efficient way of preparing organic matter for return to the soil than aerobic composting.

In such systems the criteria for the 'efficient' animal should give greater weight to traits such as the capacity to select and consume voluminous and usually fibrous materials rather than digestibility. Milk and meat will be by-products rather than primary outputs in these scenarios.

Thus as emphasis has shifted from "adapting the resource to the system" (eg: the maize-soya bean feeding system for pigs) to "adapting the animal to the resource "(Preston and Leng, 1987), the economic traits required of livestock will also change. This will be particularly true for the tropical regions. The advantages in the tropics of dual purpose (milk-beef) breeds and management systems over specialized milk and beef production as separate enterprises are increasingly being recognised at least in tropical Latin America (Preston and Murgueitio, 1992). Incorporation of work, for land cultivation and transport as a third purpose, and of fuel (biogas) + fertilizer as a fourth purpose is perhaps too demanding on needs for nutrients. However, multi-purpose work plus fuel/fertilizer plus meat is a traditional way of using cattle and buffaloes in SE Asia and is a more efficient way of using fibrous crop residues than specialist (ranching) production of meat alone.

Evaluating the Role of Livestock in Integrated Farming Systems

Our present methodologies for evaluating livestock-based activities are not suitable when the output is multi-faceted and has implications for the environment. Input-output coefficients have to be applied to the whole system and not just the animal. One approach is to make some measure of total solar energy capture in the system including that returned to the soil. Soil organic matter should be monitored as organic matter is a nutrient (source of energy) for soil organisms. Changes in soil fertility should be assessed and this can be related to effects on crop yields. The increases in annual yield of sugar cane of 10 tonnes/ha reported by Mui *et al.* (1996) can be attributed mainly to increases in soil organic matter through return of dead sugar cane leaves to the soil.

There are many new opportunities for livestock in integrated farming systems. The challenges are for the technologist to develop more efficient systems for deriving benefit from solar energy using an holistic approach; and for the economist to determine in monetary terms the presently intangible cost of pollution and the income to society of activities that enhance, rather than destroy, the environment.

References:

Mui N. T., Preston T. R., Dinh van Binh, Le Viet Ly and Ohlsson I. 1996. Effect of management practices on yield and quality of sugar cane and on soil fertility. Livestock Research for Rural Development. Volume 8, Number 3: 51-60.

Preston T. R. and Leng R. A. 1987. Matching Ruminant Production Systems with Available Resources in the Tropics and Subtropics. PENAMBUL Books Ltd: Armidale NSW, Australia.

Preston T. R. and Murgueitio E. 1992. Strategy for sustainable livestock production in the tropics. CONDRIT Ltda: Cali pp89.

Rodriguez L. and Preston T. R. 1996. Indigenous breeds and local feed resources: fundamental issues in integrated farming systems. Second Teleconference on Feed Resources in Integrated Farming Systems. FAO: Rome.

Outcome of Networking People on Livestock in Crop-based Farming Systems in Asia

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Abstract

Recognizing the importance of animals in smallholder farms, the crop-animal systems research (CASR) in Asia evolved in 1984 out of the IRRI Asian Cropping Systems Network, later renamed Asian Rice Farming Systems Network (ARFSN). Collaborative on-station and on-farm research among 4 countries was initiated on different rice ecosystems primarily to develop appropriate technologies and methodology. By 1994, the number of CASR sites of ARFSN increased from 5 to 72 in 9 countries. In many Asian countries, the crop-animal systems research has been institutionalized in the national research programs and expanded to non-rice crop systems.

The conduct of CASR requires an interdisciplinary team from the biological, social, economic, environmental disciplines immersed in on-farm situation. Differences in research and extension organizational structure, availability of interdisciplinary scientists, and financial support hinders the implementation of systems research involving animals. AFRSN provided a venue for animal scientists to reorient research towards increased animal productivity in small farms, to work closely with crop scientists, sociologists and economists, and to appreciate the farmers' priorities in resource allocation. Towards this end, a working group was organized to link researchers, extension workers and policy makers. Thus, the farming systems research methodology, involving diagnosis, design, evaluation and technology transfer, was modified by the different national research teams appropriate for a given ecosystem.

Some highlights of CASR project results are presented and discussed. More importantly, the following issues need to be addressed:
1) refinement of the economic and environmental impact assessment of crop-animal technologies;
2) testing the validity of CASR under a large-scale production system, i.e. pilot production program;
3) the ability to anticipate the broad socioeconomic ramifications of fast economic development in Asia and its effects on crop-animal integration in small farms.

KEY WORDS: network, crop livestock integration, research and extension methodology, Asia, rice, smallholder farm, on-farm research, feed, residues, by-product

Introduction

Animal production systems in Asia are generally an integral part of crop production. Farmers' production systems are complex and vary depending on the physical, biological and socio-economic environments. Farmers consistently diversify the use of their resources as there are interactions of various activities, not only within the crop and animal components, but also between them and the other enterprises or activities on the farm and off-farm. Furthermore, Asian farmers own small areas of land from less than 0.5 ha in China to about 5 ha in Thailand and Myanmar. A typical farm in Asia consists of a cropping area, and a homestead with the house, trees, vegetables and animals.

The most economically important animals are cattle, buffalo, goats, sheep, chickens, ducks and pigs. Animal production systems can be classified into three broad categories: smallholder, semi-intensive and intensive. The dominant production system is the smallholder. Most farmers raise combinations of different animals depending on their farm size, available labour, socio-economic conditions, cropping intensity, soil type, rainfall etc.

Cattle and water buffalo are raised mainly for cash, draught, meat, milk, as a source of manure for the crops, fuel, transportation, utilization of crop residues, and other related purposes. Goats and sheep are important components of farming especially in Indonesia, India, Nepal, Philippines and China. They are raised for cash, food, security, prestige and social values, and for the utilization of by-products. In West Java for example, one in every 5 farmers raises sheep and goats which contributes 14% and 17% of the income in the lowlands and uplands, respectively.

While the commercial pig and chicken farms are well developed due to the application of advanced technologies in breeding, nutrition, farm management and disease control, more than 80% of these animals are still raised in the "backyard". Approximately 90% of smallholder farmers raise chickens for food (meat and eggs), cash, utilization of by-products and for manure.

The Need for A Novel Research Approach

To improve animal production in smallholder farming systems, a change in approach was needed to solving the problems of animal production affecting the small farms in Asia. The traditional discipline-oriented research in animal science had resulted in the development of many animal production technologies. However, the impact of these has been more towards increasing productivity in commercial animal systems rather than that of animals in smallholder farms. Apparently, there was a need to reorientate animal research activities in Asia to focus more on the problems and constraints to animal production in small farms. There was a need for animal scientists to work closely not only with crop scientists, but more with farmers who are concerned foremost with crop production. An appreciation by animal scientists of how crop-based farmers allocate their limited resources to either crops or animals and of on-farm constraints to the application of matured technologies was necessary to be able to design and implement on-farm research with systems perspective.

Thus, the Asian Rice Farming Systems Network (ARFSN) conducted a series of meetings among scientists working on different commodities and disciplines, and research managers from national agricultural research stations (NARS) to develop a methodology for systems research. Initially, the methodology was for rice-based farms, but this was expanded to other crops by the collaborating countries according to their dominant agro-ecosystem. Eventually, a crop-animal systems research methodology was developed. The research methodology continuously underwent refinement depending on the needs and resources in a given environment.

Crop-animal Farming Systems Research in Asia

The evolution of the crop-animal systems research in Asia can be traced back from 1974 with the establishment of the Asian Cropping Systems Network at the International Rice Research Institute (IRRI). The network was established to facilitate collaborative research between IRRI and the national research system in selected Asian countries with the aim of increasing productivity and income from rice and non-rice crops in different rice environments. The research teams then were mainly composed of agronomists, soil scientists and economists doing on-farm, researcher-managed experiments with minimal farmer-participation.

In the early 1980's, research objective shifted to maximizing farm income particularly in the rainfed rice environment, where the farmers are involved in a more complex farming system which includes non-rice crops, animals and trees. The interdependence of rice with the other economic commodities in terms of resource allocation resulted in the expansion of the activities of the network. Towards the late 1980's, the issue of family welfare of Asian farmers was likewise recognized. Thus, the pool of researchers in the network was expanded to include animal scientists, veterinarians, sociologists and anthropologists. The network was later renamed Asian Rice Farming Systems Network to cater for all the research needs of the whole farm.

Due to the strong interaction among the physical, biological and economic environment, a systems approach to research was taken into consideration in the development of technologies that are likewise consistent with the farmers' goals and needs. Farmers' experience, indigenous knowledge and current practices were considered in the design of on-farm experiments and backed up by on-station research.

The early 1990's was ushered in with the need to sustain the natural resource base. This necessitated better complementarity between crops and animals to enhance family welfare, address equity issues and the like. Towards this end, on-farm crop-animal research was conducted with strong farmer participation based on a farming systems perspective. Four key research sites in four countries were established for the understanding of crop-animal systems and for the development of a research methodology.

The Research Methodology

Although modified by different countries, the basic components of the research methodology for crop-animal systems were the same. The steps followed were:

(1) selection of target area and research site;

(2) diagnostic/site description;

(3) design of component and system technologies

(4) testing in farmer's fields with the participation by farmers;

(5) extension of promising technologies in collaboration with extension workers.

The following are the key features of the approach: involvement of farmers in the research process; multi- disciplinary and inter-commodity research cum extension; environmentally-oriented; consideration of farmers' resources in the design of experiments; decentralized research; focused on increasing production and profitability; and a feedback mechanism between field and discipline researchers to make on-station research more relevant to farmer needs.

The description/diagnosis of the research site consists of a survey to identify the existing systems, the physical, biological and socio-economic characteristics, crop-animal interactions, and production constraints. The rapid rural appraisal method was adopted by most national programs. While the data gathered were more qualitative, it served the purpose of understanding the production systems practised by farmers, identifying the constraints and exposing scientists to real farm conditions. However, where extrapolation of research results to other areas was needed, more quantitative data were gathered.

Based on the problems and the environmental characteristics of the site and in consultation with the farmers, experiments were drawn by a multi-disciplinary team. In many cases, technologies developed on research stations were used as an intervention to existing farmers' practice, with or without modifications based on consultation with the farmer- cooperators. Due to constant monitoring of the experiments by both the researchers and the farmers, refinement of the research protocol was made possible even in the middle of the study.

Simultaneously with the development and refinement of the on-farm research methodology on crop-animal systems, several training programs, workshops and meetings for farming systems practitioners were conducted from 1987 to 1995, with ARFSN either as sponsor or as collaborator. Since 1972, more than 500 researchers took FSR and FSR-related courses at IRRI. This was augmented by similar national training programs in different countries. Most of the participants were crop scientists and very few were animal and social scientists.

The workshops and meetings were convened to provide a forum for the presentation of project progress reports and exchange of information among the members of the Network and other international research institutions.

Research Collaboration on Crop-animal Systems

The most important problems in animal production are the lack of nutritious feeds particularly during the dry season and the consequent low productivity of the animals. Farmers generally feed their animals with residues and by-products of rice, corn, wheat, soya beans, mung bean and groundnuts. To increase the utilization of crop by-products as animal feeds, two major research activities were conducted through the Asian Rice Farming Systems Network. These are on-station research and on-farm research. On-station research focussed on assessing the nutritional quality of forage crops and formulating rations which included home-grown feeds. On- station research identified and recommended forage crops that could increase the daily weight gain of ruminant animals. However, on-farm research had to be conducted to fit the recommended forage crops into farmers' cropping systems.

On-farm research was conducted at key sites representing specific rice ecosystems where farmers traditionally have an integrated crop and animals systems. The following are the outcomes of the on-farm research conducted at some of the key farming systems research sites. These sites have different combinations of crops and animals in specific rice ecosystems.

1. Zhenjiang, Hangsu, China (Irrigated)

Research at this site focussed on improving farmers' cropping patterns to supply quality feeds for swine and introducing improved breeds of swine. In the uplands, wheat or barley followed by soya bean or groundnut are grown, while wheat or barley-rice and rapeseed-rice are the common cropping patterns adopted in the lowlands. Soya bean and rapeseed cakes are used as feeds for pigs. However, the higher rice fields suffer from drought, and thus maize was tested to replace rice. In the lower fields improved varieties and agronomic practices for wheat-rice and rapeseed-rice were introduced. New cropping patterns were evaluated in the upper rice fields consisting of wheat or barley-maize, rapeseed-maize and barley-maize+soya bean. Yield of maize was 10% higher than rice and income from maize stover (sold to the dairy farm as silage) was 50% higher than rice straw. The total net income of rice and maize were the same. With the advantages of maize as animal fodder, farmers increased the area of maize from 0 to 1300 hectares in 1990.

The performance of hybrid pigs (Yorkshire x Taihu) was compared with the local breed, while the traditional system of feeding was compared with improved mixed feeds. Results showed that improved breeds fed with mixed feeds produced a higher net income, more efficient feed conversion and shorter feeding duration. This project was conducted by the Chinese Academy of Agricultural Sciences.

2. Changping, Beijing, China (Partially Irrigated)

Changping county is one of the main dairy production areas in Beijing, contributing one fourth of municipal milk production. Wheat-maize, wheat-maize (silage) and monocrop rice (transplanted and dry-seeded) are the farmers' dominant cropping patterns in irrigated upland and lowland fields. In rainfed, upland, monocrop maize is commonly adopted. Dairying is either managed by the state or cooperatives. The major constraint on dairy production was the short supply of maize and sorghum from irrigated upland fields for silage making. In the paddy fields, 60-70% were still monocrop rice and some farmers grew rice-wheat and barley silage-rice. The yield of barley was low, about 2.25t/ha. Cropping intensity in the uplands was already at a high of 200%, thus there was little potential for increasing silage production in those areas. The only way to increase silage production was to introduce silage crops during the winter- spring period after monocrop rice. In 1986, ARFSN launched a project to introduce triticale for silage production. Yields under irrigation at Yantan Township were very high (50 t/ha), resulting in a net income from the system of US$1,421, which was 114% more that for single-cropped rice and 44% more than for wheat-rice.

Results of a feeding trial conducted in Baifong village showed that there was no significant difference in milk production between cows fed on maize silage and those fed on triticale silage. The nutritive value of triticale even appeared superior, thus increasing crude protein and fat contents in the milk. Lactose percentage remained the same.

In 1988, the results of the feeding trial attracted the attention of the Beijing Municipal Bureau of State Dairy Farming Management, which organized a visit to the research site for dairy farm officials and farmers. The bureau decided to introduce triticale into its many dairy farms throughout the Beijing region. It was not only adopted in a triticale (silage)-rice pattern in the lowlands but also in triticale (silage)-maize (silage) pattern in the uplands. By 1993, the area devoted to triticale was about 2,600 ha or more than 60% of the total area devoted to winter silage crops. Average yields were 32 t/ha, while net incomes were US$207/ha, US$131 higher than from barley. Triticale was introduced and tested in another 15 provinces/municipalities in northwest China, central China and south China. The acreage outside Beijing was about 223.4 ha. The research had led to the reorientation of China's breeding programme of triticale for human food to silage use as well. The Chinese

Academy of Agricultural Sciences (CAAS) has recently released several new varieties for silage production.

3. Batumarta, South Sumatra, Indonesia (Rainfed, Upland)

Several models (combinations of crop and animals) were evaluated with the main objective of increasing farmers income to a minimum income of $1,500/year. The models were:

a) FSA - farmer's system without animal;
b) FSB - farmer's system with livestock;
c) FSC - gradual improvement with livestock;
d) FSD - introduced improvement with livestock.

FSA and FSB were existing farmers' practice; FSC had one cow, 3 goats and 11 chickens and FSD had 2 cattle, 5 goats and 23 chickens. Five farmers from each system were involved and were selected from those who adopted the improved cropping patterns. Farmers adopted the cropping patterns which included maize, upland rice, cassava and legumes such as groundnut and cowpea, grown in a relay intercrop system. After three years of on-farm testing, households adopting the models FSC and FSD achieved the minimum income target of $1500/family/year. With these promising results, FSC was evaluated in six village units involving five farmers in each village, with a total of 30 household cooperators. Farmers were carefully selected from farmer groups organized in each village and were given short training courses on the technology of the crop-animal system with emphasis on the technologies for FSC. Each household cooperator received credit for food production, 3 goats and 11 chickens. All of these households already owned cattle. Credit was provided by the project through the village unit cooperative. The payment of farmer cooperators became a revolving fund and extended to other members of the farmer group who were not involved in this project.

Within 3 years the population of cattle, goats and chickens increased. After six years of testing involving many farmers, the FSC was compared with farmers' existing systems without animals. The net income of FSC was 67% higher compared with the farmers' existing farming systems (without animals).

4. Santa Barbara, Pangasinan, Philippines

The research project was conducted in the rainfed village of Carosucan, Santa Barbara, Pangasinan, where farmers grow only one rice crop a year, leaving the land fallow after harvest. To increase cropping intensity, different cropping patterns were tested for three years. Rice followed by cowpea and mung beans were the most promising cropping patterns. After 2 years, 67% of the farmers planted mung bean and more than 90% in 1993. Net income increased from 80 to 155% more than that of farms with a monocrop of rice. Forage legumes are important components of the diet of ruminants especially for improving the utilization of fibrous residues like rice straw and for green manuring. Hence production of forage legumes in rainfed lowland areas is a strategic approach in the development of a year-round feeding system for ruminants. Scientists and farmers tested three forage crops - siratro, sunn hemp and Desmanthus. Among these forage crops, siratro proved the ideal companion for mungbean. Siratro provided four clippings for feeding to cattle, each with a yield of 3 t/ha, and a further 2.5 to 3.5 tons from the last regrowth, which was used as green manure for the following rice crop. The Bureau of Agricultural Research in Manila is now testing the improved rice-mung bean + siratro system in other provinces. Each province sent two representatives to a 2-week training course held at the Department of Agriculture to introduce the system. The main impediment to more widespread adoption is the shortage of siratro seed.

5. Ban Phai, Khon Kaen, Thailand

In Ban Phai, Khon Kaen, Thailand, the traditional cropping system was monocrop rice in the lowlands and cassava in the uplands. To improve the quality of feeds and utilize crop byproducts and residues, several crops such as corn, mung beans, cowpea, groundnuts were evaluated in the uplands and upper paddy areas. Artificial insemination was introduced to produce half-bred cows from American Brahman and Holstein-Friesian for dairying and the male for beef production. Backyard forage production using stylo, napier and ruzi grass were evaluated for night feeding and urea-treated straw was also introduced. Net cash income of the animal-based farmers was 100% more than the crop-animal based and 207% more than the crop-based. In all groups, the income from animal production was higher. Farmers at all experimental sites, including the neighboring villages, adopted the production of ruzi grass in bigger plots close to their homesteads.

Lessons Learned From Crop-animal Collaborative Research

The organization of the crop-animal systems research network was a learning experience. The complexity of different farming systems, diversity of production systems and the socio-economic constraints of rice-based farming households provided challenges to researchers and extension workers. The following were the lessons learned from the research network:

1. Organizational Difficulty

The methodology for crop-animal farming systems research required multi-disciplinary teams of social scientists, animal nutritionists, agronomists, livestock specialists, veterinarian, etc. However, these specialists come from different offices, ministries and departments. Thus, it was difficult for these specialists to coordinate their work and moreover to conduct field visits especially if the research sites are remote. There is generally a lack of social scientists, including economists, who have the interest and time to work with the other disciplines at the farm level. However, there are exceptional cases in Thailand, Indonesia and the Philippines where social scientists from agricultural universities worked together with scientists from farming systems research institutes.

2. Methodological Problems

Since the evaluation of systems and component technologies managed by farmers was replicated across farms, the variability of results was generally high, resulting in statistically insignificant differences. While more replicates are ideal, the conduct of research becomes more difficult and expensive. Occasionally, the farmers assigned to the control group duplicated some of the recommended practices. Similarly, there was tendency for some researchers to dictate to the farmers the experimental interventions rather than involving farmers in all phases of research particularly in getting their feedback.

3. Research Emphasis

There was more emphasis on nutrition and forage research and less on the different aspects of animal production. This is expected since the lack of forage for ruminants and high cost of concentrates for monogastric animals are the dominant problems under Asian conditions. Furthermore, crop by-product utilization by ruminants is the major point of crop-animal integration.

