Information on Palm Species

Abstracts

Nutritional evaluation of the *Jessenia bataua* palm: source of high quality protein and oil from tropical America. Balick, MJ and Gershoff, SN. 1981. *Economic Botany*. 1981, 35: 3, 261-271.

Samples of fresh fruit, oil and dried outer pulp (mesocarp and epicarp) were collected in the Amazon Valley in 1976, 1977 and 1978 and analysed. The composition of the oil was similar to olive oil, and the mesocarp pulp protein was similar in quality to good animal protein and better than most grain and legumes. Rats fed diets with mesocarp oil and pulp showed weight gains comparable with those fed on diets of corn oil and casein. The tree occurs in forests up to an alt. of 1000 m in N. South America, including Panama and Trinidad, and the fruit is used by indigenous peoples as a source of oil and a milk-like beverage.

Subsistence benefits from the babassu palm (*Orbignya martiana*). May, PH, Anderson, AB, Balick, MJ and Frazao, JMF. 1985. *Economic Botany*. 1985, 39: 2, 113-129.

Stands of babassu occupy an area of Brazil estimated at 200,000 km^2 concentrated in the States of Maranhao, Piaui and Goias. The babassu's cryptogeal germination, establishing the apical meristem of the plant below ground for its early growth and development, enables it to survive human disturbance. The fruit kernels are used as food, the husks for charcoal production and the mesocarp for animal feed. Other uses and those of the leaves (including medicinal uses) and stems are listed.

Understanding how the babassu is used by rural families will help to make current efforts at domestication and whole-fruit processing more responsive to human needs.

Pejibaye palm (*Bactris gasipaes*, Arecaceae): multi-use potential for the lowland humid tropics. Clement, CR and Mora-Urpi, JE. 1987. *Economic Botany*. 1987, 41: 2, 302-311; 30 ref.

Pejibaye palm can be used for: whole fruit for direct human consumption; palmito; fruit for flour and meal production; use as animal ration; and fruit for oil production. It is concluded that *B. gasipaes* has high potential for regaining its importance as a crop in the humid neotropics.

In the short term, perhaps the greatest potential of the pejibaye is for use as animal ration. The high starch levels, along with existing protein, oil, and carotene, are an excellent base for this use, and the ration can be enriched with soybean or lsh meal to augment protein levels as required. All the other uses of pejibaye, too, will provide residues that can be processed as animal ration.

In Costa Rica, flour and meal production programs are intimately related to the production of animal ration. There are already some privately owned plantations that put their first-quality fruits onto the internal market and prepare animal ration from second-rate fruits. One advantage of use as ration is that the skin and seed can be ground with the mesocarp. Chickens readily accept this mixed ration after it has been cooked.

Processing for oil production also will leave a high-quality byproduct. Since up to 40-60% of the dry weight of the mesocarp in oily cultivars will be oil, there will be a corresponding increase in levels of protein, starch, and fiber after extraction. High levels of protein are obviously desirable, but those of fiber may not be, especially if the kernel has been ground with the mesocarp (Arkcoll and Aguiar 1984).

In well-maintained plantations with adequate fertilization, and with cultivars selected for meal production, it should be possible to produce 15-25 tons/ha/yr of dry matter suitable for animal ration. Residues from oil production should vary between 2-5 tons/ha/yr. Both these figures are far above what is possible with maize in the humid tropics, although maize is the principal animal ration at present. The potential significance of these production figures is well illustrated by the city of Manaus, in Amazonas, Brazil, which imported approximately US $1,000,000 worth of cereals for animal ration in 1982, while its own region's production of maize, rice, and soybeans did not begin to supply its human needs. Although Costa Rican production of these cereals is good, grains are still imported for animal feed. In both regions, chicken and pork for domestic use are more expensive than they would be if each area produced its own animal rations.

***Attalea colenda* (Arecaceae), a potential lauric oil resource. Blicher- Mathiesen, U and Balslev, H. 1990. *Economic Botany*. 1990, 44: 3, 360-368.**

Attalea colenda, a palm tree native to the coastal plain of western Ecuador, produces from 1 to 4 infructescences per tree every year, each with an av. of 5065 fruits. The oil content of the seeds is 56.9% dry weight. Kernel oil production per infructescence is 7-16 kg. A hectare with 50 trees could produce 0.35-3.2 tons of oil per year. The kernel oil is chemically similar to coconut oil and kernel oil from the African oil palm, with a high concentration of lauric acid. The increasing demand for lauric oil crops makes *A. colenda* a potential oil source.

