Comments on: Scavenging Poultry and Ducks

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).

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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.

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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).

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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.

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

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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.

Bui Xuan An, University of Agriculture and Forestry Thu Duc, Ho Chi Minh, VIETNAM e-mail: an%sarec%ifs.plants@ox.ac.uk

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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 figure

s 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.

Stephen Swan <swans@wave.co.nz>

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

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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, Espa�a. 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.**

Claudio A. Flores Valdez. E-mail: caflores@taurus1.chapingo.mx

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

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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.

Bob Orskov

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.

Andrew Speedy, Dept Plant Sciences, University of Oxford, South Parks Road, Oxford OX1 3RB, UK Tel: 441865275111 Fax: 441865275074 Email: speedy@ermine.ox.ac.uk

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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.

Marco A. Esnaola L, Ing.Agr.PhD. Profesor Produccion Animal Departamento Zootecnia, ZAMORANO PO Box 93, Tegucigalpa, Honduras Fax: 504-766244 Telefono:504-766240 o 50 y 504-766168
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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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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)

Feed components	Blocks				Crumbs	
	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 ***	Hay (or straw)
MOLASSES*			
<45 %	Breakable (excessive losses)	Breakable (excessive losses)	Breakable (excessive losses)
45-50 %	Good hardness (no losses) Good palatability Reduced intake Soft faeces Poor performance (ADG 10.2 �5.1 g/d)	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 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	Not tested	No losses

	Sufficient performance (ADG 25.8 �6.9 g/d)		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.

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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.

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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 (10^3cell/ml)	52,890	11,000 - 150,000
E. coli of effluent (10^3cell/ml)	75	2 - 450
Coliforms of loading (10^3cell/ml)	266,780	11,000 - 480,000
Coliforms of slurry (10^3cell/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

	LOCATION OF DAMAGE			
DAMAGE BY	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.

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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

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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.

Contents

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farming systems in Africa by E.L.K. Osafo *et al.* (Comments)

New developments in livestock systems based on crop residues in China by Guo Tingshuang and Yang Zhenhai (Comments)

Ruminant feeding strategies for sustainable agricultural production in upland mixed-farming systems of Indonesia by J.C. Tanner *et al.*

Feeding draught milking cows in integrated farming systems in the Tropics - Ethiopian Highlands case study by E. Zerbini and B. Shapiro

The role of low-cost plastic tube biodigesters in integrated farming systems in Vietnam by B.X. An

Rice-based livestock systems in Northeast Thailand - strategies for the integration of fish culture by David Little et al.

Stubble Grazing by Sheep by T. Treacher *et al.* (Comments)

Tree mixtures within integrated farming systems by Mauricio Rosales and Margaret Gill (Comments)

Landless Women and Poultry: The BRAC Model in Bangladesh by Md.A. Saleque and Shams Mustafa

Traditional Poultry Production Systems and the Role of Women in Parts of Western India by D.V. Rangnekar and S. Rangnekar

The role of scavenging poultry in Integrated Farming Systems in Ethiopia by D. Tadelle

Effect of Cropping Patterns on Egg Production of HYV Hens in a Semi-Scavenging Poultry Model in Bangladesh by Md. Mahfuzar Rahman, Hans Askov Jensen and Frands Dolberg

The role of scavenging ducks, duckweed and fish in Integrated Farming Systems in Vietnam by B.X. Men (Comments on Scavenging Ducks and Poultry)

Use of Rabbit Slaughtering Wastes as a Protein Source for Muscovy Ducks by Amici A., Margarit R. and Finzi A

Poultry and fish production - a framework for their integration in Asia by D. Little and K. Satapornvanit

The Use of Leguminous Leaves as Fish Pond Inputs by David Little, Amararatne Yakupitiyage, Alma Castanares, Peter Edwards and Leonard Lovshin

An Investigation into a Low-Input Pig-fish System Appropriate for the Mekong Delta, Vietnam by Duong Nhut Long and David Little

Opuntia-based ruminant feeding systems in Mexico by C.A. Flores Valdez and G. Aranda Osorio

The integration of fodder shrubs and cactus in the feeding of small ruminants in the arid zones of North Africa by A. Nefzaoui (Comments)

Crop-livestock Production Systems in some Rain Fed Areas of Western India by D.V. Rangnekar

Constraints to the Promotion of Integrated Farming Systems in Small Island States by F.A. Neckles

Livestock in Integrated Farming Systems by T R Preston

Outcome of Networking People on Livestock in Crop-Based Farming System in Asia by C.C. Sevilla and T.R. Paris

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) by E. Murgueitio and R. Espinel (Comments)

Information on Livestock Feed Resources and Integrated Farming Systems from the Electronic Journal Livestock

Research for Rural Development by A. W. Speedy and T. R. Preston

Final Comment

Example of useful information for updating the FAO database Tropical Feeds: *Trichanthera gigantea* (Humboldt & Bonpland.) Nees: a review by M. Rosales

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;
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,	Tropical rain forest W Africa,
R. vinifera, *R. sudanica,* *R. ruffia*	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.

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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

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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 wa

stes 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

	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	B	Final	B
	No	No	Yes	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 Torula	Processed waste + torula yeast

	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 yeats
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

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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

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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.).

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