4. Socio-economic Constraints

In spite of the availability of crop-animal technologies developed, tested and evaluated on the research station and at the farm level, the adoption rate is low due to several socio-economic constraints (Paris *et al.*,1995). These are:

a) Farm labour shortage due to the higher off-farm wages and greater opportunity costs of family labour (especially males);

b) Unfavourable government agricultural policies which provide disincentives for small livestock development;

c) Unavailability of required inputs and support services;

d) Risk aversion and perceptions of technology by farmers;

e) Inadequate training and extension for technologies which require knowledge and information;

f) Lack of credit to the poor without collateral. For example, the dairy industry in Thailand prospered due to incentives and support which the Thai government gave at the community and farm level. Farmers were encouraged to specialize in forage seed production. In the Philippines, farmer cooperatives supported by the Land Bank provided credit not only for rice inputs but also for procuring large and small animals.

5. Farmer Participation

While farmer participation was very much emphasized in the methodology of crop-animal on-farm research, very few trials have included women farmers who play crucial roles in large and small animal production. It is now realized that they will play even greater roles in the management of farm animals and in sustaining household food security due to the increasing male migration to the cities. More efforts are now being undertaken to recognize women's roles in crop and animal production and in including them in research and extension activities.

Conclusion

ARFSN, as its major contribution to agricultural research in Asia, has exposed and trained local scientists in the conduct of on-farm animal research. As such, it has instilled into the researchers the need for collaborative research not only among institutions but, more importantly, with the farmers. With the current concern for sustainable agriculture amid dwindling funds for tropical agriculture research, ARFSN has put in place a critical mass of human resource with skills and capabilities to pursue research based on farmers' needs and aspirations. Provided with support by their respective national research programs, this pool of scientists can largely contribute to the improvement of rural life in Asia through appropriate research approach.

References

Chater, S and Carangal, V. 1996. On Farmers's Fields: Portrait of a Network. International Rice Research Institute, P.O. Box 933, Manila, Philippines

Carangal, V. R. and Sevilla, C. C. 1993. Crop-animal systems experiments in Asia. Proceedings on VII World Conference on Animal Production. Volume I 367-386 pp. Alberta, Canada.

International Rice Research Institute. Technical report of the Asian Rice Farming Systems Network. 1995. Prepared by T. Paris. (Unpublished).

Paris, T. and Sevilla, C. 1995. Priorities for socio-economic research in farming systems in South-east Asia. In Global Agenda for Livestock Research. Proceedings of the Consultation for the South-East Asia Region held at IRRI, Los Banos, Philippines on 10-13 May 1995. Edited by C. Devendra and P. Gardiner. 107-116.

Sevilla, C.C. and Carangal, V. R. 1995. Methodology for crop- animal systems findings. In: Crop-animal interaction. Proceedings of an international workshop. Edited by C. Devendra and C. Sevilla. IRRI Discussion Paper Series No. 6. International Rice Research Institute, P.O. Box 933, Manila, Philippines, p. 533-549.

The Outcome of Networking 24 Latin American and Caribbean Countries on Integrated Use of Sugar Cane and Local Resources in Animal Feeding (The CIPAV Experience)

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Abstract
In 1993, FAO instigated a cooperation agreement for the establishment of the Information Network for Tropical America and the Caribbean on the utilization of the sugar cane and other locally available resources for animal feeding. The Network funded by France includes Antigua and Barbuda, Barbados, Belize, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Honduras, Jamaica, Mexico, Nicaragua, Panama, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, and Venezuela. The objectives of the Network are:
I) to promote, the exchange of technical information, practical and theoretical experience, and training methods, within and between countries.
ii) to organize practical demonstrations of the most appropriate techniques under local conditions in the countries with limited experience of the new production systems.
iii) to promote the evaluation and production of local plant genetic resources, which complement rations based on sugar cane, through the

exchange of appropriate plant genetic material among the countries of the Network.

In order to fulfill these objectives, FAO has commissioned the Colombian NGO "The Centre for Research in Sustainable Systems of Agricultural Production" (The CIPAV Foundation) to be the Central Organization, with 10 years' experience in the generation of agricultural technologies based on the use of sugar cane, forage trees and organic residues for animal feeding, decontamination of water and gas production by means of continuous-flow-plastic-biodigesters, and pioneer in the production of a computerized scientific journal.

KEY WORDS: integrated systems, sugar cane, supplementation, protein forages, publications, network, international cooperation, Latin America

Background

Since the 1970s, scientists from different parts of the world, investigating technical proposals for the agricultural development of tropical countries, have found that many technologies developed in temperate countries and transferred to the tropics have had little success in social terms for the agricultural sector of these countries.

In most cases they are based on the import of packages involving production of high-yielding cereals, with intensive mechanization and high inputs derived from oil (fuel, fertilizers and pesticides).

Most of the cereal production, together with imports from temperate countries, is used to feed imported animals with "maximum genetic improvement", whose nutritional requirements can hardly be satisfied under the natural conditions of the tropics (wet and dry).

All the technological elements are, of necessity, imported from the north and consequently require foreign currency which increases the operating costs. This, together with the low yields (compared with those of the countries of the temperate zone), results in minimal financial benefits and, at the same time, they have lead to the degradation of the ecosystem and a decline in traditional production systems.

In the search for solutions, since the 1980s, scientists like Drs Ronald

Leng, Thomas Preston, Vilda Figueroa and Rena Perez (among others) have devoted efforts to research that aims at seeking alternatives for agricultural production in the tropics and sub-tropics, based on the hypothesis that "the primary production strategy in the tropics must be based on the efficiency of plants to transform solar energy into concentrated energy sources (sugars, starches and oils), as well as protein production for animal feeding".

With this objective, they demonstrated, initially in Cuba, that it was possible to totally replace cereals as the energy source for animal feeding, with the use of molasses (A molasses, B molasses and final molasses) from the sugar industry, supplemented with unconventional protein sources (yeasts, organic wastes and protein pastes) for pig fattening, without detriment to animal performance. Since 1986, projects were established in Colombia by CIPAV with the advice of Dr. T.R. Preston, where the evolution of research and the commercial application of the technologies have demonstrated that:

- Fattening pigs from 20 to 90 kgs liveweight, using sugar cane juice ad libitum and a restricted protein supplement (200 g/animal/day) based on soya grain or cake permits at least 500 g/animal/day live weight gain.
- The use of forage from trees and aquatic plants as part of the protein supplement for pregnant sows (1 to 2 kg/animal/day on a fresh base) permits litters from 8 to 10 pigs at birth and weaning, with live weight of 1200 g at birth and 9 kg at weaning at 45 days.
- The strategic feeding of dual-purpose cattle with sugar cane bagasse and sugar cane tops or fibrous crop residues, supplemented with leaves of forage trees, poultry litter, rice bran and multi-nutritional blocks, prevents loss in weight and improves the reproductive performance of the herds, even during the dry season and, under good climatic conditions, permits daily gains higher than 600 g/animal/day in the males and average production of 10 to 12 litres of milk/cow/day.
- An appropriate nutritional strategy for dual-purpose cows, allows both milking and restricted suckling which leads to increases in milk production of over 25% and the improvement in the post-weaning growth of the calves.

- The use of females for animal traction (cows and buffalo) in agricultural activities permits an annual saving of the equivalent of 45% of the energy used by an electrical motor, and, at the same time, generates annually 1.73 tonnes of milk, 0.182 tonnes of meat (1.3 calves), 13 tonnes of manure and 1.82 tonnes of waste forage which can be used as a fertilizer.
- Sugar cane with a spacing of 0.7 - 1 m between rows (the sugar industry in Colombia uses 1.5 m) gives a total biomass production of around 250 tons/hectare/year without the use of agricultural chemicals.
- Fractionation of sugar cane for animal nutrition, allows the incorporation of different species into integrated systems of sustainable production, where the sugar cane tops and bagasse are used for ruminants, organic fertilizer and energy production and the juice is used for monogastric nutrition and for the production of molasses for the family. The animals are supplemented with forage trees (which are grown together with the sugar cane), aquatic plants (established in waste ponds), multi-nutritional blocks (for ruminant and rabbits) and soya grain or cake (for monogastrics).
- The integration of biological water de-contamination systems using continuous-flow-plastic-biodigesters and ponds with aquatic plants has enabled the generation of methane gas to be used instead of non-renewable fuels, protein for animal feed and nutrient recycling.
- Different investigations carried out with other scientists from Colombia, Cuba, Venezuela, Nicaragua, Vietnam, Tanzania, United Kingdom, Sweden, Denmark and Australia have shown that there are many plant species in the tropics and the sub-tropics which have great potential for animal and human nutrition. Known species which have a high efficiency in the transformation of solar energy into other forms are sugar cane (*Saccharum officinarum*), bananas (*Musa* spp.), cassava (*Manihot* spp.) and the African palm (*Elaeis guineensis*). With regard to protein production, some of the trees and shrubs which deserve mention are *Gliricidia sepium, Erythrina poepigiana, E fusca, E. glauca, E. edulis, Prosopis juliflora, Trichanthera gigantea, Morus* sp., *Urera* sp., *Tithonia diversifolia, Malvaviscus penduliflorus, Canavalia* sp., and the aquatic plants *Azolla* spp., *Lemna* spp. and *Salvinia natans.*

With the practical and scientific demonstration of the hypotheses by the pioneers researchers and continuing investigations, it has been possible to generate, over the last 10 years, technological proposals which, at the same time, have been taken and transformed by farmers in different tropical countries. In 1993, FAO decided to establish the Information Network for Tropical America and the Caribbean on the utilization of the sugar cane and of other locally available resources for animal feeding.

Sugar Cane Network Fao-america

The CIPAV Foundation (Cali, Colombia) was designated as the Central Organization which, under the patronage of the FAO, coordinated the "Information Network for Tropical America and the Caribbean on the utilization of the sugar cane and of other available local resources for animal feeding" (FAO project GCP/RLA/116/FRA funded by the French Government). In each country, a committee has been created as the responsibility of an organization which provides a National Coordinator, who is the principal facilitator of the activities of the National Committee, the permanent liaison between countries, and the direct contact with the CIPAV Foundation, which at the same time liaises with FAO and another Network in Asia. To activate the Network, CIPAV, through short duration missions to each country, has accomplished different activities:

- Training and advice to the National Coordinators, National Committees, other technicians and farmers through field days, demonstrations, tours and conferences.
- Advice to the National Coordinators, National Committees and other technicians in the design of experiments and information analysis.
- Training on the use of software for investigation and communication (spreadsheets, word processors, graphical packages, compression and converters programs, E-mail tools, etc.), documents produced in electronic form (Livestock Research for Rural Development (LRRD), books in Windows Help Format) and templates for presentation and publication of printed books and electronic documents containing information generated in the research.

CIPAV produces technical and scientific material which is distributed between the different country members of the Network, and invites local researchers to write articles to be published in LRRD.

The Sugarcane Feeds Centre (SFC), Trinidad, implemented similar activities for the English-speaking Caribbean countries. This institution was selected as it has a long experience in the use of sugarcane and other local resources as animal feeds in the Caribbean islands and as it also conducts a wide range of on-going experiments and demonstrations concerning these topics. Three international workshops have been organized by the SFC for the Caribbean countries. Furthermore, the SFC director carried out short missions in Guyana, Saint Vincent, Saint Lucia, Dominica and, Antigua and Barbuda, in order to increase liaison with Ministry officials and support and encourage the National Coordinators to strengthen the impact on farmers.

Outcome of the Network

Publications

a) Material on sustainable agricultural technologies has been published both in Spanish and English, in different formats (computerized journals, posters, proceedings, manuals, books and videos), and distributed between the country members of the Network. These include more than 1,000 copies of 19 issues of LRRD (each one containing 10 articles); all the articles can be obtained through FTP or the World-Wide-Web, in versions for DOS and Windows. In addition there are the computerized journals: "Non-Ruminant Small Herbivores" (CENDI, Venezuela) and "Pig Production" (Instituto de Investigaciones Porcinas, Cuba).

b) 1,200 copies of 5 primers: "Sugar cane", "Feeding of Cattle for Small Farms", "How to Raise Pigs with On-Farm Resources", "Training of Working Animals" and "The Cipres Production System" (the last two only in Spanish) and some copies of the primer "The Rope Pump to Extract Water".

c) More than 50 packages of the poster collection "The Bag of Trees to Eat".

d) Copies of the proceedings: "Forage Trees as Sources of Protein", "Sustainable Systems of Agricultural Production for Small Farmers", "Nacedero (*Trichanthera gigantea*): an Integrated Production Species" (all in Spanish).

e) 120 copies of the Manual "Continuous Flow Plastic Biodigesters: generation of gas and bio-fertilizer from waste water".

f) 240 copies of 4 books: "Strategy for Sustainable Livestock in the Tropics" (Preston T.R., Murgueitio R.), "Matching Ruminant Production Systems with Available Resources in the Tropics and Sub-Tropics" (Preston T. R. and Leng R.), "Forage Trees and Shrubs Used in Animal Feeding as a Protein Source (CIPAV)", "Pig Production with Tropical Plants and Nutrient Recycling" (Figueroa V.); and some copies of the books "Sustainable Agricultural Systems for the Tropical Mountains (CENDI - CIPAV)" and "Fauna Investigation and Management for the Development of Sustainable Systems (CIPAV)". The first four are printed on paper, the rest were published both on paper and electronic form (Windows Help Format).

g) The video "Didimo's Sweet Pigs" in English and Spanish.

Events

The representatives of CIPAV have held technical conferences for more than 1,500 persons, demonstrations with the participation of more than 500 persons, and training workshops in project design, analysis and data handling with more than 100 persons (technicians, students and farmers). They have participated in technical study tours and evaluation to more than 50 farms (private and state).

The National Coordinators and the National Committees have organized their own training events for groups of farmers, students and technicians.

The National Coordinators of Costa Rica, Honduras, Cuba, Venezuela and Colombia, with the collaboration of their respective National Committees and FAO, have organized international seminars on Integrated Systems of Agricultural Production, with the participation of National Coordinators of different countries and the participation of more than 1,300 persons (technicians, students and farmers).

In 1995, an NGO that works in El Salvador (Veterinaires Sans Frontieres - VSF) organized, with the involvement of other national organizations and a representative of CIPAV, a national event on Integrated Systems of Agricultural Production with 100 participants (farmers and technicians).

Exchanges

Some National Coordinators, members of National Committees or Institutions of the Central American countries and CIPAV have begun the exchange of technical information, technologies and material:

- tours among neighboring countries (Honduras, Costa Rica, Nicaragua, El Salvador), or to CIPAV (Nicaragua, Costa Rica, Honduras).
- live material of californian red worm (*Eisenia phoetida*), nacedero (*Trichanthera gigantea*) and *Azolla* sp, from Colombia to Honduras and Costa Rica and from Honduras to Costa Rica, Nicaragua and Belize.
- 8 continuous-flow-plastic-biodigesters taken from Colombia to Nicaragua, Honduras, El Salvador and Costa Rica.
- local exchanges of sugar cane varieties resistant to drought and with easy management.

Research, Transfer and Technical Proposals

In several member countries of the Network, the National Coordinators and the National Committees have developed some sort of research activity, and transferred or developed new technologies. Some examples are:

- In Guatemala, the Science and Technology Institute (ICTA) and the Veterinaires Sans Frontieres work in the agricultural characterization, reproduction and use of local forages of the Altiplano and small mountains, for small ruminant nutrition (goats and ewes) with indigenous communities.
- In El Salvador, the National Coordinator and the organization Center of Agricultural Technology Transfer (CENTA) are carrying out research into the reproduction and establishment of Erythrina verteruana, and at the same time they are starting work on the use of this forage as a protein supplement for milk production; they have

also begun trials on feeding hens with californian red worms. The NGO's VSF and FASTRAS have established, with different groups of small farmers, different components of the system (sugar cane, forage trees, soya and earthworms for feeding native hens, pigs and cattle, and plastic biodigesters).

- In Honduras, the National Coordinator and the National Committee are carrying out serious research on establishment and resistance to drought of sugar cane and forage trees, pig feeding with sugar cane juice supplemented with different protein sources (soya cake and shrimp meal), grazing of pregnant sows, establishment of a dual-purpose cattle herds, buffalo production, plastic biodigesters and aquatic plants.
- In Nicaragua, the technical personnel of the World Food Programme have set up projects for training and technology transfer on strategies for cattle feeding in the dry season (sugar cane, fibrous residues and multi-nutritional blocks). A technician from the National Institute of Agricultural Technologies (INTA) is working on the adaptation of the dual-purpose cattle system to the severe drought zone of Chontales and he has organized an event with the exclusive participation of farmers, to present the results of the projects on their farms.
- In Costa Rica, the National Coordinator and the National Committee have established different investigations into the use of residues of banana production for animal feeding and multi-nutritional block production, establishment of silvopastoral systems and dual-purpose cattle management, and are starting projects on animal traction.
- In Cuba, the National Coordinator and the National Committee are making progress in the establishment of forage trees and production systems with cooperative farmers, and the installation of continuous-flow-plastic-biodigesters.
- In Venezuela, the National Coordinator and a group of collaborators established an integral farm and are studying different animal species: feeding with multi-nutritional blocks; characterization, behaviour and management of native stingless bees; conservation of wild species in danger of extinction; and systems such as the 'alpargata forrajera', for the fresh forage supply to the animals.

Bibliography

Espinel R., Galindo W. 1994. Red de informacion para America tropical y el Caribe sobre la utilizacion de la Cana de Azucar y de otros Recursos locales disponibles en la alimentacion animal. Proyecto GCP/RLA/116/FRA Primera Mision en Centro America y el Caribe. FAO - CIPAV.

Espinel R., Gomez M. E. 1995. Red de informacion para America tropical y el Caribe sobre la utilizacion de la Cana de Azucar y de otros Recursos locales disponibles en la alimentacion animal. Segunda Mision en Centro America y el Caribe. FAO - CIPAV.

Espinel R. 1995. Red de informacion para America tropical y el Caribe sobre la utilizacion de la Cana de Azucar y de otros Recursos locales disponibles en la alimentacion animal. Informe final de actividades en 1995. FAO - CIPAV.

Espinel R. 1996. Red de informacion para America tropical y el Caribe sobre la utilizacion de la Cana de Azucar y de otros Recursos locales disponibles en la alimentacion animal. Primer Informe de actividades en 1996 (Sin publicar). FAO - CIPAV.

Espinel R., Char J. 1996. Red de informacion para America tropical y el Caribe sobre la utilizacion de la Cana de Azucar y de otros Recursos locales disponibles en la alimentacion animal. Tercera Mision en Centro America y el Caribe (Sin publicar). FAO - CIPAV.

Figueroa V. 1996. Produccion Porcina con Cultivos Tropicales y reciclaje de Nutrientes. CIPAV.

Galindo W. 1995. Las Hembras Multi-proposito; Vacas y Bufalas. Tesis de Maestria en Desarrollo Sostenible de Sistemas Agrarios. Pontificia Universidad Javeriana - Instituto Mayor Campesino - CIPAV. Colombia.

Gomez M. E., Rodriguez L., Murgueitio E., Rios C. I., Molina D. C. H., Molina C. H., Molina E., Molina J. P. 1995. Arboles y Arbustos Forrajeros Utilizados en Alimentacion Animal como Fuente Proteica. CIPAV.

Ocampo D. A. 1995. La Palma Africana, Recurso Estrategico en Sistemas Integrados de Produccion Tropical. Tesis de Maestria en Desarrollo Sostenible de Sistemas Agrarios. Pontificia Universidad Javeriana - Instituto Mayor Campesino - CIPAV. Colombia.

Perez A. E. 1990. Plantas Utiles de Colombia. Editorial Victor Hugo. 14a edicion.

Information on Livestock Feed Resources and Integrated Farming Systems from the Electronic Journal Livestock Research for Rural Development

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Abstract
Livestock Research for Rural Development was the first scientific journal to be published only in electronic form, firstly on diskette and subsequently via ftp (file-transfer-protocol) and over the World-Wide-Web. The objective was to both publish information and make it available to scientists in developing countries, who had difficulty in the past due to the high costs of conventional publishing. It was started in 1989 and 20 issues (200 papers) have been distributed to over 600 persons in more that 40 countries. There are no restrictions on copying and onward-distribution so a far greater number of readers probably exist.

The focus has been on nutrition and management within systems appropriate to the tropics. There have been articles on most livestock species, including buffalo, goats, sheep, pigs, ducks and poultry, as well as cattle; and many tropical feeds, but particularly sugarcane and its by-products, legume trees, palms, water plants and other unconventional resources. These have included more detailed aspects such as chemical treatment, mineral supplementation and anti-nutritional factors. Several

papers have been included on systems methodology and the development process.

KEY WORDS: Electronic journal, livestock research, rural development, tropical feeds, unconventional feed resources

Background

Research on feed resources, and particularly journals where such information is published, are still monopolised by institutions in the industrial countries situated in temperate latitudes. There is a great need to expand research on feeds and feeding systems appropriate to tropical environments, and to promote means for dissemination of the information which can be a major stimulus for doing the research in the first place.