***Phytelephas aequatorialis* (Arecaceae) in human and animal nutrition. Koziol, MJ and Pedersen, HB. 1993. *Economic Botany*. 1993, 47: 4, 401-407.**

Field observations revealed the consumption of several parts of the vegetable ivory (tagua) palm not previously reported to be eaten by man or animals. The whole male inflorescence provides cattle with a fodder nutritionally similar to ryegrass, while the flower clusters provide man with 102 kcal/100 g of energy, about 4 times the energy density of cauliflower or broccoli. The central mesocarp is similar in composition and energy density to other fruits and is a comparatively rich source of calcium (116 mg/100 g), potassium (841 mg/100 g), and zinc (1.3 mg/100 g). The interior mesocarp, with 22% fat, is a high energy density (288 kcal/100 g) fodder for chickens and is rich in linoleic acid (21%). The immature endosperm, eaten as a snack, is of negligible importance in human nutrition.

Molasses/Urea Blocks

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Extract from FAO Tropical Feeds Database

Ruminant diets in most developing countries are based on fibrous feeds: mainly mature pastures (particularly at the end of the dry season) and crop residues (e.g. wheat and rice straw, maize and sorghum stovers). These feeds are imbalanced and particularly deficient in protein, minerals and vitamins; they are highly lignified their digestibility is low. These characteristics keep intake and productivity low.

The principles for improving the use of these poor quality roughages by ruminants include:

- satisfying the requirements of the rumen microorganisms to ensure efficient fermentation of fibre and increased production of microbial protein relative to volatile fatty acids;

- balancing the products of fermentative digestion with dietary nutrients (mainly through the use of bypass protein) to meet the needs of growth, milk, meat and wool production.

In practice this can be achieved by supplying, in order of priority:

1. A supplement of fermentable nitrogen and minerals.

2. A small amount (10 to 20 percent) of good quality forage, preferably a legume or grass cut at an early stage.

3. A small amount of a supplement containing materials that bypass the rumen: these include protein meal (e.g. toasted soya cake, solvent extracted groundnut cake) or starch based supplements (e.g. maize and sorghum).

This strategy is applicable in developing countries, e.g. in the Sahelian region of Africa, where ruminants are fed on pastures throughout the year with limited access to supplementary crop residues, or in Asia where they are fed mainly on rice straw and their diets are low in true protein for prolonged periods.

Mixtures of liquid molasses and urea, which provide fermentable nitrogen and are a good source of minerals, have been used for many years by ranchers in Australia and Southern Africa. Mineral licks (sometimes including urea) have also been extensively used in various parts of the world. However, small farmers have rarely benefitted from these supplements usually because of difficulties of handling these in small quantities. Molasses in the liquid form is difficult to transport (requiring expensive tanker trucks), to store (requiring tanks), to handle (it is highly viscous) and to distribute to animals (troughs or other receptacles being needed). Mineral licks which are usually imported are highly expensive and their cost/benefit ratio is often questionable.

By-pass nutrients, with the exception of legume leaves, come generally from rather expensive feeds which are either in demand for human nutrition (cereals) or exported for foreign exchange (oil cakes). However, because recent research has generally shown that their inclusion at a low rate in the diets is efficient, they should be economical to use in many situations.

Block Formulation

The blocks can be made from a variety of components depending on their availability locally, nutritive value, price, existing facilities for their use and their influence on the quality of blocks. They can also include specific components.

- Molasses provides fermentable substrate and various minerals and trace elements (but low amounts of phosphorous). Because of its pleasant taste and smell, it makes the block very attractive and palatable to animals. The degree Brix of the molasses should be as high as possible, and preferably higher than 85, to ensure solidification.

- Urea, which provides fermentable nitrogen, is the most important component of the block. Urea may increase the intake of straw by cattle by about 40 percent and its digestibility by 8 units (or 20 percent). The intake of urea must be limited to avoid toxicity problems but sufficient to maintain ammonia levels in the rumen consistently above 200 mg N/l for growth of microorganisms and high rates of degradation of fibre. Blocks are an excellent way of controlling intake and allow continual access.

- Wheat or rice bran has a multiple purpose in the blocks. It provides some key nutrients including fat, protein and phosphorus, it acts as an absorbent for the moisture contained in molasses and gives structure to the block. I may be replaced by other fibrous materials such as dry and fine bagasse or groundnut hulls which are finely ground but some loss of nutritive value occurs.