It is now well recognized that research and scientific publications in temperate developed countries have little relevance to the problems facing researchers and farmers in tropical developing countries. Furthermore, in most tropical developing countries laboratory analytical facilities are poor and expensive to develop and maintain. It is not surprising therefore that many of the techniques used to assess feeds in temperate countries are not applicable in the tropics.

The need is not for a set of "tropical feeding standards" but for information about the nature of tropical feed resources and how they are used by animals. Such information is being gathered by research workers in developing countries, many of whom are funded by the innovative support organization, IFS (the International Foundation for Science*). Indigenous knowledge, handed down from farmer to farmer, is also one of the most appropriate sources of such information. The problems are, firstly, to document this knowledge and secondly to disseminate it widely among potential users. Many of the researchers are turning to on-farm research where they can fulfill these objectives more effectively than in laboratories or research stations.

A first effort to provide a vehicle devoted to more appropriate tropical studies was achieved with the publication of the journal Tropical Animal Production from 1976 to 1982. Some years later, the electronic journal Livestock Research for Rural Development was established in 1989 in the belief that conventional methods of publishing scientific information were too expensive, not appropriate and not sustainable in the context of developing countries. The concept is more fully documented in the original paper by Preston and Speedy (1989). There were two principal objectives:

1. To offer an alternative forum to "young" scientists in tropical developing countries for the exchange of scientific information;
2. To utilize electronic information technology to minimize costs of preparation and distribution.

Over the 8 years of its existence there have been minor changes in style in response to the opportunities presented by developments in computer technology and data exchange, especially the growth of the Internet and the Word-Wide-Web. But the basic principles have been maintained of offering a forum to scientists in tropical developing countries combining minimal cost, easy access and rapid publication of appropriate information.

Information on Livestock Feed Resources and Integrated Farming Systems

The focus has been on nutrition and management within systems appropriate to the tropics. For example, *the following articles reported studies on small farming systems*

Effect of supplements of balanced concentrates and cottonseed cake on milk production in Mauritian villages (Boodoo A A *et al.*, 1990)

Suggestions for intensive livestock-based smallholder systems in semi-arid areas of Tanzania (Ogle B, 1990)

Economia campesina y uso de los recursos naturales en zonas de colonizacion (Rojas H, 1990)

Role of women in homestead of small farm category in an area of Jessore, Bangladesh (Paul D C and Saadullah M, 1991)

Goat production in south-west region of Bangladesh (Paul D C, Haque M F and Alam M S, 1991)

Technology and competitiveness of small dairy farms in Costa Rica (Holmann F *et al.*, 1992)

Smallholder milk production, milk handling and utilization: A case study from the Nharira / Lancashire farming area, Zimbabwe (A N Mutukumira, D M J Dube, E G Mupunga and S B Feresu, 1996)

Papers relating to specific alternative feeds used for different types of livestock include:

Utilizacion de la cachaza de palma africana como fuente de energia en el levante, desarrollo y ceba de cerdos (Ocampo A *et al.*, 1990)

Azolla filiculoides as replacement for traditional protein supplements in diets for growing-fattening pigs (Becerra M *et al.*, 1990)

Utilizacion de jugo de cana y cachaza panelera en la alimentacion de cerdos (Sarria P, Solano A and Preston T R, 1990)

"A" molasses in diets for growing ducks (Men B X and Su V V, 1990)

Effects of substituting dolichos bean meal with soya bean meal on the performance of broiler chicken (Sarwatt S V *et al.*, 1991)

A comparison of sugar cane juice and maize as energy sources in diets for growing pigs (Speedy A W *et al.*, 1991)

Multi-Nutrient Blocks as supplement for milking cows fed forages of low nutritive value in South Vietnam (An B X *et al.*, 1991)

Utilizacion de follaje de Nacedero (Trichantera gigantea) en la alimentacion de cerdos de engorde (Sarria P *et al.*, 1991)

Molasses-urea block (MUB) and Acacia mangium as supplements for crossbred heifers fed poor quality forages (Bui An X *et al.*, 1992)

Effect of Leucaena leucocephala and Brassica napus on growth of pigs fed wheat bran diets (Muir J P *et al.*, 1992)

Ammoniated rice straw or untreated straw supplemented with a molasses-urea block for Sindhi x local cattle (Bui Van Chinh *et al.*, 1992)

Feeding ensiled poultry excreta to ruminant animals in Syria (Hadjipanayiotou M *et al.*, 1993)

Evaluation of Sapindus saponaria as a defaunating agent and its effects on different ruminal digestion parameters (Diaz *et al.*, 1993)

The use of sugar cane juice and molasses in the diet of growing pigs (Bui Huy Nhu Phuc, 1993)

Efecto de tres forrajes arboreos sobre el consumo voluntario y algunos par metros ruminales en ovejas africanas (Vargas J E, 1993)

Laboratory evaluation of ensiled olive cake, tomato pulp and poultry litter (Hadjipanayiotou M, 1994)

Study on the use of algae as a substitute for oil cake for growing calves (Chowdhury S A *et al.*, 1994)

Fattening pigs with the juice of the sugar palm tree (Borassus flabellifer) (Khieu Borin, T R Preston and B Ogle, 1995)

Duckweed - a potential high-protein feed resource for domestic animals and fish (Leng R A, Stambolie J H and Bell R, 1995)

Effect of protein supply in cassava root meal based diets on the performance of growing-finishing pigs (Liliana Ospina, T R Preston and

B Ogle, 1995)

Lombriz roja Californiana y Azolla-anabaena como sustituto de la proteina convencional en dietas para pollos de engorde (Lylian Rodriguez, Patricia Salazar y Maria Fernanda Arango, 1995)

The forage tree Erythrina fusca as a protein supplement for cattle and as a component of an agroforestry system (Piedad Cuellar, Lylian Rodriguez and T R Preston, 1996)

There is a very valuable paper on the different types of forage trees used in Tanzania:

Indigenous knowledge in utilization of local trees and shrubs for sustainable livestock production (Komwihangilo D M *et al.*, 1994)

Papers on research and development methodology have also been given:

Adding a learning to a blueprint approach - or what a small amount of flexible money can do. (Dolberg F, 1991)

Integration of livestock with agro-climatic zone-based land use planning (Gupta A, 1992)

Studies on the knowledge of rural women regarding local feed resources and feeding systems developed for livestock (Rangnekar S D, 1994)

Research, Extension and Training for Sustainable Farming Systems in the Tropics (T R Preston, 1995)

These are intended as examples of the type of studies reported. The full references are given at the end of this paper. A comprehensive list of the contents to date can be obtained by sending an e-mail message to the conference coordinators.

Availability
Livestock Research for Rural Development is now available in three formats:

- The MS-DOS format
- The Windows.hlp format
- The Adobe Acrobat.pdf format

The MS-DOS Format:
This is the normal DOS version that has been the standard format up to the present and which runs from the DOS Prompt by typing "J". It is appreciated that not all readers have access to 486 and higher processors and that this "stand alone" version of the journal continues to fulfill an important role. It will continue to be produced in the CIPAV office in Colombia and distributed to those contributers who wish to receive LRRD in the MS-DOS format. For those readers who have an InterNet connection, the MS-DOS version can be down-loaded by "FTP" from:

saman.unellez.edu.ve /pub/revistas/lrrd

The Windows .HLP Format:
This new Windows version is based on the Windows Help system (run with WINHELP.EXE). This works just like any Windows Help file and needs no special instructions. For those readers who have an InterNet connection, the new Windows Help version can be down-loaded by "FTP" from:

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The Acrobat .PDF Format:
This version of LRRD maintains the precise format of the original paper as prepared by the Word Professing Software (in this case WordPerfect 6.1 for Windows). The advantage is that it is much easier to prepare than the DOS or Windows Help versions. It has excellent search and "hypertext" capabilities that facilitate moving from contents to papers and back again etc. The disadvantage is that you need the specific software "Acrobat Reader" to be able run it. The Acrobat Reader can be downloaded "free" from the InterNet; also it (the reader) will occupy about 1Mb of space on your hard disk.

The "Acrobat" version is available for LRRD 7.2 onwards. The "Acrobat" version for 7.2 onwards as well as previous MS-DOS versions are available on the World Wide Web at:
http://ifs.plants.ox.ac.uk/lrrd/lrrd.htm

For readers resident in Vietnam these versions of the journal are available on the "VIETNET" List Server located at the University of Agriculture and Forestry in Ho Chi Mi City. Researchers in developing countries are encouraged to establish national networks such as VIETNET as a means to facilitate the distribution of LRRD from the editor to a server in each country to which each national researcher may have access for retrieving the last issues. Obviously, this server may also be used for providing others sources of information.

For the last 2 years, the publication of LRRD has been supported by FAO through its regional network on Feed Resources in Latin America and the Caribbean funded by France.

Submission of Papers

Papers are submitted on disk (either 3.5 or 5.25inch) in WordPerfect or similar format, to the regional language sub-editor. The paper can be in any of the official languages: Spanish, Portuguese, French and English, but the preferred format should be followed.

Authors are required to have their papers refereed, before submission, by at least two scientists who have both postgraduate qualifications and proven experience. A signed statement by the referees should accompany the submission. When authors have difficulty in locating appropriate referees, they should contact the nearest sub-editor who will provide names of suitable candidates.

Full details of how to submit and the Notes for Authors are given in the latest issue of the journal.

Further details can be obtained from
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rene.sansoucy@fao.org

References

A N Mutukumira, D M J Dube, E G Mupunga and S B Feresu, 1996. Livestock Research for Rural Development 8:1
An B X *et al.*, 1991. Ibid. 3:2
Becerra M *et al.*, 1990. Ibid. 2:2
Boodoo A A *et al.*, 1990. Ibid. 2:1
Bui An X *et al.*, 1992. Ibid. 4:2
Bui Huy Nhu Phuc, 1993. Ibid. 5:2
Bui Van Chinh *et al.*, 1992. Ibid. 4:3
Chowdhury S A *et al.*, 1994. Ibid. 6:3
Diaz *et al.*, 1993. Ibid. 5:2
Dolberg F, 1991. Ibid. 3:1
Gupta A, 1992. Ibid. 4:1
Hadjipanayiotou M, 1994. Ibid. 6:2
Hadjipanayiotou M *et al.*, 1993. Ibid. 5:1
Holmann F *et al.*, 1992. Ibid. 4:1
Khieu Borin, T R Preston and B Ogle, 1995. Ibid. 7:2
Komwihangilo D M *et al.*, 1994 Ibid. 6:3
Leng R A, Stambolie J H and Bell R, 1995. Ibid. 7:1
Liliana Ospina, T R Preston and B Ogle, 1995. Ibid. 7:2
Lylian Rodriguez, Patricia Salazar y Maria Fernanda Arango, 1995. Ibid. 7:3
Men B X and Su V V, 1990. Ibid. 2:3
Muir J P *et al.*, 1992. Ibid. 4:2
Ocampo A *et al.*, 1990. Ibid. 2:2
Ogle B, 1990. Ibid. 2:2
Paul D C, Haque M F and Alam M S, 1991. Ibid. 3:3
Paul D C and Saadullah M, 1991. Ibid. 3:2
Piedad Cuellar, Lylian Rodriguez and T R Preston, 1996. Ibid.8:1
Preston T R , 1995. Ibid. 7:2
Preston T R and Speedy A W, 1989. Ibid. 1:1
Rangnekar S D, 1994. Ibid. 5:3
Rojas H, 1990. Ibid. 2:2
Sarria P, Solano A and Preston T R, 1990. Ibid. 2:2
Sarwatt S V *et al.*, 1991. Ibid. 3:1
Speedy A W *et al.*, 1991. Ibid. 3:1
Vargas J E, 1993. Ibid. 5:3

Trichanthera gigantea (Humboldt & Bonpland.) Nees: A Review

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Introduction

Trichanthera gigantea is a tree of the Acanthaceae family and is apparently native to the Andean foothills of Colombia, but is also found along streams and in swampy areas from Costa Rica to northern South America (McDade, 1983) and in wet forests from Central America to Peru and the Amazon basin, being also fairly common on certain islands in the Amazon estuary (Record and Hess, 1972).

It is a very promising fodder tree for a wide range of ecosystems. Its range has been reported from 0 to 2,000 (Murgueitio, 1989), 800 to 1,600 (Acero, 1985), and from 500 to 1,800 metres above sea level (Jaramillo and Corredor, 1989). It is well adapted to the humid tropics with an annual rainfall between 1,000 to 2,800 mm (Acero, 1985., Jaramillo and Corredor, 1989), but it has been found growing in the Cocho region with an annual rainfall between 5,000 to 8,000 mm/year (Murgueitio, 1989). It grows well in acid (pH 4.5) and low fertility but well drained soils. It is often found along streams and springs (Acero, 1985).

Taxonomy

Family:	ACANTHACEAE
Subfamily:	ACANTHOIDEAE
Tribe:	TRICHANTHEREAE
Genera:	*Trichanthera*
Species:	*Trichanthera gigantea*

Vernacular names: Aro blanco, nacedero, rompebarriga (Leonard 1951), nacedero (Tolima), quiebrabarrigo (Antioquia), cajeto (Ocaña), fune, madre de agua (Villavicencio) (Colombia); suiban, cenicero, (Bolivia); tuno (Guatemala); naranjillo (Venezuela); palo de agua (Panama); beque, pau santo (Brasil) (Perez-Arbelaez, 1990).

It was first described by Mutis in 1779, who noted the hairy anthers. In 1801, Humboldt and Bonpland thought that this was a species of the genus *Ruellia* and classified it as *Ruellia gigantea* (all species of the genus *Ruellia* are herbaceous). In 1817, Kunt suggested the creation of the genus *Trichanthera* (Trich hair, anthera anther). In 1847, Nees, based on the early descriptions, named the genus *Trichanthera* (Perez-Arbelaez, 1990). In 1930, Leonard described a new species, *Trichanthera corymbosa*, from a specimen collected in Norte de Santander, Colombia and ascribed it to the north east of Colombia and Venezuela. So far, these two species and one variety, the British Guiana form *Trichanthera gigantea* var. *guianensis* Gleason (Record and Hess, 1972), have been described in the *Trichanthera* genus.

Key to the species:
Calix lobes rounded; inflorescence racemose, secund: *T. gigantea*
Calix lobes obtuse or acute; inflorescence corymbose: *T. corymbosa*

Description
Shrubs or trees (sometimes bushy and bearing adventitious roots) up to 5 metres high (a height of 15 metres witvih a trunk diameter of 25 cm has been reported from Colombia (Record and Hess, 1972)), the top rounded; branches quadrate, the angles rounded, the tips minutely brown-tomentose; lenticels prominent; leaf blades ovate to oblong, up to 26 cm long and 14 cm wide, acuminate at apex, narrowed at base, glabrous, or the costa and veins pubescent; petioles 1 to 5 cm long; inflorescence a terminal compact more or less secund panicle 5 to 15 cm long and 4 to 5 cm broad, brown-tomentose; bracts triangular, 3 mm long; calyx 10 to 12 mm long, brown-tomentose, the segments 7 to 10 mm long, 5 mm wide, rounded at apex; corolla 3 to 4 cm. long, red and glabrous proximally, yellowish and silky-tomentose distally, red and

glabrous within, the tube 1 to 1.5 cm long, the limb 2 to 3 cm. broad, the lobes oblong to oblong-ovate, 3 to 5 mm wide; ovary tomentose; style 4 to 5 cm long; capsule 1.5 to 2 cm long, obtuse at apex, silky-pubescent, the hairs closely appressed; retinacula 3 mm long, curved, truncate and erose at tip; mature seed 1 to 4 in each capsule, lenticular, 3 to 4 mm broad, glabrous (Leonard, 1951).

Its wood has about the consistency of Red Maple (*Acer rubrum*). The pith is large and septate (Record and Hess, 1972).

Like all acanthaceous plants, *Trichanthera* has cystoliths, small mineral concretions appearing as minute short lines on the upper surface of the leaf blades, the upper portions of the stems, on the branches of the inflorescence and on the calyx (Leonard, 1951).

Traditional Uses

It had been used by the campesinos in Colombia as a medicinal plant to cure colic and hernia in horses, retained placenta in cows and intestinal obstructions in domestic animals (Perez- Arbelaez, 1990., Vasquez, 1987). Medicinal properties for humans have been also attributed to it. Its green stems are used to cure nephritis and its roots as a blood tonic. Its sprouts are used in maize porridge for human consumption (Vasquez, 1987). In some regions it is used as a lactogenic drink for nursing mothers (Ruiz, 1992). It has also been used as a fodder plant and as a live fence, for shade and for protection of water springs (Perez-Arbelaez, 1990., Devia, 1988., Gowda, 1990).

Reproduction and Propagation

In Panama, McDade (1983), by bagging the flowers prior to anthesis, demonstrated that the flowers do not self-pollinate as none of the stigmas of bagged flowers had any pollen grains. Other experiments shown that at least eight grains of pollen are necessary for fruit set and that mean seed set per fruit is very low (less than one of a maximum of eight), suggesting that pollination limits seed production by this species at this site. In Colombia, one species of bat, *Glossophaga soricina*, and several species of hummingbirds, ants and large bees have been observed visiting the flowers of *Trichanthera* from early to mid afternoon, when the anthesis occurs (Perez-Arbelaez, 1990., Gomez and Murgueitio, 1991). In the Cauca valley in Colombia, Acero (1985) reported the following characteristics of seeds and fruits: number of seeds/kg: 4,050,000; fruits/kg: 1,123; and seeds/fruit: 35 - 40. It has been reported that seeds do not germinate or are difficult to germinate (Acero, 1985., Murgueitio, 1989., Gowda, 1990). The percentage germination of the seeds has been found to be very low, from 0 to 2% (CIPAV, 1996).

Mangrove plants or mangroves (as distinct from mangrove communities or mangals) can be defined as tropical or subtropical ligneous plants that occur in intertidal and adjacent communities. Such plants exhibit various adaptations (e.g., aerial roots in many) to their environment. *Trichanthera gigantea* often has prop roots. It may eventually be shown to occur as a mangrove as well. Mangrove trees are not currently known among other Latin American genera of the Acanthaceae family (Daniel, 1988). The mature stems close to the ground, have the capability to form aerial roots that, when in contact with the soil, give rise to a new plant (Gomez and Murgueitio, 1991).

The propagation of this species by campesinos has been carried out using stakes, as these are easy to grow and it avoids the problems of scarcity of seeds and difficulty of germination (Gowda, 1990).

The greatest percentage germination (95%) in the tree nursery has been found using sticks 4 cm diameter and 50 cm long (Acero, 1985). In other experiments, a 92% germination was found using sticks from 2.2 to 2.8 cm diameter and 20 cm long, with a minimum of 2 leaf buds. The percentage germination was less then 50% when using bigger sticks from 3.2 to 3.8 cm diameter and from 20 to 30 cm long (Jaramillo and River, 1991).

Mortality during this period has been found to be very low (3%) (Gowda, 1990). The sticks should be obtained from the basal part of the young stems of the tree and kept in a humid and shaded place for one day and then planted in a substrate made of soil, sand and organic matter in proportions 5:1:2. The first leaves appear 27 - 29 days after planting and the trees are transplanted to the fields 50 days after that (Jaramillo and River, 1991., Acero, 1985).

Harvesting and Foliage Production

The first harvest can be made when the trees are 8 to 10 months old, giving production of foliage of 15.6 and 16.74 ton/ha (fresh matter basis) respectively at a density of 40,000 plants/ha (0.5 x 0.5 m. spacing) (Jaramillo and River, 1991). *Trichanthera* is harvested every three months, yielding 17 ton/ha per cutting (0.75 x 0.75 m. spacing) (Gomez y Murgueitio, 1991). Planted as a living fence, *Trichanthera* can yield 9.2 tons/year of fresh foliage per linear kilometre harvested every three months (1 x 1 m. spacing) (CIPAV, 1996).

Yields of fresh foliage of 8 and 17 ton/ha per cutting have been reported when the cutting height was 0.6 and 1.0 m. respectively (Gomez and Murgueitio, 1991). According to CIPAV (1996), the ideal height at cutting is 1.0 m. In regions were the temperature is high and precipitation low, better results are achieved by cutting at a height 1.3 to 1.5 m. Total biomass production (fresh foliage and young stems) has been calculated as 53 tons/ha per year (CIPAV, 1996).

Its vigorous regrowth, even with repeated cutting and without fertilizer applications, indicates that nitrogen fixation could occur in the root zone either through the action of mycorrhiza or other organisms (Preston, 1992). Nodules in the root zone were observed suggesting the association with mycorrhiza or other organisms (Gomez and Murgueitio, 1991). Significant populations of mycorrhiza (64 spores/24 g soil) have been reported (CIPAV, 1996). *Trichanthera gigantea* responds almost linearly to nitrogen from urea (up to 240 kg N/ha per year. The optimum level appears to be 160 kg/ha per year (Nguyen and Phan, 1995).

Nutritive Value

The chemical composition of the leaves and stems of *Trichanthera gigantea* is summarized in Table 1. The thin stems are included as they are also consumed by the animals. The crude protein content of the leaves varies from 15 to 22% and apparently most of this is true protein. The calcium content has been found to be particularly high compared to other fodder trees (Rosales and Galindo, 1987., Rosales *et al.*, 1992). This can be explained by the presence of cystoliths in the leaves, characteristic of the Acanthaceae family, as described above. This can explain the use that the campesinos in Colombia make of *Trichanthera gigantea* as a lactogenic drink and suggests a good potential for feeding lactating animals.

In a qualitative screening test (biochemical preliminary test) for anti-nutritional compounds, no alkaloids or condensed tannins were found in *Trichanthera* and the saponin and steroid contents were low. In other, more precise tests the contents of total phenols and steroids were found to be 450 ppm and 0.062% respectively (Rosales *et al.*, 1989). The great variation in its total phenol content, from 450 to 50,288 ppm (Table 1), has been suggested as the cause of the variation in its nutritional value. The degradability of *Trichanthera* has also been determined (see Table 2).

More recently a more complete characterisation of the nutritive value of *Trichanthera gigantea* has been accomplished. Results are shown in Table 3.

Analysis of its carbohydrate fraction revealed that this plant had the greatest amounts of water soluble carbohydrates, total and reducing sugars when compared with other fodder trees and shrubs. It also showed a surprisingly high amount of starch and its neutral detergent fibre was found to be the lowest. The high amounts of non-structural and storage carbohydrates, combined with the low amounts of structural carbohydrates, may explain the good biological results found with monogastrics. Results in Table 3 show only the presence of phenols with great capacity to react with protein. No condensed tannins were found (tests included a characterisation of phenolic peaks by means of a spectrophotometer). This suggests that tannins from *Trichanthera* may be of the hydrolysable type.

The protein in the leaves has a good amino acid balance as illustrated in Table 4. These results were compared to the amino acid contents of Azolla spp. by Preston (1995). It was found that although the amino acid composition of *Azolla* was slightly better, both had an excellent balance of amino acids, better than that of soya bean.

Table 1: Chemical composition (g/kg) of *Trichanthera gigantea* (on dry matter basis).

	DM	Crude Protein	True Protein	Ash	Crude Fibre	NDF	Ca	P	K	Mg	Total phenols (ppm)
Leaves											
	-	152.5	-	-	-	-	38.0	2.6	31.8	11.4	450a
	200	179.3	-	-	-	-	23.4	3.7	37.6	7.5	- b
	-	166.2	141.3	167	167	-	-	-	-	-	- b
	-	150.9	-	-	-	-	-	-	-	-	22,200c
	224	169.3	-	-	-	-	24.0	3.8	24.2	9.0	50,288d
	269	225.0	-	171	-	297	-	-	-	-	- e
	-	182.0	-	199	183	-	43.0	9.2	-	-	- f
Leaves and Young Stems											
	191	223.0	-	220	440	-	-	-	-	-	- e
Stems											
	-	11.9	-	313	300	-	64.0	2.1	-	-	- f
Thin Stems											
	170	86.7	-	-	-	-	26.1	4.2	69.6	7.2	- b
Thick Stems											
	270	46.25	-	-	-	-	21.9	3.6	38.0	4.8	- b

Sources:
a Rosales *et al.*, 1989; b Gomez and Murgueitio, 1991; c Jaramillo and River, 1991; d Rosales *et al.*, 1992; e Solarte, 1994; f Nhan, *et al.*, 1996

Table 2: *In sacco* degradability of *Trichanthera gigantea* (on dry matter basis).

	In sacco degradability %			
0	12h	24h	48h	72
Leaves				
-	52.4	70.0	77.2	-a
-	52.0	60.0	77.0	-b
-	-	60	-	b

Sources:
a Rosales and Galindo, 1987; b Angel, 1988; c Rosales *et al.*, 1992.

Table 3: Chemical composition (g/kg) of *Trichanthera gigantea* (on a dry matter basis).

Crude protein	178.2
Water soluble protein	35.4
Soluble protein as % of crude protein	19.8
Water soluble carbohydrates	43.2
Starch	248.2
Total sugars	170.1
Reducing sugars	91.6
Cell walls (NDF)	294.1
Lignocellulose (ADF)	217.6
Ether extract	31.2
Organic matter	804.1
Protein precipitation activity (cm2/g)	323.5
Condensed tannins (optical density/g)	0
Total phenols (optical density/g)	208.8

Source**:** Rosales, 1996.

The potential fermentability of *Trichanthera* has been assessed by the gas production method. Results showed that the fermentation of this plant species was among the highest when compared to other fodder tree and shrub species. This is related to the high amounts of carbohydrates as shown above (Table 3). Results are shown in Table 5. This is also in agreement with the high rumen degradability if this plant species. In both cases, a very rapid fermentation occurs, illustrated here by the rate of fermentation of the rapidly fermentable fraction. Most of the fermentation occurs during the first 12 hours (see degradability data).

Table 4: Amino acids contents of *Trichanthera gigantea*. Leaves were four months old and growing in 3 different environmental conditions.

	Expressed as g/16gN		Expressed as g/kg leaf	
	Means	SD	Means	SD
Aspartic acid	10.7	0.45	16.4	2.45
Threonine	5.1	0.29	7.8	1.22
Serine	5.1	0.26	7.8	1.10
Glutamic acid	11.9	0.16	18.2	2.36
Glycine	6.1	0.29	9.4	1.44
Alanine	6.2	0.22	9.5	1.42
Valine	6.1	0.19	9.3	1.32
Isoleucine	4.9	0.29	7.5	1.25
Leucine	8.7	0.46	13.3	2.09
Tyrosine	4.0	1.11	6.0	1.14
Phenylalanine	6.0	0.33	9.1	1.55
Histidine	2.8	0.49	4.4	1.29
Arginine	6.5	0.42	9.8	0.90
Proline	5.5	0.38	8.5	1.51
Total Lysine	4.0	0.82	6.0	0.95
Cystine	1.7	0.15	2.6	0.38
Methionine	2.0	0.26	3.0	0.10

Table 5: Gas production kinetics of *Trichanthera gigantea.**

Gas pool size (ml)			218.6
Rate (h^{-1})			
Rapidly fermentable fraction	2.83		
Slowly fermentable fraction		0.20	

*Fermentation carried out for 166 hours according to the Theodorou*et al.* (1994) method.
Source: Rosales (1996).

Feeding Value

In feeding trials with 35-day-old New Zealand rabbits commercial concentrate was substituted with *Trichanthera gigantea* at 10, 20 and 30% levels. The best biological responses were obtained when replacing at the 30% level. At this level the live weight gain was 32.12 g/day and the feed conversion was 4.29 compared with a live weight gain of 32.29 g/day and a feed conversion of 3.49 obtained when concentrate was used alone (Arango, 1990).

Live weight gain of 9 g day and 4.7 feed conversion have been obtained in guinea pigs Cavia porcellus fed with *Trichanthera* foliage, sugar cane juice and 30 g of protein supplement (40% protein) (CIPAV, 1996).

Live weight gain of growing hens fed a diet of maize, earthworms and *Trichanthera* was 8.4 g/day. Those fed with maize, earthworms, soya bean and *Trichanthera* gained 16.8 g/day. The gain of the control group (commercial concentrate) was 17.4 g/day, but this had the highest production costs (CIPAV, 1996).

Pigs eat it well, especially during pregnancy. However, when eaten in amounts that theoretically supply all the protein needs (about 3 Kg/day), pregnant pigs rapidly lost body condition when given only *Trichanthera* as a supplement to sugar cane juice. Up to 30% replacement of the soya bean protein by *Trichanthera* appears to be feasible (Preston, 1995).

Results, in terms of litter size and gain to weaning, from replacing 75% of the soya bean meal with *Trichanthera* in cane juice diets for pregnant sows have been very encouraging. Litter size did not differ from that of the control group and gain to weaning was slightly higher, with high levels of the leaves (Mejia, 1989). In another experiment, leaves from *Trichanthera gigantea* were used as a partial replacement for soya bean (extracted meal or cooked whole seeds) during the pregnancy phase of sows fed a basal diet of sugar cane juice. *Trichanthera* was offered ad libitum and complemented with either soya bean meal or cooked whole soya bean seeds. The control treatment received only cooked whole soya bean seeds as the protein source. There were no significant differences in productive traits (days empty, numbers, weights and growth rate of the piglets) due to treatment. Protein conversion rate (kg protein/kg of weaned piglets) was best on the *Trichanthera*+cooked soya beans (0.425) and worst on the *Trichanthera*+soya bean meal. The control treatment was intermediate (0.608). It is concluded that the leaves of *Trichanthera gigantea* can provide about 30% of the protein (about 1 kg/day of fresh leaves) of the diet of pregnant sows fed cane juice (Sarria, 1994).

Results with growing pigs have been less satisfactory. Performance was reduced at all levels of substitution of soya bean meal by *Trichanthera*. Rate of live weight gain decreased (625, 584, 522 and 451 g/day) and feed conversion deteriorated (3.04, 3.27, 3.63 and 3.89) with increasing substitution (0, 5, 15 and 25%) of soya bean protein by *Trichanthera* leaves. Intake of cane juice, protein and of total dry matter decreased with increasing substitution by *Trichanthera* leaves (Sarria *et al*., 1991).

A cafeteria trial using foliage of *Gliricidia sepium*, *Trichanthera gigantea* and *Leucaena leucocephala* was carried out with weaned lambs (African hair sheep breed) to establish their preference. Relative intakes (kg DM/100 kg live weight/day) were: *Gliricidia sepium* 1.84, *Trichanthera gigantea* 0.73, and *Leucaena leucocephala* 0.19. Results suggested that the factor which most influenced intake of a particular tree foliage was the degree to which the animals were accustomed to eating it and highlighted the need to give the animals an adequate time to adapt to such feeds before they are able to consume appreciable quantities (Mejia and Vargas, 1993).

References

Acero, L. E. 1985. Arboles de la zona cafetera colombiana. Bogota, Ediciones Fondo Cultural Cafetero. Volumen 16. 132pp.

Angel, J. E. 1988. Avances en la evaluacion de recursos nutricionales tropicales en Colombia. In: Reporte de Investigacion 1(1) CIPAV, Cali, Colombia, pp 26.

Arango, J. F. 1990. Evaluacion de tres niveles de nacedero *Trichanthera gigantea* en ceba de conejos Nueva Zelanda. Tesis de Grado. Zootecnia. Universidad Nacional de Colombia, Palmira.

Centro para la Investigacion en Sistemas Sostenibles de Produccion Agropecuaria (CIPAV). 1996. Arboles utilizados en la alimentacion animal como fuente proteica. Cali, Colombia, 123 pp.

Daniel, T. F. 1988. A systematic study of Bravaisia DC. (ACANTHACEAE). In: Proceedings of the California Academy of Sciences. San Francisco. Vol. 45(8):111-132.

Devia, A. 1988. Cercas vivas y barreras cortavientos. Revista Esso Agricola No 2, November 1988.

Gomez, M. E. and Murgueitio, E. 1991. Efecto de la altura de corte sobre la produccion de biomasa de nacedero (*Trichanthera gigantea*). Livestock Research for Rural Development 3 (3):14- 23.

Gowda, J. H. 1990. Evaluacion de dos especies arboreas agroforestales del Valle del Cauca en la parte central de Colombia *Erythrina poeppigiana y Trichanthera gigantea*. Sveriges Lantbruksuniversitet. Informe 126. IRDC Uppsala. 17 pp.

Jaramillo, C. J. and Corredor, G. 1989. Plantas forrajeras: proteina barata para el ganado. Revista Federacion Nacional de Cafeteros de Colombia.

Jaramillo, P. H and Rivera, P. E. 1991. Efecto del tipo de estaca y la densidad de siembra sobre el establecimiento y produccion inicial de nacedero *Trichanthera gigantea* Humboldt & Bonpland. Tesis de Grado. Zootecnia. Universidad Nacional de Colombia, Palmira.

Leonard, E. 1951 .The Acanthaceae of Colombia. I. Contributions from the National Herbarium Washington. United States National Museum 31:1- 51.

McDade, L.A. 1983. Pollination intensity and seed set in *Trichanthera gigantea* (ACANTHACEAE). Biotropica. 15(2):122- 124.

Mejia, C. E. and Vargas, J. E. 1993. Analisis de selectividad de ovejas africanas con cuatro tipos de forrajes. Livestock Research for Rural Development 5(3):37-41.

Mejia, C. E. 1989. Observaciones sobre el uso del follaje de Nacedero (*Trichanthera gigantea*) como supplemento proteico en dietas de jugo de cana para cerdas gestantes. In: Reporte Anual de Investigacion (I Semestre), CIPAV. July 1989. 122 pp.

Murgueitio. E. 1989. Los arboles forrajeros en la alimentacion animal. In: Proceedings of Primer seminario regional de biotecnologia. CVC-Universidad Nacional de Colombia. pp 5-9.

Nguyen Ngoc Ha and Phan Thi Phan. 1995. Vegetative propagation capacities and effect of fertilization on biomass production of *Trichanthera gigantea*. Livestock Research for Rural Development 7(1)10Kb.

Nhan, N. T. H., Van Hon, N., Preston, T. R. and Dolberg, F. 1996. Effect of shade on biomass production and composition of the forage tree *Trichanthera gigantea*. Livestock Research for Rural Development, Volume 8, Number 2, pp 93.

Perez-Arbelaez, E. 1990. Plantas utiles de Colombia. Editorial Victor Hugo, Medellin. 14th edition. 832 pp.

Preston T. R. 1992 The role of multipurpose trees in integrated farming systems for the wet tropics. In: Legume trees and other fodder trees as protein source for livestock. FAO Animal Production and Health Paper No. 102. Edited By A. Speedy and P. Pugliese. pp 193-209.

Preston, T. R. 1995. Tropical animal feeding. A manual for research workers. FAO Animal Production and Health Paper No. 126. 305 pp.

Record, S.J and Hess, R. W. 1972. Timbers of the new world. Use and abuse of America's natural resources. Arno Press. New York. 642 pp.

Rosales, M. 1996. In vitro assessment of the nutritive value of mixtures of leaves from tropical fodder trees. D.Phil. thesis, Department of Plant Sciences, Oxford University, Oxford, UK. 214 pp.

Rosales, M. and Galindo, W. 1987. Aportes al desarrollo de un sistema de alimentacion para cabras en el tropico. Tesis de grado. Universidad Nacional de Colombia. Facultad de Ciencias Agropecuarias; Palmira.

Rosales, M., Preston, T.R., Vargas, J.E. 1992. Advances in the characterization of non conventional resources with potential use in animal production. British Society of Animal Production. Animal Production in Developing Countries. Occasional Publication No.16. pp. 228-229.

Rosales, M. Galindo, W. F., Murgueitio, E., and Larrahondo, J. 1989. Sustancias antinutricionales en las hojas de Guamo, Nacedero y Matarraton. Livestock Research for Rural Development. An International Computerised Journal Vol 1, No.1. 29,748 Bytes

.

Sarria, P. 1994. Efecto del nacedero (*Trichanthera gigantea*) como reemplazo parcial de la soya en cerdas en gestacion y lactancia recibiendo una dieta basica de jugo de cana. Livestock Research for Rural Development 6(1):62-73.

Sarria, P., Villavicencio, E., and Orejuela, L.E. 1991. Utilizacion de follaje de nacedero *Trichanthera gigantea* en la alimentacion de cerdos de engorde. Livestock Production for Rural Development 3(2):51-58.

Solarte, J. A. 1994. Experiences from two ethnic groups of farmers participating in livestock research in different ecological zones of the Cauca Valley of Colombia. M.Sc. Thesis. Swedish University of Agricultural Sciences. Uppsala. 80pp.

Theodorou, M.K., Williams, B.A., Dhanoa, M.S., McAllan, A.B. and France, J. 1994. A simple gas production method using a pressure transducer to determine the fermentation kinetics of ruminants feeds. Animal Feed Science and Technology 48:185- 197.

Vasquez, M. L. 1987. Plantas y frutas medicinales de Colombia y America. Editorial CLIMET. Cali.

Comments on Introductory Paper

From: Jeroen Dijkman (AGAP) <Jeroen.Dijkman@fao.org>

Comment on introductory paper

Whereas I fully agree with the sentiments and desires expressed in both the introductory and second paper, I would like to raise a number of issues relating to the points made thus far.

It has been (rightly?) argued that, ideally, farming methods should be sustainable on all levels. What this actually means in practice (and what do we use for our baseline?) and how one assesses it (or dare I say, measure it) is a completely different proposition. As far as I am aware, but I stand to be corrected , there has been no significant work done on the establishment of actual practical indicators of the various levels of sustainability other than 'what they could be'. In the current research funding-climate I do not see anyone making the needed long-term commitment that will change this situation, either.

The next immediate question, which was raised in the first paper, is time.

But what time-scale do we talk about? Five, 10, 30, 100 years? And can we be sure that if something appears to be 'sustainable' for 5 years that this will still be the case in 25 years time?

There are, in my view, also more inherent dangers to the application of any set time-scale to both the development of indicators and the interpretation of trends and results in general. This is probably best illustrated for the 'pasture-tree systems in arid or semi-arid savannah'. In these systems the carrying capacity concept has long been used as the scientific standard against which rangelands were judged to be overgrazed, and to prove that pastoralism, as practised in the majority of the world's rangelands is inherently inefficient and environmentally destructive (e.g. Hardin, 1968; Lamprey, 1983). Long-term research has shown, however, that severe droughts are integral part of the long-term dynamics in Africa. Some evidence indicates a climate induced movement of the Saharan vegetation belts, but there is no evidence to substantiate the claims that grazing livestock are a major causal agent. Frequently, areas perceived as degraded due to the over-exploitation by pastoralists, quickly recover as soon as the rains return. Nevertheless, the portrayal of pastoralists as instigators rather than victims, and the assumption of livestock induced desertification and rangeland degradation as a basis for research, has made policy makers and international organisations move away from pastoralists rangeland development issues (e.g. Sandford, 1983; Ellis and Swift, 1988; Behnke and Scoones, 1993). I think that we stand to make similar mistakes in other systems if we move without properly understanding their dynamics. Moreover, I think that we are, again, in danger of pointing the finger of accusation at small-scale farmers.

In principle, of course, there is nothing wrong with farmers burning down a patch of rainforest and cultivating it until it is exhausted. From their point of view it may even be the most beneficial option. There are still a fair number of places where there is still enough new land. On a global basis, the actions of these farmers probably have much less influence than any large-scale commercial logging or mining operation, and it are the greater political issues that form the root-causes to a number of these problems that need to be addressed.

So the next question is 'sustainability for who' and more to the point for 'whose benefit'? Of course we should be thinking about the design of sustainable options that provide people a secure and good long-term income so they can afford a reasonable standard of living, but in many instances it may be more profitable to take the quick 'easy' money and run. In addition, whereas we have the relative luxury being able to contemplate the next 25 years or so of our existence, such considerations may not be foremost in the mind of a person trying to find an income/meal for the day. In many cases people are well aware of the long-term implications of their actions, but they still have to survive today.

At a more practical level of course, there are a number of other important issues related to the establishment of so called 'sustainable systems'. In many cases the establishment of these models takes a good number of years (e.g. perennial trees may take a long period to bare fruits). The models, therefore, need to be designed in such a way that the farmers also have a good income throughout this 'establishment' period. I know there have been some 'successful' pilot experiments, but can we sure that experimental (small-scale) models actually translate to the 'scaled-up' real world?

In addition, there is the issues of land-tenure. Dr. Dolberg mentioned land-less farmers and in the same way people who 'share-crop' or farm on rented land should be included in the discussions. Quite often the tenancy agreements are such that any establishment of more longer term or more 'sustainable' measures are of no actual interest to the tenant.

There are of course numerous other points, but I am sure I have rattled on long enough by now. There is, however, one final comment I would like to make. I have no doubt that the studies reported in the second paper were carried out properly, but I do think we need to ask ourselves 'who is asking the questions' and with 'what purpose'. I have participated in a number of PRAs and too often the solutions identified by the 'community' are, basically, what the researchers had in mind at the onset of the PRA. Whereas there may be nothing wrong with that in principle, I do think we have to remain self-critical and open minded. Nowadays it seems that as long as we do things 'participatory' no further questions need to be asked.

From: Andrew Speedy <speedy@ermine.ox.ac.uk>
Reply to Comments from Jeroen Dijkman:
I will let others comment more fully on some of your points. 'Indicators of sustainability' is a buzz-phrase and you are right to highlight the time scale. But measurements can be made. Soil, biomass production, input-output studies... Who is doing this and who has some data??? Over time, the system must be adaptable, especially if local and wider markets change. This must be a feature of the system. Adaptability to climate variations is another point. many of the savannah systems are vulnerable because they do not include trees (which are deeper rooting and withstand drought). These were present in the natural system before pasture 'improvement'. But again concerning the question about sustainable grazing systems using common lands??? Can anyone cite successful

examples. CIAT? ILRI? ICRISAT?

On an optimistic front, there are good results with establishment of fodder trees (*Leucaena, Gliricidia, Erythrina*) in 2 years in tropical regions. CIPAV have data! (CIPAV please comment!). Again, here is an opportunity for people to contribute hard data. I am struck by the lack of DM production data even on these popular species.

I have posed a number of further questions. It is hoped that participants will feel very free to add comments. Certainly we should not be complacent about results of participatory work and systems studies. What is clear from the literature (or lack of it) is that we need hard data.

That has been said several times. Here is the opportunity to 'publish' results!

Jeroen Dijkman, FAO (AGAP)

From Lylian Rodriguez ,lylian%sarec%ifs.plants@ox.ac.uk>
Comments on introductory paper

I am Lylian Rodriguez a Colombian working in an NGO-CIPAV in Colombia and studying and working in Vietnam for the past two years. I would like to comment in some points raised for some participants.

1.Regarding the introductory paper: Livestock Feed Resources Within Integrated Farming Systems. A.W. Speedy, C. Dalibard and R. Sansoucy, FAO Rome.

"*In this first conference, the evduation of the nutritive value of tropical feeds for ruminants was reviewed by Leng (1996) and extensively discussed by the participants. To summarize, there are many data on the chemical analysis and calculated nutritive value of animal feeds but the emphasis has been on grains and supplements used in temperate systems. Far fewer data exist on the less conventional feeds and forages, especially those found in the tropics.*"

I think the question is not only about the availability of information but also which are the appropriate analyses to do in order to assess the nutritive value of tropical feeds? A lot of work has been done analyzing hundreds of samples and hundreds of items but, in the end, how does it benefit the development of feeding systems? Another question is how to develop simple techniques that would be suitable under difficult conditions? We may come to the conclusion that not many analyses are needed to assess tropical feeds and that a combination between simple technics and feeding trials having the animal as the best laboratory is the best approach.

"Multinationals have now taken over control ofthe system, and many developing countries are caught in the vicious circle of requiring commercial production to generate thehard currency needed to pay for the inputs."

In Vietnam News September 2, 1995 an article "Wars do not end Conflicts", Hari Chathrattil wrote: "The failure of the Green (agriculture), the Blue (aqua culture) and the White (dairy farms) Revolutions in India to bring about any degree of parity between the rich and the poor is eloquent testimony to the non applicability of the industrialization process. All these revolutions depend on modern technology and not on people. Ultimately the target beneficiaries of all this development -poor people- are left in the lurch."

"Agricultural education and training in both the developed and developing world put much more emphasis on specialization than on integration. Institutions separate crop and animal production at all levels (extensionists, researchers and decision makers), and the two groups ignore each other and struggle separately for power and budgets. They develop separate projects instead of cooperating with each other and exploiting the benefits of integration."

A change in the method of education is fundamental. The world needs sustainable education. Are we new professionals ready to work towards a suitable approach? It is difficult when traditional teaching is focussed on technological packages as a consequence of the green revolution and when the major objective is to train people to work for the multi-national enterprises, to sell concentrates or medicines or pesticides.

The professionals involved in the education system need to create a deep and wide conscience about appreciating the real situation facing poor farmers and what needs to be done in order to promote truly sustainable agricultural systems and to try to understand these issues.

My BSc is in Animal Husbandry and, when I was at the university, I did not have the opportunity to learn even about "forage trees" It wasn't anywhere in the curriculum!! But we had to learn about how to cultivate grasses like King grass and so on. Just an example!! Many of my classmates are working with multinationals!! That was in Colombia but the situation in Vietnam is similar near to the cities like Ho Chi Minh where there are some big enterprises. But in the remote areas the situation is even worse because day by day there are less people who want to study agriculture. Why is it happening? Maybe because what they are learning at the universities is not that farmers need!! The change most be at pre and post graduate level. We need change in many aspects!!

2. About Jeroen Dijkman's comments:
"In principle, of course, there is nothing wrong with farmers burning down a patch of rainforest and cultivating it until it is exhausted. From their point of view it may even be the most beneficial option. There are still a fair number of places where there is still enough new land. On a global basis, the actions of these farmers probably have much less influence than any large-scale commercial logging or mining operation, and it are the greater political issues that form the root-causes to a number of these problems that need to be addressed. - So the next question is 'sustainability for whom?' and more to the point for 'whose benefit'? Of course we should be thinking about the design of sustainable options that provide people a secure and good long-term income so they can afford a reasonable standard of living, but in many instances it may be more profitable to take the quick 'easy' money and run. In addition, whereas we have the relative luxury being able to contemplate the next 25 years or so of our existence, such considerations may not be foremost in the mind of a person trying to find an income/meal for the day. In many cases people are well aware of the long-term implications of their actions, but they still have to survive today."

I agree and I therefore believe that the approach must be more global "to develop sustainable systems of production" and we should involve credit in development but suitable credit for the poor people, for those landless that don't have any other way to get timber, fire wood to sell and for cooking and for those who have to burn forest to plant something to get the food for today but don't know what will happen tomorrow. But if there are appropriate strategies combining, credit, appropriate technology, research, extension and again appropriate education development could be more solid and sustainable.

We had the opportunity to visit Bangladesh recently with a Vietnamese colleague and we could see how the institutions such as Grameen bank and BRAC and other NGOs are having a very big impact on people (Grameen Bank with 2 million members and BRAC 1.6 million) and with high involvement of the community. They provide suitable credit for the poor where they are not asked for collateral to borrow money and where they start with small loans and people invest it according to their own skills so they usually diversify activities. We could see that the role of livestock is very important, especially poultry for the poorest of the poor and certainly the access to appropriate credit has been a change in their lives.

"There are of course numerous other points, but I am sure I have rattled on long enough by now. There is,however, one final comment I would like to make. I have no doubt that the studies reported in the second paper were carried out properly, but I do think we need to ask ourselves 'who is asking the questions' and with 'what purpose'. I have participated in a number of PRAs and too often the solutions identified by the 'community' are, basically, what the researchers had in mind at the onset of the PRA. Whereas there may be nothing wrong with that in principle, I do think we have to remain self-critical and open minded. Nowadays it seems that as long as we do things 'participatory' no further questions need to be asked."

It is a very interesting point!! Certainly Participatory Rural Appraisal has became a "fashion" and, as you said, in most cases the answers or the results of those activities are the answers that the outsiders are expecting.

In our work, we had to change our objectives according to the farmers' ideas and that was how we came to the local breeds of pigs. Participation is a mutual learning process where "outsiders", local authorities and farmers can increase their awareness of what to do to achieve change. But what is true participation? There are many kinds of participation from passive participation, where people are involved merely by being told what is to happen, to self-mobilization, where people take initiatives independently of external institutions (Pretty 1995). Through our project activities, it has been shown that participation is also a learning process, based principally on confidence among outsiders and the target group.

Regarding the project, it may give you a more clear idea by quoting one of the conclusions: In this project there was a clear example in how do we "outsiders" think about "appropriate technologies" (Chambers, 1983) to be applied at village level and the result was a "learning" from farmers and the project changed from, milk production as an additional purpose for the local cows to biodigesters to duck weed as a source of protein to local breeds on pigs and, finally, to get and overall view of the socio-economic situation of the village. Definitely it is a way to really, but not completely, understand the village situation. There must be an active process where outsiders try to understand the situation, offer alternatives which may have some impact in the village, using an iterative process of trial-error (Dolberg, 1994) and villagers participate actively making criticisms and suggestions to the outsiders, giving ideas which may change the researcher's objectives. The starting point must be around this approach, it can not be achieved only with participation in information giving (Pretty 1995) where people participate by answering questions posed by extractive researchers using questionnaire surveys or similar approaches and people do not have the opportunity to influence proceedings. What agriculture needs is a willingness among professionals to learn from farmers.

3. Regarding Andrew Speedy comments:
"On an optimistic front, there are good results with establishment of fodder trees (Leucaena, Gliricidia, Erythrina) in 2 years in tropical regions. CIPAV have data! (CIPAV please comment!). Again, here is an

opportunity for people to contribute hard data. I am struck by the lack of DM production data even on these popular species."
Yes, in the case of Colombia, a lot of work has been done in the use of forage trees such as *Gliricidia, Leucaena, Erythrina, Trichanthera gigantea* with medium and small scale farmers and there are results for almost 10 years. In this system trees such as *Gliricidia sepium*, *Leucaena leucocephala* and *Erythrina fusca* are planted at densities in the range 600 to 1100/ha (*E. fusca*), 10,000 to 20,000 (*G. sepium, L. leucocephala*) and 25-50/ha (*Prosopis juliflora*), in association with grasses such as Star grass (*Cynodon nlemfuensis*) and Argentina grass (*Cynodon dactylon*). The trees are lopped at intervals of 90-120 days in the case of *E. fusca* and *G. sepium*, browsed at intervals of 40-60 days for *L. leucocephala* or left for the fruits to fall and be consumed in situ or collected (*P. juliflora*).

I was working in a medium scale integrated farm in Colombia where there is a silvopastoral system involving *Erythrina fusca* and star grass and there are two fields that were planted from a combination of cuttings and seed. The first had an area of 1 ha, with 1,102 trees at distances between them of 3m. The second was 9,913 m^2, with 512 trees at a distance of 4m between trees. The original vegetation in both fields was African Star grass which quickly re-established itself to form a stable association with the trees. Management consisted of rotational grazing with 6 divisions in each area using electric fences. Occasionally the milking herd of dual purpose Holstein-Zebu F1 cows grazed the pasture but mainly this was with calves both pre- and post-weaning. The foliage of the trees was cut from branches 2m above ground level. The first harvest was 16 months after planting and subsequently at 3-4 month intervals. The shade effect of the trees ranged from zero, immediately after harvesting, to 100% after 3-4 months of regrowth when the next harvest of the foliage was due.

Estimations of biomass production of the star grass (by cutting 1 m squares prior to grazing) were of the order of 90-100 tonnes/ha/year. The mean yields of erythrina foliage were: 13.3 and 15.7 kg/tree/harvest for the 3*3 and 4*4 spacings, respectively. Annual yields averaged: 51 and 28 tonnes fresh foliage/ha/year. With these yields it was estimated that the legume foliage used as a supplement (9 kg/day for animals of 300 kg live weight) would support 8-13 animals/ha/year; and that the capacity of the pasture was 3 animal units (400 kg live weight)/ha/year. More information available in (Cuellar Piedad, Rodriguez Lylian and Preston TR) in LRRD 8.1.

I hope my friends in Colombia will add more information.

Lylian Rodriguez

From: Chedly Kayouli (Tunisia) < 101763.2164@compuserve.com>
Comments on Introductory Paper

Integration vs. Specialization...

1: Several formerly colonized countries which have replaced the traditional farming system by large scale commercial productions that has been encouraged by the old colonial powers are nowadays living through the drama of the so-called New World Economic Order and many products are not competitive for export; furthermore some crops have impoverished the soil.

2: As the majority of education programs in developing countries are inspired by those of developed countries and have opted for specialization, many institutions in Third World countries are still unfortunately unaware and continue to implement specialized agricultural projects. I trust that the recently establishment of the University for Tropical Agriculture Foundation (UTA Foundation) in Ho Chi Minh City will help many young scientists and researchers in acquiring a new educational program on the benefits of sustainable tropical livestock-based agriculture.

3: What about the vicious circle and the equation: Food Security + Sustainable management of resources = Improving welfare of rural poor.

I think that Food Security is a utopian notion of the end of this century and perfectly illustrates the failure of most agricultural projects in developing countries and particularly in Africa, implemented by international agencies and local governments. It is surprising to observe again in the emergency programs the same errors as those committed earlier:

First: Demographic pressure is a major cause threatening food security; human population in Africa had increased from 238 million in 1950 to 665 million in 1993. So what has been done to slow down the population growth rate?

Secondly: The Third World is facing too many different sources of food insecurity: low carry-over stocks of grain, less arable land, unsustainable use of land and water, cumulative effects of soil erosion and other forms of environmental degradation, and severe frequent drought. These are the major problems, while almost all new food security programs put much more emphasis on the use of chemical fertilizers and higher yielding cereal varieties. The cultivation of cereals (wheat, rice, maize, millet..) is seen by many people as the primary activity in the farming system to ensure food security and they often ignore the role of livestock for food security for almost all farm families in developing countries as:

(i) an important food source (e.g. in Third World pastoral communities)

(ii) a source of income and generator of employment (mainly in North Africa, the Saharan zones, the Middle East, the Central Asian Republic...)

(iii) a supplier of production inputs: in many low-income countries, animals are the main source of (1) draught power (transport sector, crop cultivation...) and (2) fertilizer: Nitrogen fertilizer plays a key role in improving soil fertility. In this respect manure is considered an essential input to increase crop production. Recently in Laos and Niger, we have recorded a meaningful increase of between 15 to 24% per hectare of paddy rice and millet when farmers spread manure from animals fed urea treated rice straw (because of its higher nitrogen content) than when they use that produced by animals fed untreated straw.

Therefore, decision makers and institutions should be aware of the key impact of animals to promote and strengthen the capability of farmers to run an integrated Livestock-Agriculture system and improve food security.

Comments on Integrated Farming System

Here I share the same ideas presented by Jeroen Dijkman and I can add the following comments:

I think that scientists have contributed little in this matter and their intervention has often disturbed efficient traditional methods practised by rural families. In fact the farming system is dynamic. There are considerable variations in the farming systems in developing countries and they often change in response to exogenous factors such as drought, economic policy reforms, patterns of demand on market, etc. For example, in many Sub-Sahara African zones, farmers have adapted their farming system for survival and adopted strategies which minimize risk in an uncertain natural and economic environment. Population growth and shortage of grazing lands are the main factors which sharply accelerate the process of integrating livestock into crop production systems and crop residues are becoming increasingly valuable as animal feed. Consequently, I have difficulty seeing how, when cultivable land becomes scarce in relation to population as occurs in South-east Asia and many African countries, integrated farming systems with major fodder crop components would be developed. Understanding the ways in which poor farmers overcome production constraints and develop farming system is fundamental to the analysis of the systems before parachuting in with « top-down » schemes.

Chedly Kayouli, Professor of Animal Sciences, Institut National Agronomique de Tunisie, 43 Avenue Charles Nicole, 10082 Tunis, TUNISIA

From Floyd Neckles <fanec@eclacps.undp.org>

Comments on the introductory paper

I am in the English-speaking Commonwealth Caribbean which consists of two bigger mainland nations, Belize and Guyana, and a chain of much smaller island-states.

The general background is agreeable. There should be emphasis on the "whole ration" and also what is expected from the particular animal or group of animals. The benefit to be derived from the animal product on its disposal is important as agriculture in this part of the world is part of a very "monetised" economy. Level of performances must be suitably high with returns to the farmer that are compatible stimulating continued production. This does not mean that all units or aspects of a farm should be aimed at producing for sale. It is found that home consumption of products of the farm and also sale on informal markets contribute to either savings or to cash income. Integrated farming is being encouraged even where "monoculture" livestock or crop farms have been established and are operating.

I agree with Rodriguez in that there has been what I loosely call agricultural "mis-education" in training at the university level. This refers especially to systems of production and the use of farm and other resources. Often the technological solutions promoted for increasing production may be high cost and alien to existing agricultural practices and local circumstances. This is not to say that the basic principles learnt are not relevant but rather technical solutions offered should seek to be relevant to the particular context. Sometimes there has been dismissal of existing, traditional activity without attempting to grasp its relevance and basis.

Integration vs Specialisation:

In a sense we are fortunate that with small land area of the islands even the agriculture with its emphasis on export crops utilised some of the small-holder systems:

(a) the tree cultivations were mixed with the possible exception of sugarcane (even here the small farmer tended to interplant other crops and in some industries estates reserved land for root crops, etc.);

(b) animals were used for transport, power, manure and their meat and milk. They were reared in pens or zero-grazed, staked between the trees.

This changed with the attempt at modernisation in the 1960's and after. Then tractors replaced livestock for power, inorganic replaced organic fertiliser and livestock and crops were separated with special projects developed to increase livestock output by modernising production systems using improved grasses, imported animals and feeds, etc. Many small farmers own/contract tractors for work and organic manure is used mainly in vegetables. They are returning to the traditional systems with integrated activity and use of local feeds.

There is a consideration I want to raise. In the early 1980's, we, at the Sugarcane Feeds Centre, felt that imported protein supplements should be replaced by local sources. It was felt the feed sources should be as far as possible from within the nation and should come from diversified national agricultural production. By the end of the decade it was recognised that local by-product feeds were being excessively priced, even in instances where no real shortage existed. The approach then had to be modified to encourage producers to utilise their resources, especially land, to produce as much of their needs themselves while reducing dependence on external sources to the minimum practicable or to the optimum level. This ought maybe to have been the emphasis from the start! but agricultural systems and production is in any event "evolutionary!"

System Definition:

The system definition based on agro-ecological zones is obviously applicable to the larger land masses. It is, however, also applicable to the small island situation. While the general climatic conditions in the geographic region are similar, there are significant variations in the rainfall between islands (influenced by latitude?) and between areas within the islands mainly influenced by topography. Along with the soil origin, history of cultivation (often historically damaged, eroded, etc. from previous plantation exploitation), water retention capacity, etc., there are differences in the agricultural possibilities - crops cultivated, system of production, etc. and related by-products and the animal rearing activity.

This influences how natural or introduced forages are used. In fact, in attempting to train and work in production systems in the region, the approach taken has been to encourage thought on the ecology, the resulting crop farm production and how animals may be better integrated considering social, cultural, historic and economic matters.

I will attempt to capture and explain more fully in a short presentation on feeding resources in integrated systems in small island states in the course of preparation for this conference.

Floyd Neckles, Director, Sugarcane Feeds Centre Trinidad and Tobago

From Miltos Hadjipanayiotou <miltos@arinet.ari.gov.cy>
Comment on the introductory paper

It is stated in the introductory paper that animals have access to heterogenous materials (forages, fodders, trees etc), and that their nutritional value is affected by many factors (plant age, season, location etc).

Are the farmers aware of the above mentioned factors? Do they apply any control usage of them for maintaining the existing feed resources? Are the existing resources used in a way to obtain the maximum output of nutrients (quantitatively, qualitatively) and at the appropriate stage of production?

Finally, in case of absence of such knowledge, I am wondering whether it might be worthwhile considering the fact of producing/collecting such information locally, and thus contributing towards better and greater use of resources.

From: S. Bellon (INRA France) bellon@avignon.inra.fr
Comments on Hadjipanayiotou's comments on introductory paper

Hadjipanayiotou asked:

"Are the existing resources used in a way to obtain the maximum output of nutrients (quantitatively, qualitatively) and at the appropriate stage of production?"

For instance, one could address what "resources" actually are and why a "maximum" output should be expected?

This issue is obviously related to sustainability...

From: Jean S. ZOUNDI <zoundi@burkina.coraf.bf>

Hadjipanayoitou did a very pertinent analysis on the introductory paper. The question is important because in most cases the producers do not clearly feel the output of the digestion in terms of nutrients. What is important for them is the increase of liveweight and the body condition of their animals. They often perceive the feed quality only through the level of intake: they will recognize a poor quality feed for its poor intake and they will often use products as salt to increase the intake.

Despite the difficulty of appreciating fodders quality and the need to combine them adequately to offer the maximum of nutrients to the animal, it is still very important to take into account all the parameters when setting up the feeding systems. The producers' understanding is related to their level of instruction and training. Experience shows that in many places, the acceptation of innovations will be mainly dependant on these factors.

From Dr Thomas Acamovic <t.acamovic@ab.sac.ac.uk>
Comments on feed analyses

In terms of analyses of tropical feeds: I don't think that we know what the 'appropriate' analyses are for tropical feeds. I feel that components of feeds and other attributes that are not currently measured require attention (eg the composition of the polysaccharides, phenols, etc). These are very complex moieties and their effects may vary between plants although the types of compounds concerned may be crudely classified into what appears to be simple compounds eg. fibre, NSPs, tannins etc. Thus on the contrary to Rodriguez I feel that more, and more discriminative methods may be required (not sure what, mind you) to adequately characterise tropical feeds but techniques such as NIR yield a lot of information but requires adequate interpretation. NIR is however practically very simple to use, dry and grind the sample and scan it. The equipment and interpretation is however complex.

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From E. R. Orskov <ero@rri.sari.ac.uk>
Comments on analysis of feed

Lylian's comments on feed evaluation are very pertinent. What is the most appropriate analysis? So much of chemical analysis have been done in order to fill tables in publications with little regard for whom the data is to benefit. In almost all cases robust biological tests are the most valuable, e.g. *in sacco* and *in vitro* gas production. Yet they do not always give the information required. There are exceptions. Sometimes palatability is a problem which cannot always be predicted by any known analysis: *Trichanthera gigantea* is loved by pigs but goats don't like it, based on experience by Dr. Preston's group in Vietnam. However we must work on finding robust evaluation methods. Crop residues are generally well evaluated by the above methods and much progress such as development of upgrading methods would not have been possible without use of rapid evaluation methods. Evaluation methods are needed for farmers to estimate exchange rate value for feeds and for planners of livestock production to match the potential of the prevalent feed resource base to the type of animal production. I agree that static western evaluation methods are of little value to farmers and planners when mainly roughages are fed.

I would finally like to add some comments on products from animals. We are educated to think specialistic, using parameters such as feed conversion etc. with scant regard for the resource value of the excreta. For pigs in Europe this has had the consequence that in many instances the manure is poisonous for sheep, fish and soil due to the high copper content because copper for pigs is a so-called growth promoter.

We must learn to see livestock in their holistic interaction with plant and soil because at least 90% of our clients are not specialistic livestock keepers. As pointed out by Dr. Kayouli, there are a multitude of products often not recognized.

The greatest products of grazing cattle under coconut trees in Sri Lanka at a high stocking rate was not animal gains or milk but coconut yield, due to greater biomass turnover and high water holding capacity of the soil. Supplementing the cattle gave responses both in increasing coconut yield, animal reproduction and milk and in soil fertility. There are many such examples.

Poultry is kept by Kikuyu farmers in Kenya not only to produce eggs and meat but to produce excreta which is the supplement for the cattle consuming maize stover. Input to the farm is not artificial fertilizer but food. The success of urea treatment of straw is much greater if it is used for several purposes, upgrading, feeding of rumen microbes to stimulate intake and to provide manure with a higher nitrogen content. We need to train research workers to look at resource use from its production to its mineralization. Pollution is caused by inefficient resource use and attention to labour efficiency. We do not need in the foreseeable future to increase biomass production for feeding the world but we can gain enormously by paying attention to biomass utilization. Many small farmers in Asia, as pointed out by Lylian, give examples on how this can be done and even in China and Vietnam many resources are under-utilized. Livestock can and should play an important role in this process, but we need to have plant breeders, soil scientists and socioeconomics to be on board to make it happen and in some areas we need people with expertise in aquaculture and biogas.

Attention to total biomass use and of course soil fertility using livestock, biogas, aquaculture etc. also create rural employment which is so important as it will otherwise be converted to urban poverty of which there are many examples already with consequence for social unrest, crime etc. Has anybody from Asia or elsewhere information on what can be produced from say 1 tonne of rice straw in terms of nutrients for animals, biogas, fish and fertilizer or similar situations with complete resource use.

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From Peter Uden <peter.uden@huv.slu.se>

Comments on the use of feed analysis

It has become fashionable to denounce the use of feed analysis as a research tool in tropical animal nutrition. I do not agree with this particular school of thought. Lack of funds may be a reason for a reduced emphasis in laboratory analysis but so far we have no other tool to make comparisons between trials and to relate the feed to the animal responses. If we know nothing about the feed other than its name and the quantity consumed, how on earth shall we be able to sort out cause and effect?

The plant-animal interactions are strongly influenced by the environment, the genotype of both the plant and the animal, the phenological state of the plant and the physiological status of the animal. Plant composition does control the nutritive value even though we do not fully understand the relationships yet.

All functional feeding systems in the world rely on the successful merger of plant nutritive value estimated by laboratory analysis and information about the animal. For a successful "merger", animal trials are required where response factors are estimated. This has cost and will cost money, but a lot of knowledge can easily be transferred to the tropics. Magical interactions only found in the tropics have been used as arguments for not being able to transfer nutrition knowledge from temperate to tropical countries. I personally think this is based more on ignorance than on insight.

Development of feeding systems in the tropics will have to follow a similar path as that in the industrialized world. There are no short cuts and no basic differences between either plants and animals in temperate and tropical regions. Diversity is just greater in the tropics and our knowledge less.

How should we decide on what to spend our money in a nutrition trial? On laboratory analysis or on animals? Besides the fact that no scientific journal would publish the results without a minimum of analytical data, we would never be able to make any predictions which could benefit others.

Every country needs a functional feed evaluation system. Let's slowly build up the capacity for laboratory analysis and don't fool anyone than only nylon bags and in vivo trials are enough.

Dr Peter Uden, Department of AnimalNutrition & Management, Box 7024 750 07, Uppsala, Sweden, tel.: 46-(0)18-672058, Fax 46-(0)18-672995 e-mail: peter.uden@huv.slu.se

From Mauricio Rosales <rosales@vax.ox.ac.uk>
Comments on Orskov's comments about *Trichanthera*

Dr Orskov commented on the fact that chemical analysis cannot always predict palatability and used the example of *Trichanthera gigantea* being readily consumed by pigs but not accepted by goats, according to Dr Preston's experience in Vietnam. Although it is a good example to illustrate his point, it may leave the impression on the participants that this is always the case. I have been involved in the research on *Trichanthera* since it was started by CIPAV back in 1987. The first trial was carried with two breeds of goats. A local and an alpine breed, recently imported from Europe, were offered *Trichanthera gigantea* as a supplement to a diet of sugar cane tops and king grass. There were no negative effects on the animals, *Trichanthera* was readily accepted and milk production increased over the control. Since then, the use of this plant species has been validated in different feeding trials with rabbits, guinea pigs, hens, chickens, pigs, African hair sheep and dairy cattle. It has also been tested, to a lesser extent, on equines and buffaloes. Results have been positive most of the time, however, certain special cases, like that highlighted by Dr Orskov, were identified. Several hypothesis were put forward to explain the few cases when low biological responses were found: deleterious factors and amino acid imbalances (in pigs especially). Screening of anti-nutritive factors, including phenols, alkaloids, saponins and steroids were carried out. Results showed only the presence of phenols with great capacity to react with protein (hydrolysable tannins). No condensed tannins were found (tests included a characterisation of phenolic peaks by means of a spectrophotometer). It was also found that *Trichanthera* has a good balance of amino acids. The general result was that there is a wide variation in the nutritive value of this species.

Phenolic compounds for example showed a huge variation from 0 to 50,000ppm. This highlighted the need to identify if this variation was genotypic (different provenances), phenotypic (due to management), or a combination of both factors.

Trichanthera gigantea was introduced to Vietnam in 1991 and as far as I know (if this has been the only importation) this plant material came from one plot in the Cauca Valley, and due to the fact that this species is mostly reproduced by stem cuttings, it may well come from a single parental tree (the percentage of germination of the seeds is from 0 to 2% compared to 95% for vegetative propagation of the stems). The fact is that they may be dealing with a provenance which may not be palatable for goats. This can be one of the factors explaining the lack of acceptance by this animal species in Vietnam. The animals' lack of adaptation and deleterious factors in *Trichanthera*, as a response to a different environment, may well be others (This species is apparently native to the Andean foothills in Colombia, but its natural distribution is along streams and in swampy areas from Costa Rica to northern South America).

This species has several advantages over other fodder trees. It has an altitudinal adaptation range wider than most fodder tree species (from 0 to 2,000 metres above sea level). It is well adapted to the humid tropics with an annual rainfall between 1,000 to 2,800 mm and it grows well in acid (pH 4.5) and low fertility but well drained soils.

It grows better under a canopy. This is a fact well known by farmers in Latin America, who for centuries have grown *Trichanthera* associated with banana, plantain and under the shade of other tree crops. It has evolved in rainforest conditions in a medium stratum. One of the mechanisms of adaptation to these conditions is to have large leaves to capture sun light. To give an idea, a mature leaf of *Trichanthera* can grow as big as A4 size paper (under controlled conditions it can have a slightly smaller area than A3 size paper). These characteristics make this species ideal for multi-strata systems. The size of the leaves also facilitates its harvest and may facilitate its consumption by pigs.

Trichanthera gigantea is not a legume and it responds almost linearly to nitrogen from urea (up to 240 kg N/ha per year; optimum level appears to be 160 kg/ha per year). This characteristic also made this species valuable for multi-strata, integrated tree cropping systems and mixed stands, as it responds extremely well when planted in association with a legume tree species.

Analysis of its carbohydrate fraction revealed that this plant had the greatest amounts of water soluble carbohydrates, and of total and reducing sugars, when compared with other fodder trees and shrubs. It also showed a surprisingly high amount of starch and its neutral detergent fibre was found to be the lowest. The high amounts of non-structural and storage carbohydrates combined with the low amounts of structural carbohydrates may explain the good biological results found with monogastrics. Analysis of *Trichanthera* foliage has also revealed a very high amount of calcium much greater than any other fodder trees or shrubs used in comparison. This is explained by the fact that this is a species of the ACANTHACEAE family. As in other acanthaceous plants, *Trichanthera* has cystoliths - small mineral concretions appearing as minute short lines on the upper surface of the leaf blades, the upper portions of the stems, on the branches of the inflorescence and on the calyx. These mineral concretions are particularly rich in calcium. This explains the use that the campesinos in Colombia make of *Trichanthera gigantea* as a lactogenic drink for nursing mothers and may also explain the good biological results found with dairy cattle, goats and sheep.

Research on *Trichanthera gigantea* continues. Five genetically different provenances have been identified (Clara Rios, personal communication, 1996). Differences in agronomic characteristics and nutritive value of the provenances have been established (some data is yet to be analysed). CIPAV's research programme on Trichanthera gigantea addresses several objectives which are, among others:

- to identify provenances and the creation of a bank of diverse germplasm,
- to compile the indigenous knowledge of the multiple uses of this species among farmers,
- to study the propagation and agronomic characteristics of this species,
- to study its use in multi-strata systems, and
- to characterise the variation in nutritive value between and within provenances.

There is already information available in most of these areas. Although a good deal of information has been published in various numbers of "Livestock Research for Rural Development", this species has not yet been included in FAO's "Tropical Feeds" and despite being successfully introduced and adopted by farmers, it has not been formally introduced' to the scientific community. A brief introductory paper, not by any means complete, will be presented later in this conference to serve both purposes.

Mauricio Rosales

From Dr E R Orskov <ero@rri.sari.ac.uk>
Comments on Mauricio Rosales' comments on *Trichanthera*
Many thanks for this very comprehensive letter explaining so much about *Trichanthera*. I have to admit I know very little about the tree though I admit it is very impressive the way it performs in the shade. We, Dr Preston and I, had a MSc student feeding it to goat. It seems that we have a lot to learn and I thank you for putting it right. It was just surprising to us that the pigs liked it but goats did not. Maybe Dr Preston would like to comment on this as well.

Thank you again for such constructive comments made in response to a perhaps rather ignorant remark. The reward is that many of us have learned something.

Bob Orskov

From Carlos A. Sandoval-Castro <pagr-cs@wye.ac.uk>
Comments on Peter Uden's point
The point made by P. Uden is very clear and very often ignored, especially when working in the tropics. If we want to improve the production of food from tropical resources, we need to be able to predict the performance of the animal and to do so, we need to be able to construct either empirical or mechanistic models.

Although mechanistic model should be made in an ideal situation, empirical modelling may offer an insight to the various relationships and interactions arising when feeding "non conventional" feeds.

The lack of ability to predict performance in the tropics will be as clearly stated by P. Uden, lack of knowledge or understanding of the transaction occurring in the animal.

The laws of thermodynamic should remain the same in the tropics as in temperate countries. However, the coefficients for utilization of nutrients may have to be adjusted for particular breeds, environments and diets, and it is on these points that further research should be made.

Results from Australia already suggest that *B. indicus* cows may have a nutrient partitioning which could be different from that of *B. taurus.* However, I believe that so far no system to predict animal performance accounts for this.

Somebody from Australia may please add further to this point, i.e. Hunter, Mc. Sweeney, Magnon.

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From Dennis Poppi <D.Poppi@mailbox.uq.oz.au>

Comments on the use of feed analysis

I have enjoyed following the conference and found the various observations most interesting.

On the shade issue Max Shelton and Barry Norton have a lot of data which was published in the ACIAR publication.

However the issue that got me to write was to support Peter Uden for people to do some chemical analysis. Chemical analysis can be used badly but that is no excuse for not basically describing the resource we are using. I am all for animal testing and we must believe what the animal tells us but if we are to move forward we need some descriptors of feed. Chemical analysis is one but not the only one. I am against the massive lists of every chemical known describing a feedstuff but in my own work a simple OM, N, NDF and perhaps lipid with some diets tells me a lot and what I might expect. I also like to have data on *in sacco* rates and most importantly intake and digestibility by the animal and/or preferably animal performance. I rate animal performance the highest priority but without some underling descriptors of the food the information is limited. I realise in some areas it is difficult to get chemical analysis done and in other areas it is done without regard for what purpose it is to be used but it is still important to have.

I have found the observations of people from different areas most interesting in this conference and it is what makes advances when someone notices things about an animal or a plant. I always found the story of Ray Jones and the discovery of the *Leucaena* bug fascinating because of his well known ability to observe and wonder why. I suppose you don't really need chemical analysis for that!! Still it is the stories from around the world in this conference which I have found fascinating.

Dennis Poppi, Dept Agriculture, University Of Queensland, Australia

From E. R. Orskov <ero@rri.sari.ac.uk>
Comments on feed evaluation

I would like to make some comments re Peter Uden's remarks. I fully agree that we must develop feed evaluation systems. They are needed as I have indicated before both for planners of livestock production and for farmers to have some exchange rate of feeds and in general, Western systems of feed evaluation are not very good since they do not predict intake which is crucial when we are dealing with roughage based diets.

What we have to discuss is what are the priority measurements? Dr Uden thinks we are fooled if we think of *in vivo* and *in sacco* only.

We can probably all agree that we need the lab to obtain dry matter organic matter and N which must be combined with biological measurements obtained in vivo or some forms of in vitro measurements including nylon bags. After we have done that, we need to be more critical as to the cost effectiveness.

Sometimes there is no constant electricity in the lab so even some in vitro measurements are not good. What priority measurements would Dr

Uden suggest which would benefit the user. Surely not ADF: in a recent paper given by Dr Van Soest at the EAAP meeting in Norway he brilliantly illustrated the futility of those measurements as it has different meaning when day length is increasing and when day length is decreasing. We need to divide the feed into soluble and insoluble fractions. This could be done with the nylon bags or other simple methods.

If we suspect antinutritive factors, we need to look for that but they are only present in some feeds so we do not need to look for that in all feeds.

If we determined lignin routinely, can that help in addition to measurements already discussed? Lignin in leaves is not the same as lignin in stems. Lignin in legumes is not the same as lignin in monocots.

If we are to be paid by our clients the farmers, which must be the test, for routine analysis what analyses in addition to the ones mentioned could he afford to pay for?

We certainly need to generate more knowledge on this but with the present knowledge, there are many laboratory analyses routinely done which have no value whatsoever, but let us discuss priorities.

Dr E R Orskov

From Tony Goodchild <t.goodchild@cgnet.com>
Comments on feed analysis

I'm glad that the "Shut the Feed Analytical Laboratories" topic is getting an airing again.

I think we all accept that all tropical feeds vary in nutritive characteristics from batch to batch, according to growing conditions, harvesting, processing, storage, . . . They even vary according to the variety of the source crop, and (as Peter Uden rightly says) according animal genotype and physiology. Probably every farmer in the world who feeds livestock knows and cares about this. Carlos Sandoval-Castro has already commented on the need to model the farmers' animals. Farmers also have to use the batch of feed that's available: they can't swap it for "average" sorghum stover or "average" peanut haulms or "average" cottonseed cake . . . even if they could find it ! And surely our job is to produce advice for as many farmers as possible, not just advice for the rare farmer who actually HAS "average" feeds.

Therefore rapid reliable methods for predicting nutritive value are needed. (If one needs to do a full feeding trial* for each and every farmer, farmers would be better off doing the trials themselves, and we would be better of training ourselves for some other career such as anthropology!). [O.K. there's the very excellent nylon bag technique--but in our experience it's nearly as expensive as an animal trial; isn't that true, Dr Orskov?]

Let's accept that some--maybe most--conventional laboratory tests were inappropriate for tropical conditions. Surely that is NOT a reason for stopping laboratory testing. On the contrary, it means there is MORE work for labs to do. One of their jobs will be to decide which of the dozens of tests available are most appropriate for predicting the production of tropical livestock fed tropical feeds. Having identified these tests, the labs would then, as Peter Uden says, need to calibrate them using tropical livestock fed diverse samples of tropical feeds.

And in any case, a large proportion of conventional laboratory tests have been found inappropriate for temperate conditions, too. How many feed evaluation laboratories are being closed in developed countries?

In future we might see laboratory tests for nutritive value come down in price (making it easier to test batches of feed from villages or farms), and have a greater flexibility for calibration (making interpretation more appropriate to local needs). Already, NIRS (Near Infrared Reflectance Spectroscopy) is showing signs of moving in that direction . . . As you probably know, one scan with a modern NIRS instrument generates about 700 data points, from which dozens of chemical or animal-performance measurements can be predicted, PROVIDED THAT (laboratory or animal-house) CALIBRATION HAS BEEN DONE.

Apparently no-one has yet mentioned NIRS in the conference discussion. Would anyone hazard a guess as to when a respectable NIRS instrument will be as cheap and as portable as a laptop PC? I'd say it will be here in the time it will take for us to achieve our next food production revolution!

Tony Goodchild, International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria <t.goodchild@cgnet.com>

From Chedly KAYOULI <101763.2164@compuserve.com>
Comments on feed analysis

I have read with interest Peter Uden's comments on the use of feed analyses. Although this discussion has little relationship with the main subject of the conference, I have some remarks to present:

1. No researcher ignores the importance of the use of feed analysis as a research tool in the tropics. Most tropical researchers have received their high-scholastic education in temperate countries including myself and we made a mistake when coming back and transferred nutrition knowledge from North to South without taking into account the reality in developing countries: How many feed laboratory analyses exist in those countries! (many) and how many are working! (only few), the lack of funds is not the major factor but the maintenance, the repair of equipment and the lack of qualified persons are often limiting factors without forgetting the quality of the water and electricity as raised by Dr Orskov. In addition, considerable feed analyses have been undertaken and are now available, but those purely chemical methods have not proved to be sufficiently accurate for the practical prediction of tropical feed value.

2. I believe that the functional evaluation system in the tropics should not be based on traditional laboratory analysis; when working on poor quality feeding resources and local breeds some simple feed evaluation research can bring better information. I share the same opinion with Dr Orskov, not through solidarity but from my own modest experience in Tunisia, where I have obtained better results with methods using living micro-organisms than with traditional laboratory analysis: The nylon bag technique provides a useful means of evaluating feed digestion; recently the use of the gaz production method could be considered of good potential as providing precise information on nutritive value of forages and even of tannins-rich feeds as browse species. The gas production technique is a fast, simple and inexpensive method to obtain reliable

information and it is more complete on the total degradation of feedstuffs (predicting digestibility), on the kinetics of degradation (predicting intake) and also (for people equipped with gaz chromatograph) giving information on production of volatile fatty acids and gaz (predicting metabolizable energy).

Kayouli Chedly, Institut Agronomique National Tunis, Tunisie

From: Andrew Speedy <speedy@vax.ox.ac.uk>
Comments on the feed evaluation/animal trials debate

It was the hope of the organizers of this conference that the subject would be feed resources within integrated farming systems. Nevertheless, Peter Uden has raised the question of feed evaluation which was the main subject of the last conference. The distinction is important.

We are confusing basic research which aims to understand the biochemical and physiological processes of the animal and systems research which seeks to answer questions about animal performance within environmental (farming) systems.

Of course there is a case for basic research using *in vivo, in sacco, in vitro* and even more fundamental laboratory techniques in order to understand the processes. And there is no reason why this should not be done by scientists in developing countries. Indeed, with many forages (tree leaves etc.) there is a very good case for doing this research on site because of serious questions about working with dried and processed samples when studying antinutritional factors. It is the complex questions which relate to tropical forages that require such laboratory study. But the case for routine analysis of concentrate feeds, protein supplements and especially straw and silages is much more questionable, certainly if they are done in the belief that they can be used in isolation to predict animal performance. The relationship between chemical components and energy value of straws for example has an r-squared value of about 0.3 and that for silages about 0.4. In other words, they are useless for prediction, even in developed countries.

Using such data in whole animal and systems research must consider the issues of nonadditivity of nutrients, problems of sampling (given geographical, climatic, seasonal, soil, management and other factors), animal intake and animal selection, as was stressed in our introductory paper.

What is more important is that the whole area of systems research in the field environment is another and perhaps more important area of research which has been less effectively addressed in the past. Good on-farm research seeks to answer real questions about performance within systems and there is a need to consider the methodology and examine the data which is coming forward. I commend to participants the paper by Dr Janet Riley, statistician from Rothamsted, given at the workshop in Tuna Denmark in 1995 (available on the Web: http://ifs.plants.ox.ac.uk/tune/riley.pdf).

By all means let the laboratory scientists discuss the fundamental aspects of animal physiology but the purpose of this conference is to consider the equally valid area of systems research and the role of management and environmental factors.

As for what direction to place funds for research, I would advocate more use of limited funds for on-farm systems research which has been neglected in the past. The scientific value in answering the questions which pertain to farmers' needs and development are equally if not more valid.

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From Marco Esnaola <mesnaola%eapdzo@sdnhon.org.hn>
Comments on feed analysis

I feel that this subject not only deserves more attention but I also think that Seminars or Practical Courses should be organized in different parts of the world. This alternative lab feed analysis such as in sacco digestibility, ammonia level in rumen, tannins and others should be taught by experienced instructors to lab technicians that have been trained mostly in the classical Proximal Analysis Methods. I am telling you this because we have recently experienced great practical difficulties in getting rumen liquor samples from buffaloes in order to analysis ammonia levels. To my knowledge besides Dr. Preston's recent FAO book, not much has been written on this subject.

Marco Esnaola, Escuela Agricola Panamericana, El Zamorano Honduras

From Dr Thomas Acamovic <t.acamovic@ab.sac.ac.uk>
Comments on feed analysis

1. Interested in the comments of Uden, Poppi Sandoval Castro & Orskov. I agree with some of the points made by all but the comments seem to me not to be mutually exclusive.
2. It is obvious that chemical analyses is important, if not essential, for the assessment of feedstuffs for animals. At the risk of repetition, the important question is which chemical analyses are the most important? This may differ for different plants in different parts of the world and also for the different animals that will consume the plants.
3. It seems to me that we should try and cut corners if appropriate. We should use the knowledge of temperate and other systems but be aware of the differences and potential pitfalls. e.g. determination of 'protein' may be useful as is the determination of 'fibre' but what does that mean when the different types of protein and carbohydrate between plants will vary considerably as will their susceptibility to enzymatic and bacterial degradation. These factors, along with the various antinutrients, will strongly influence the nature of the feed, especially for monogastrics. Thus it could be argued that lots of CP determinations are wasteful of resources if it is their utilisation characteristics that are important.
4. It may be that nylon bags give reasonable results in some cases but not in others. Similarly for chemical analyses. I'm not sure that simplistic methods are appropriate, especially if the underlying mechanisms, are not known. Jones may have observed differences and asked why (probably as a lot of farmers around the world do) but he still needed the analyses

to sort out the problem and in that particular case 'simple' analyses were not sufficient.

I think the 'observation and why' is the key to avoid unnecessary laboratory and animal work where an integrated and flexible approach is used to assess feedstuffs and predict accurately (in most cases) animal performance.

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Van Soest's Abstracts: Further information related to the debate on feed analysis

For information, you will find hereafter the Abstract of a Paper presented at EAAP - 47th Annual Meeting, Lillehammer 1996, and mentioned by E.R. Orskov on 14 October in his comments on feed analysis.

Rene Sansoucy and Christophe Dalibard, Co-moderators

A Critique on the Problems of Predicting Feed Quality

P.J. Van Soest, 324 Morrison Hall, Cornell University, Ithaca, NY 14853, USA. (Email: tbk1@cornell.edu)

Estimation of feed quality usually involves the calibration of some laboratory-based measurement against in vivo values. Common measurements include fiber fractions, enzymatic digestion, protein and near infrared (NIR). Laboratory-based measurements are usually correlated empirically with digestibility, with the result that true scientific basis is not sought for the sake of practicality. Components like cell wall, ADF, lignin and NIR associations are environmentally affected so that calibrations with nutritive values vary depending upon source of samples. Mechanistic approaches have been put forward in the ruminant field and need more application. These approaches involve lignin ration to cell wall, rate of fermentation, gut retention time and metabolic losses. These components can potentially account for differences among animal

species. The lignin ration to cell wall can also account for much of the environmental variability that occurs in fibrous feeds. The physicochemical restriction upon degradability and availability of energy and protein lie at a macromolecular size above that assayed by most analytical procedures. Thus current chemical methods are less satisfactory than biologically based ones, such as rumen fluid or enzymes that will reflect unmeasured physical and chemical limitations.

From: Frands Dolberg <frands@citechco.net>

Comments on Andrew Speedy's comments on the feed evaluation/animal trials debate

As an addition to Andrew Speedy's comment I may add that by getting scientists involved in on-farm research, I feel options have become many more than we used to think of before. That is important.

What is perhaps even more important is that it has put many of us on the learning curve as we see and discover things "out there" we did not see before.

Finally, being "out there" has raised important questions of priority, i.e. where is money and time best spent and we have seen that earlier methodologies were not always appropriate as we see from the discussion on feed evaluation.

However, I have just attended a CTA-sponsored workshop in Hohenheim about biometry in agricultural research.

More than 40 participants expressed concern about the present (mis) use of biometry in research in developing countries and they were hitting hard at people like us participating in this conference, not to drive us back to the experiment stations or laboratories, but to have us do a better job "on-farm".

I mention this as one more example of how "getting out there" has widened the world and left many established procedures challenged and in a flux, which I however, take to be fruitful and to be welcomed.

Frands Dolberg

From: Rios Arjona Guillermo <rarjona@tunku.uady.mx>
Comments on feed evaluation

I have been following this conference which gives very good material with reference to *Livestock Feed Resources Within Integrated Farming Systems*. However, in the first paper you call the attention on *Feed Evaluation*, a subject that I believed was discussed in the first electronic conference (I missed it). After this first paper, I started to see some comments about this subject. So, are we missing something. I would like to give some of my impressions about the same subject.

I believe that chemical analyses and animal experiments are still essential to make the link between what is real and the researcher ideas, with reference to animal production. As far as I know, chemical analyses were part of a whole to develop the present feeding systems in developed countries. So, why is it put in judgement? Are we going to deny the present feeding systems and the animal production output they produce?

In most tropical countries (non developed), improved animal feeding systems have not existed for hundreds of years, but only traditional practices were found. Their low outputs were adequate. They are still surviving. However, to know now if they are or not efficient, could be the key to promote them. Improved feeding systems are necessary in tropical areas in order to help the farmers to optimize the feed resources for increasing animal production levels and meeting the goal, in the context of a local or national market rather than an international one.

To develop improved feeding systems will be necessary to plan strategies and targets. At this point, analytical analyses will be very important. But actually, who knows which analyses are necessary and important to properly define the nutritive value of an ingredient or of a diet in the tropics? Which levels of animal production could be expected? Who knows which analytical analyses are important to describe a tropical feed? Presently, tables describing nutritive value of tropical feeds are not giving enough information (if any) on the anti nutritional compounds, and also, are not describing the relation of these compounds with nutrient availability, tested in animal feeding research.

The other problem is when people from developing countries did their postgraduate studies in overseas countries. Most of the time, they learned one or two analytical techniques. So, when they are back to their country, they try to use them, without questioning if they are adequate to our own feeds, or if others are necessary. These techniques are generally the most up-to-date ones. Sometimes, the people teaching in these postgraduate studies are the developers of such techniques. So they are keen to spread their use everywhere but they do often not question their relevance in other parts of the world. More care need to be taken on that.

Indeed, I believe that less data exist on chemical analyses and nutritive value of less conventional feeds and forages, especially those found in the tropics. Because, in the past, nobody was interested. Also, few interest was put in the understanding of animal production in the tropics.

It is necessary to know for a feeding system the following:

1. For an input fed, how much output is produced with which efficiency and profit?
2. How much of the input is returned to the ecosystem and how does the ecosystem recycle (efficiency) it to produce again?

Therefore, chemical analyses are needed to understand the animal production in the tropics.

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From: Wolfgang Bayer <WB.WATERS@LINK-GOE.de>

Comments on forage quality

The forage calendars (I use "rules of thumb" in "guestimating" forage quality - I found some of the comments made re chemical analyses very interesting, but was amazed, that nobody raised the question of sampling - if animals graze or if they can select, sampling becomes a crucial issue. What use is the best method, if plants or plant parts are analysed which animals do not consume?) and the aims of animal husbandry give usually plenty of food for thoughts with respect to forage and feed management and animal husbandry.

One important aspect, I miss thus far, is the question of "optimizing".

The "rough and tough" economics give some guidance of what is possible under the present circumstances. For me it proved very useful, to make a difference between "supply driven" and "demand driven" systems.

Supply driven systems are systems where prices are such that high external inputs do not pay. This means that farmers or herders have to make the best out of existing feeds and forages (e.g. by letting animals select).

Demand driven systems can be found in Europe or north America and these are systems where a production target is set (e.g. a growth-rate of pig of say 600 g/day or for a dairy cow 7000 kg of milk per lactation) the needs of the animals are calculated, a ration is put together, deficits found, necessary inputs to alleviate these deficits defined, bought, included into the rations. Supply driven or demand driven systems rarely do occur in "pure" forms, these are rather end points of a continuum, but smallholders and pastoralists I know, are much closer to the supply driven end than to the demand driven one. The demand driven end is usually taught at university, and forage chemistry was designed to serve that end. I think that a large part of the confusion comes from applying such chemistry to predominantly "supply driven" situations.

There has been relatively little work on "supply" driven systems. Personally I found Gerrit Zemmelink's work (Wageningen University) very stimulating and useful in this respect.

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From R. Sansoucy and C. Dalibard
Feed Analysis and Evaluation

A very interesting and stimulating discussion has been started on Feed Analysis and Evaluation. Up to now we have received more than 15 comments from different participants on this topic.

It is certainly not our intention to stop discussions of interest to participants. However, we would like to point out that :

1. Feed Analysis and Evaluation was the subject of the first paper of the First FAO Electronic Conference on Tropical Feeds last year and that it was abundantly discussed on this occasion.
2. As announced in the Invitation Letter, this Second FAO Electronic Conference is more concentrated on *Livestock Feed Resources Within Integrated Farming Systems*, with emphasis on production systems.

In fact, we consider that the subject deserves more in-depth "analysis". Therefore, if many of the participants so wish, we could envisage opening a FORUM to pursue discussion on this subject, after the end of this conference, starting next January. All participants would be informed and would be invited to contribute.

From now on, all new comments on the subject will be kept back as contributions to this new Forum in January.

We hope you will find this proposal agreeable.

Rene Sansoucy and Christophe Dalibard, Moderators

From: Dr Abd Rahman b Md Salleh <rahman@jph.gov.my>
Comments on tropical agriculture: where is it going?
Andrew Speedy's comments on the feed evaluation/animal trials debate appears to be an attempt to bring the discussion back to the central theme of the conference:
"It was the hope of the organizers of this conference that the subject would be feed resources within integrated farming systems.../...What is more important is that the whole area of systems research in the field environment is another and perhaps more important area of research which has been less effectively addressed in the past"
In response to this comment above, I would like to raise an even more basic issue: TROPICAL AGRICULTURE - WHERE IS IT GOING?

I have been following this electronic conference with some interest from the time it started and have noted that the main themes discussed have been on supporting and improving the activities of smallholders and based on maintaining indigenous breeds. I wonder if the use of so much resources from within the tropical countries and through bilateral and multilateral technical assistance programmes for such activities is in itself a sustainable undertaking and in the best interest of the under developed countries.

Coming from an underdeveloped country in transition the following issues are worth considering:

i) Smallholders are generally prisoners of the system suffering from poverty and waiting to escape as soon as the opportunity presents itself. They will accept assistance and subsidies but their underlying need is to better themselves and especially their children by whatever means possible. In Malaysia's case that improvement came mostly through industrialisation. Employment (jobs) appears to be the best method of poverty eradication.

ii)The smallholder agricultural activities in most countries in the tropics suffer from a high labour to other resources ratio especially land and results in low output per unit man-day that perpetuates their subsistence economic level of existence.

iii) The smallholder system has actually been optimised over the years to give the best there is in an integrated system within the overall constraints of the system. Intervention usually involves external resources that have to be handled by additional manual labour but results in marginal output/income increases. For example estimates of grass cut and carried manually to feed livestock is perceived to be heavier and heavier over time compared to volume if it is done day in day out by the farmer. The dairy cow of better genetic potential provided to farmers thus suffers from inadequate nutrition and becomes an additional burden to the system. Such additional manual labour is generally not sustainable as it is often not related to a very significant increase in income.

iv) Is it realistic expectation that agricultural production particularly food production in the tropical zone should continue to be carried out by smallholders to feed the cities where demand rises in direct proportions to economic growth led by the industrial sector?

Is it not an irony therefore that the part of the globe that receives the most solar energy and rain water becomes increasingly dependent on the temperate zone for its food supply? It is obvious that the capacity for plants to grow rapidly in the warm temperature environment has not been studied and exploited to its most optimum capacity.

What is needed is that more of the research and development resources available be directed to adapting known agriculture technologies to suit the inherent characteristics of the tropics and to create new methods which may be radically different from those practised in the temperate zone but have the same productive capacity. It is very well to go into profound discussions on the merits and otherwise of analysing the nutritive value of fodder resources and agriculture byproducts as well as the economics of tapping palm trees as an animal feed resources but the theme of this conference is appropriate integrated livestock rearing system in the tropics that is sustainable!

The belief that the smallholders will continue to be the main thrust area for the tropics to feed itself into the future is a romantic notion that should appropriately be dumped into the wastebasket of history.

From Manuel Sanchez <Manuel.Sanchez@fao.org>
Comments on "Where is Tropical Agriculture going?" (Dr. Rahman Salleh's comments)

It would be nice to get into the debate about what way to follow towards improving the living standards of people in tropical countries, considering that the most of the so called "developed" countries have very serious social problems at various levels (individual, family, society) that none of the so called "developing" countries would like to have (like unemployment, drug addition, obesity, etc, just to name a few).

Nevertheless, in this electronic conference we are discussing matters related to how to make better use of local resources to increase animal production within sustainable systems.

It is clear that the green revolution (including the industrialized monogastric production as part of it) has allowed significant increases in food production but with a huge negative impact on the environment and on biodiversity. We certainly urgently need alternative sustainable models. We can not say that intensive swine production, with imported feeds from the other side of the world and causing pollution of soil and water, despite the high productivity per sow, is a good example to follow.

Nor is dairy and beef production based on grass monoculture, that gradually destroys soil fertility and limits opportunities for bioversity, specially in those areas that previously had forests.

The greatest damage to tropical animal agriculture has been the imitation or adaptation of production systems from temperate (developed) countries. Soil and environmental conditions, as well as plant and (sometimes) animal resources are so different, that appropriate local systems are needed. For instance, the concept that ruminants, both large and small, have to be reared on grass in the tropics as it is done in temperate areas, is causing in many places irreversible negative effects on the ecology that could be in the near future an issue in environmental suits.

The only hope to develop sustainable livestock and agricultural production systems is with small holders, who can conserve the environment and biodiversity. Monoculture agriculture as practised by large owners or companies not only is causing damage to our planet but also to our societies in their sake of short and medium term profits, by exploiting labour (both local and imported, legally or illegally) and by preventing the highly valued rural development.

The keys for finding these sustainable systems are to be found in the traditional combined with our scientific knowledge. For example, some of forages belonging to the third generation, following grasses and legumes, composed of the highly nutritious broad-leave plants like *Morus*, *Hibiscus*, and *Malvaviscus*, which allow milk yields of 20,000 l/ha without concentrates, have been used by the Chinese farmers for hundred and maybe thousands of years.

It is clear that in most cases technologies from temperate areas are not going to improve the living standards of the people living in tropical countries in a sustainable manner, thus for our own sake and that of our descendants, lets keep looking for those systems and technologies that best fit our present needs without damaging the environment and without putting in danger future generations.

M. Sanchez, Animal Production Officer, AGA, FAO, Rome

From Robert Faust <drfist@ilhawaii.net>
Comments on sustainable farming systems
I thought I'd make a comment from my unique perspective as a tropical farmer and as a researcher in tropical polyculture and Hair sheep based agroforestry systems. I have been a researcher, farmer and consultant for 25 years. The issue on sustainability is well put, how many years does it take: 5, 25? I say it takes a thousand years to prove sustainability of an agricultural system. Here on the island of Hawaii, it was proven, and would be working today, if Capt. Cook never showed up. I presented a paper on the subject at the IFOAM conference in Copenhagen this summer and it will be on the IFOAM page of abstracts and published in the proceeding. In terms of sustainability, of course going broke, is not sustainable, so the first criteria is going to be can you survive financially. If you cannot make it financially how can you continue and how can you call it sustainable? It becomes kind of an academic exercise to talk about it, when very few academics have ever done it. In the real world of agriculture it is a struggle just to survive, let alone take a risk with your family life trying something new. I am all for all these good things, I have a full example of what can be done, but I am practically the only one with the knowledge, skill and resources to run it, there is quite a learning curve to successfully survive at tropical small farming. The real trick is to make it work for the small farmer, this is a policy issue, beyond the scope of science, if the problem was just information there would be no problem, there is sufficient information out there. The problem is usually money, and it is easy justifying "slash and burn agriculture" or till , spray and erode "modern: agriculture, when your family is hungry or those mortage payment or tractor payment is due. The real question is how do you change the overall system to allow innovation. As you well know the applied part of agriculture is on the low end of the priorities on the part of academia. Maybe the applied science people with hands-on experience should start teaching in a formal setting, I am available.

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From Dr.Collin Boyle <menzo@caribsurf.com>

Comments on Sustainable Livestock Production in the tropics

I want to agree with the comments made by Manuel Sanchez of FAO concerning the use of forages as feed for livestock.

I am from a small island state in the Caribbean (St. Vincent and the Grenadines). In recent times, our farmers have been hit by the harsh reality of the ever escalating prices of concentrate feeds for their livestock to a point where the profit margin is decreasing rapidly.

Feeding of ruminants in this country, has historically been based on improved grasses e.g. African Star, Pangola, Tanner, Elephant grass, etc., supplemented by concentrate feeds. During the rainy weather, the grass is abundant. In the dry period, which spreads over approximately six months, the grass if not irrigated is scarce. Farmers are therefore forced to utilize excessive concentrate feeds.

Generally, farmers utilize to a limited extent live fences of Gliricidia as supplementary feeding and interestingly, these trees are not affected by the dry weather.

Recently, with the assistance of FAO, we have been seriously exploring more sustainable methods of ruminant and pig production. Instead of using the Gliricidia as live fences only, we have embarked on a programme of cultivation of legumes and forage trees high in protein content on our livestock stations. We are also cultivating the traditional pastures with these trees, and supplementing the diet of the animals with multinutrient blocks produced locally. This hopefully will achieve the following:

1) Increase stocking rate of animals/acre because of the high output of biomass of these plants /acre when compared to grasses.

2) Provide cheap and ready source of high quality feeding materials all year round.

3) Reduce drastically the amount of concentrates used, thus reducing the cost of production.

4) Decrease soil erosion.

5) Enhance the environment (increased O_2 / CO_2 exchange).

Dr. Collin Boyle, Chief Veterinary Officer, St. Vincent and the Grenadines

From Robert H. Faust <drfist@ilhawaii.net>
Comments on Collin Boyle's comments on Sustainable Livestock Production in the tropics

In regards to Dr. Boyle's situation in St. Vincent, it sounds like a similar situation here in Kona Hawaii: same grasses, same 6 mts. dry season. I have been developing an agroforesty system using St. Croix (African) Hair Sheep, *Gliricidia*, *Sesbania sesban*, and *Desmodium* ground cover. The idea is to graze weeds and *Paspalum notatum* in coffee and fruit orchards, in alley cropping and shaded with N fixers. Areas are let untouched till the dry season, then they are turned into masses of *Desmodium*; the N fixing trees are limbed for feed. Works great, problem is I am in Hawaii, all the lamb meat come from New Zealand or the US mainland, frozen, and cheap: no market for my sheep.

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From E Fernandez-Baca <ferbaca@amauta.rcp.net.pe>
Comments on the conference

I have been following with interest the development of this FAO electronic conference on Livestock feed resources within integrated farming systems, as well as the comments of the participants representing such an enormous diversity of cultural, socioeconomic and ecological conditions. There seems to be a general consensus on the need to develop sustainable animal production technologies within integrated farming systems, for which purpose the proper utilization of local feed resources is one of the essential elements. The research results and individual experiences that are being communicated along this electronic conference show the progress achieved on this subject and are, with no doubt, valuable contributions to attain the goal of sustainable production. However, what is a matter of concern is the fact that in spite of the availability of such information the extent to which this is applied in the field, especially at the resource-poor small farmers' level, is very limited.

Therefore a great deal of additional effort is needed to ensure the proper dissemination of research results and the experiences of progressive farmers.

Furthermore, fundamental adjustments are needed in the curricula of most higher education agricultural schools and universities which are highly influenced by those of developed countries in temperate regions. Quite often professionals educated with such a model are more difficult to convince than farmers on the need to adopt approaches more in line with the local conditions. It would be highly desirable a more active involvement of professors and students of agricultural schools and universities in this type of research to contribute not only to the generation of new technologies but to its dissemination.

Saul Fernandez-Baca (former FAO Officer) Peru

From Carlos Lascano <C.LASCANO@CGNET.COM>
Comments on feeds within farming systems

I have been following with interest the electronic Conference on Feed Resources in Farming Systems. Papers presented and comments made by several participants have been useful, even though to my surprise the debate on chemical analysis of feeds continues. On the other hand, I feel that in some cases there has been inadequate consideration of the farming system in which feeds being described are or will be used, utility of the resource to farmers and their impact on natural resources. Thus, at this time, I would like to share with colleagues in the conference a new initiative led by CIAT on improved feeding systems for dual purpose cattle systems in marginal areas of Tropical America. The project known as TROPILECHE, operates under the CGIAR System Wide Program convened by ILRI.

A brief description (6 pages) of the Project "Improved legume-based feeding systems for smallholder dual-purpose cattle production in tropical Latin America" (TROPILECHE) can be obtained by sending a message to:

MAILSERV@MAILSERV.FAO.ORG
No subject required. The message should be simply:
SEND [TFCONF2]LASCANO.TXT

This project is currently underway in two benchmark sites: subhumid hillsides in Costa Rica (Esparza Region) and forest margin in Peru (Pucallpa region). I hope that this contribution illustrates a holistic approach to feed resources in the context of livestock production in pasture-based systems, common in LAC.

Any participant in the Conference that is interested in obtaining more information on TROPILECHE please contact me.

Carlos E. Lascano <c.lascano@cgnet.com> CIAT, Cali, Colombia

From Danilo Pezo Quevedo <dpezo@cariari.ucr.ac.cr>
Comments on introductory paper

In the introductory paper, the organizers of this electronic conference (Speedy, Dalibard and Sansoucy) stressed the opportunities for integrated production systems in terms of their potential contribution to food security, sustainable land use and improve the welfare of the rural poor. Usually these complex multi-component integrated systems are seen as related to small and perhaps medium size farms, whereas specialized systems to larger enterprises. I am convinced that to respond to the new agricultural policy elements of the 90's (e.g. market globalization, reduction or elimination of subsidies, sustainability) and to increase competitiveness in tropical animal production systems, regardless of farm size and type of livestock enterprise, some of the adjustments needed are diversification (integration with either crops, trees, or both) and rational management of the interactions among these components and with the natural resource base.

Danilo A. Pezo, Consultant in Pastures and Ruminant Nutrition, Visiting Professor, University of Costa Rica

From Frands Dolberg <frands@citechco.net>
Comments on Fernandez-Baca's and Bellon's comments

Concerning involvement of students in research in rural areas, I can refer to two papers. One describes experience from Bangladesh and is in vol 3.1: 1-10 of the journal Livestock Research for Rural Development, which can be www accessed on:

http://ifs.plants.ox.ac.uk/lrrd/lrrd.htm

The other on:

http://ifs.plants.ox.ac.uk/tune/tune95.html

is an experience from the Altiplano in Bolivia and that experience (more than 30 students) is described by Abel Rojas in the proceedings of a meeting in Denmark, but available on the address above on the Internet.

In both cases, the research involvement of several students over a number of years (5 and above) was associated with substantial production increases. Inland fresh water fish in the case of Bangladesh and milk in the Altiplano. It is really an unrealistic dream that we can assist resource poor farmers without a sound backing of knowledge.

Recently, I got across a comparable experience in Zambia, where a CIMMYT team in the mid-80 had supported on-farm research by students.

There is the ongoing programme spearheaded by Dr. T.R. Preston with students from several countries (a large number from Colombia and Vietnam), which clearly shows that provided the attitudes of teachers (critical factor as you point out) is in place, it is perfectly feasible to conduct research of relevance for small farmers.

However, not only teacher's and supervisor's attitudes are critical factors. Compartmentalisation in agencies and governments are as well. One department is meant to be only for development or extension while another only for research, which is not fruitful. It is often when we try to implement/do extension we identify problems and that is when we should be able to call in research instantly. As a minimum, development and extension projects should therefore contain budget lines for research.

Frands Dolberg

From Reg Preston <thomas%preston%sarec%ifs.plants@ox.ac.uk>
Comments on Dr Abd Rahman's comments on tropical agriculture: where is it going?

Dr Abd Rahman is advising us to be realistic and accept the inevitable (according to his logic) that we will come to accept traffic congestion, air pollution and the social ills of too many people in too little space with nothing very much to do except watch "blockbuster" or "Dallas-type" programmes on TV to carry us away from the stark realities of the outcome of economic progress. Having lived in a country in Latin America whose social infrastructure has been effectively destroyed by the incurable drug-consuming habits of the "most economically developed" country in the world I and many like me are not ready to accept the "inevitable" pathway and consequences of "development".

Why should we produce food for the cities? Why not create conditions in the countryside that will provide the essentials of a better life (health, education, information are the main ingredients needed)? Because the cities are where the votes are and therefore politicians will ensure that they are favoured by government policies which effectively means that they are subsidized by the rest of the country. Is it romantic to think that the polluter (the cities) should pay? Is it romantic to voice opinions that perhaps not everyone is happy with consuming products of genetic engineering which by definition are not sustainable. BSE (mad cow disease) is a warning of the dangers inherent in the "high- tech" pathway; the reaction of the public showed clearly the lack of confidence in both "science" and "government".

Fossil fuel has driven the present model of economic development. Until the reserves begin to dry up (50 years?) the rich countries will continue their unsustainable life style. But then what? `Nuclear energy for all? The optimists (in the rich countries that will supply the technology) will no doubt say yes. But will it create jobs - even fewer than the fossil fuel industry! Overall public opinion would seem to be against such a scenario.

So we are likely to have to rely once again on the sun's energy which means an important role for biomass as source of food and fuel and the tropics will have the comparative advantage. Dr Rahman rightly reminds us that we have done little to capitalize on this comparative advantage (incidentally it is the agronomist who have shown the way in Malaysia with the tremendous success of the oil palm tree). But I think I am right in stating that the livestock scientists have shown much less initiative as the closest the livestock get to the oil palm is to be allowed to graze underneath it. The pig and poultry producers prefer to use "temperate crops" in the form of imported grains in spite of the fact that technologies have been developed for using the oil and the fruit of the oil palm tree for both pigs and poultry.

Poor farmers, by definition, practise sustainable agriculture (or they used to until the demand for "development" came along in the form of cattle ranchers and loggers). They have developed technologies that use minimum external inputs and maximum use of family labour (their major comparative advantage) and, frequently, use plants/trees of high productivity and efficiency of using solar energy (a free external input). So if we help "poor" farmers (poor financially but rich in skills and culture) then we are likely to be putting efforts into worthwhile ecosystems; and with our scientific skills perhaps we can find a way to harvest the sap from palm trees without having to climb them. And maybe a more careful study of indigenous breeds will help us to develop ways of using more efficiently the leaves from such highly productive protein-rich crops as water plants and multi-purpose trees. And if we help "poor" farmers to be less "poor" that is not a bad thing. And if at the same time, with our integrated approach to rural development, we develop cheap, renewable sources of fuel for cooking (biogas) and lighting (solar voltaic panels and gasifiers) and communication (computers, cellular phones) maybe when the "poor" farmers become less poor they will prefer to stay in the countryside working part- time on the farm and part time (with their electronic communication technology available at village level) in the "information" industry which we are told will be the dominant job provider in the next century.

Romanticism? Much of the technology exists; of the potential of tropical natural resources there can be no doubt. The constraint is our "Northern" training which plays squarely into the hands of the corporate industrial sector happy to use cheap labour in the form of displaced rural dwellers and quite prepared to keep them dependent on their "Northern" technology instead of keeping them develop their own "tropical" systems.

This conference is precisely concerned with developing such "alternative" systems. But first we must believe in the "south" and in the resources of the "south" especially the tropical farmers, for their knowledge and experience will serve us much more than all the agricultural science imported from the "north".

So Dr Rahman, please stimulate your livestock scientists to stop looking down (at grass growing under the trees) and to project their sights upwards at the incredible resource known as the palm family. And to emulate with livestock what their agronomist colleagues have done in developing the cheapest source of edible oil on the world market.

Reg Preston, Vietnam

From Hermenegildo Losada Custardoy <hrlc@xanum.uam.mx>
Comments on T.R. Preston's comments on "death for the cities" by a group of Mexican researchers forwarded by Hermenegildo Losada Custardoy

We are a group of researchers, working in one of the largest and most polluted urban centres of the world, who are trying to understand and therefore to digest the concept of sustainability. We agree with most of the comments from T. R. Preston referring to rural sustainability and the rights of the poor population to have better standard of living, in particular in the developing countries that often have to support the developed ones. Where we disagree is that large urban centres have to disappear in order to implement sustainability. In this respect we have arrived at the conclusion that what really needs to disappear is the 'Western' model that most of the large population centres of Latin America have adopted as their prototype which clearly is 'against' nature, and therefore sustainability. We consider this 'Western' model is responsible for a misunderstanding of development which often associates concrete with a better standard of life. The result of this fatal misunderstanding is that most of the cities tend to create pollution as a new export product. As a result of our research we have reached the conclusion that more appropriate is the use of the 'Eastern' model, in which nature is an integral part of the city. One question that arises from this proposal is how to reach development without poverty, which seems to be the main limitation of sustainability in the city. We believe that a model for sustainable living in the city is more likely to be developed from an understanding of this relationship with nature as demonstrated by the peri-urban farming systems of countries such as India, Africa and here in Mexico.

In our experience here in Mexico City a good deal of the traditional agriculture and livestock production has undergone a transformation from the conventional system towards a new sustainable proposal, meaning that the systems have found a new way to survive by adapting to their new urban conditions. For example, the use of rubbish in dairy stables represents a very important source of food for the production of milk; there is a wide use of swills to feed poultry and pigs; and we have also found an extensive use of manure in peri-urban agricultural production. This leads us to the conclusion that the role of the scientists is limited because the local producers are keen to find their own solution. We feel it is more appropriate to accept that these peri-urban systems are alive, and it is worth continuing research on these situations where we believe a sustainable proposal based on the experience of the peri-urban producer could be just one of the solutions for these large urban centres.

From T.R. Preston <thomas%preston%sarec%ifs.plants@ox.ac.uk>
Comments on comments by a group of Mexican researchers

An important point has been made and I stand corrected. I should have said the "Western" model of the city, because as he points out the "eastern" model is much more linked with nature. In fact, Bob Orskov and I when driving to the airport commented on the fact that there was no reason why all the roof tops should not have trees growing there and thus the city could become green and in the process act both as a sink for the CO_2 it produces but more importantly grow more of its own food.

Several of Losada's papers can be found in Livestock Research for Rural Development on WWW at <htp://ifs.plants.ox.ac.uk/lrrd/lrrd.htm>

Dr. Thomas R. Preston, Vietnam

From Michael Allen, Auckland, New Zealand
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Comments on Sustainable Technology

I have followed the various papers with a great deal of interest because it is apparent that many people in widely separated locations can use this technique to share and transfer relevant technology.

But there are some underlying assumptions in many of the comments that I believe should be addressed. If we are to achieve sustainability in food production it is essential that we are aware of other constraints produced by other demands. Reg Preston in his recent comment mentioned some of these and I could certainly expand on his views from the viewpoint of an engineer. Perhaps this is not the place.

Some of the constraints include the universal need for water and fuel for cooking. So, for example, when considering trees for forage, species which yield fuel-wood or useful timber for building may actually have a higher priority in rural life. Thus Leucaena leucocephala is widely recommended for incorporation in animal feed but it also has considerable value as a fuel wood and as a source of wood-ashes for making soap. This makes it especially valuable over and above the needs for animal nutrition.

In the second paper of this excellent conference, Rodriguez and Preston touched on the general need for rural fuel supplies. And while the durability and sustainability of biogas generators based upon plastic sheet may be questionable, the value of the resulting methane/CO2 mix cannot. That "most troublesome weed" water hyacinth Eichornia crassipes is not, I believe, highly regarded as fodder. However it will yield a massive cubic metre of biogas for every kg of dry matter if introduced into the biogas reactor feed.

As has been remarked, dung is widely used as a fuel. Animal nutritionists may argue with geneticists as to the best feed/breed for a draught animal in the tropics. And a great deal is now known about the effect of bypass protein on production rates. (I would expect their diet has been chemically analysed in many first-class laboratories to the limits of our present instrumentation). But I do not think anyone has considered the optimum feed/breed combination to produce adequate dung, milk and draft power for a typical Indian family. Please correct me if I am wrong.

I remember looking at the very small milk cows in the hill country of Java and wondering why they didn't use larger breeds. The answer, it turned out, had little to do with available feed or efficiency. It had to do with school fees! Selling the leg of a large cow to pay school fees was much more damaging than selling a small cow.

My point is that we must take an overview of what people require before we seek to optimise just a part of the overall process.

I put these views forward to the conference with some trepidation because I am only an engineer. However, we engineers have learned this particular lesson from bitter experience and I would seek to shorten the learning period of my fellow technologists.

I mentioned water as another constraint and I could digress on the technology and energy necessary to conserve and make efficient use of water in animal production. But I'll save that for another occasion.

I wonder if we have really given enough thought to how we extend the lessons of subsistence and survival farming to make a sustainable system of food production for the next 4,000,000,000 people expected shortly on our planet. (Bearing in mind that they will be largely an urban population). Again Rodriguez and Preston touched upon this in their excellent paper but, apart from Reg Preston's comments, I have not seen much discussion on the implications to animal husbandry. I suspect that the Preston solution to make the rural environment attractive to these $4x10^9$ warm bodies would be counterproductive: I think that we have all seen what urban sprawl does to prime quality farm land!

As an engineer I am aware that my profession has played a key role in facilitating exponential human population growth. Historically the only constraints which have limited city size are the pollution problem (and resultant disease), the lack of fuel, the lack of water and the lack of food.

I rather doubt that the idyllic pastoral life of sustainable technology pictured by Reg is just around the corner. Certainly we must curb our lust for non-renewable energy. But we must also seriously address the problem of overstocking the human grazing fields.

All we technologists can do, it seems, is to buy time for the human species to make a few basic changes to its lifestyle. Perhaps we have become so used to this objective that we now no longer question it!

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From Frands Dolberg <frands@citechco.net>
Comments on Michael Allen's comments

I read Michael Allen's comments with much interest.

Two fast remarks. When in the early 80 we measured weights of cows in Bangladesh and related weight to size of holding, we found a very positive correlation. Small holdings, small cows; large holdings, large cows.

However it is these small cows that landless women to a very great extent have invested in through the now world known "Grameen" type of loans, now practised by many organisations (NGOs) in Bangladesh and other countries.

This relates to the population question, because in 1974 it was estimated 6.7 children were born per woman in Bangladesh. In 1995 this figure had dropped to 3.5 children. The reason is not literary, but rather the small loans now available to many landless and rural women, giving them a hope for the future and enhancing their status in their facilities and thereby - to a greater degree - enabling them to control fertility.

However, the point is livestock - and that is small livestock - has played a very significant role as an investment objective. In recent years the emphasis has shifted to rural poultry and we will hear more of that later in this conference.

Frands Dolberg <frands@po.ia.dk>

From Paschal Osuji <P.Osuji@cgnet.com>
Comments on Estimation of sustainability

On the issue of estimation of sustainability, my colleagues Ehui (S.Ehui@cgnet.com) and Jabbar (1996) have agreed that I share the abstract of their paper on "A Framework for evaluating the sustainability and economic viability of crop-livestock systems in sub-Saharan Africa". pp 14. The abstract is provided here:

Abstract

Livestock are an important component of farming systems in sub-Saharan Africa. They are raised mainly for meat, milk and skin and provide a flexible financial reserve in years of crop failure. They also play a critical role in the agricultural intensification process by providing draft power and manure for crop production. With increasing human population and economic changes, cultivated areas in many sub-Saharan African countries have expanded onto marginal lands and fallow periods are being shortened. As a result, large areas of land have been degraded and crop and animal yields have fallen. Improved crop-livestock production systems and technologies are currently being developed in response to the growing demand for food and the degradation of the natural resource base. These technologies must not only enhance food production, but they also need to maintain ecological stability and preserve the natural resource base, i.e. they must be sustainable. However, the notion of sustainability has been of limited operational use to policy makers and researchers attempting to evaluate new technologies and/or determine the effect of various policies and technologies. This paper discusses a methodology for measuring the sustainability and economic viability of crop-livestock systems. The approach is based on the concept of intertemporal and interspatial total factor productivity, paying particular attention to the valuation of natural resource stock and flows. The method is applied to a data set available at the International Livestock Centre for Africa (ILCA). Intertemporal and interspatial total factor productivity indices are computed for three farming systems in southwestern Nigeria. Results show that the sustainability and economic viability measures are sensitive to changes in the stock and flow of soil nutrients as well as material inputs and outputs. The advantage of this

approach is that intertemporal and interspatial total factor productivity measures are computed using only price and quantity data, thus eliminating the need for econometric estimation. Sincerely,

P.O.Osuji, ILRI

From Dr Abd Rahman Salleh [rahman@jph.gov.my]
Comments About Sustainable Local Crop - Livestock Integration
Cattle Rearing in the Tropics - to make it sustainable

Since nature dictates that the solar energy in the tropics is absorbed and converted to trees - hence the tropical rainforest - cattle rearing must be subservient and complementary to tree crops which gives higher return/hectare and "preserves" the tropical rainforest effect to a greater extent. The shade effect is beneficial even to tropical breeds which are supposedly heat tolerant.

Uncontrolled grazing of cattle in palm oil plantations has been practised much earlier but it has led to overpopulation, overgrazing and social conflicts among land settlers. The more recent experience in this area in Malaysia seems to indicate that a more regulated grazing system is the best integration system for rearing cattle in the tropics that meets the sustainability test after nearly 10 years of observation.

The characteristic of cattle farming under oil palm that appear to be sustainable are as follows:

(a) It must be run as a commercial undertaking and participation of the plantation resource owner is critical.

(b) Grazing is controlled by easily movable electric fencing in 10 hectare plots together with a mobile shelter for the herdsman and watering facility for the herd.

(c) Grazing rotation is integrated with the normal plantation schedule of harvesting, weeding and fertiliser application.

(d) Herbicide use is limited to the non-edible forage species and weeding is carried out immediately after the herd has left the particular area to allow edible forage regrowth.

(e) The herdsman is trained to balance resource available with herd size and to move the herd as forage availability run low.

(f) The project owner must be motivated to increase income/hectare of land instead of income/hectare commodity output.
(g) Small holder participation is conditional on the project being run on consolidated grazing resources with land owners being shareholders only and receive minimal government support.

To date 90,000 head of cattle are managed under this system out of a national cattle population of 680,000 [in Malaysia]. The majority of the cattle population are under threat from loss of grazing resources due to urbanisation. Fortunately it is accompanied by a drop in dependence on small scale farming as a source of income due to industrialisation. In fact the process of transformation is right along the lines of the National Agricultural Policy of commercialisation and optimisation of resource use with minimal subsidies.