- Minerals may be added where appropriate. Common salt is generally added because this is often deficient in the diet and it is inexpensive. Calcium is supplied by molasses and by the gelling agent, calcium oxide or cement. Although phosphorus is deficient, there is no evidence that its addition is beneficial where animals are at below maintenance when grazing on dry mature pastures or fed low-quality forage. Mineral requirements are reduced at maintenance or survival levels. Deficiencies will generally become a problem only when production is increased, particularly when a bypass protein supplement is given and in these cases phosphorus should be included in that supplement.

- A gelling agent or binder is necessary in order to solidify the blocks. Although the mechanism of gelling is unknown, various products have been tried successfully: magnesium oxide, bentonite, calcium oxide, calcium hydroxide and cement.

The use of cement has raised some questions, from various nutritionists and extension workers, about possible negative effects on animals. In fact, research on the use of cement or its by-product, cement kiln dust, as a mineral supplement have not shown such adverse effects at levels of 1 to 3 percent of the total diet dry matter. (Nevertheless, the USDA has restricted the use of cement kiln dust since it could cause a deposit of heavy metals in animal tissue.)

- Various chemicals or drugs for the control of parasites or for manipulation of rumen fermentation (e.g. anti-protozoal agents, ionophores) can be added to the molasses blocks which can be an excellent carrier for these products.

Recent work has shown that the addition of small amount of rumen- insoluble calcium salts of long chain fatty acids could further increase the efficiency of the use of fibrous residues.

Finally, the formulae may vary according to the process adopted in manufacturing the block (Table 1).

Table 1. Examples of formulae according to manufacturing process

Process	Hot	Warm	Cold	Cold
Molasses	60	55	50	50
Urea	10	7.5	10	10
Common salt	-	5	5	5
Mg0	5	-	-	-
C03Ca	4	-	-	-

Bentonite	1	-	-	-
Ca0	-	10	5	-
Cement	-	-	5	10
Cottonseed meal or bran	20	22.5	25	25

The Manufacture of Molasses-urea Blocks

Different processes have been tried and can be grouped in three categories:

The "hot" process

This is the process which was first recommended in Australia. The molasses (60 percent) and urea (10 percent) were cooked with magnesium oxide (5 percent), calcium carbonate (4 percent) and bentonite (1 percent) at a temperature of 100-120 deg C for about 10 minutes. The content was brought to a temperature of about 70 deg C and mixture was left to cool slowly which enhanced solidification. It settled after some hours. The cooking was done in a double-jacketed rotating boiler with circulating water and steam.

The "warm" process

The molasses (55 percent) was heated to bring the temperature to about 40-50 deg C and the urea without water (7.5 percent) is dissolved in the molasses (Choo, 1985). The gelling agent was calcium oxide (10 percent). The rest was made up of common salt (5 percent) and bran (22.5 percent).

The inconvenience of these processes, particularly the "hot" one, is the necessity for providing energy for heating. However, if it is possible to use the hot molasses as it leaves the sugar factory or if an excess of steam is available, the cost of energy may be acceptable. The advantages are the reduction of time for setting and the finals product is not hygroscopic.

The "cold" process

It has been noted that, in tropical conditions, it was not necessary to heat the molasses in order to obtain a good block when 10 percent of calcium oxide was used as a gelling agent. This observation is of primary importance when blocks are manufactured in a unit separate from the sugar factory as was the case in Senegal.

The "cold" process involves a horizontal paddle mixer, with double axes, which is used to mix, in the following order of introduction, molasses (50 percent), urea (10 percent), salt (5 percent), calcium oxide (10 percent) and bran (25 percent). The mixture is then poured into moulds (plastic mason's pails or a frame made of four boards 2.5 m x 0.2 m). After about 15 hours, blocks may be removed from the mould and they may be transported by truck after 2 days.

Calcium oxide may be replaced by cement, but when cement is used it is important to mix it previously with about 40 percent of its weight in water, and common salt to be included in the block. This ensures its binding action, as the water in molasses does not seem to be available for the cement. The quality of the cement is of primary importance. Mixing the salt with cement accelerates hardening.

The disadvantage of the "cold" process is that it needs some time to set and the final product is somewhat hygroscopic. The advantages are the saving in energy, and the simplicity and ease of manufacture.

Independent of the process, the hardness of the block is affected by the nature and proportion of the various ingredients. High levels of molasses and urea tend to decrease solidification. The concentration of gelling agents and bran is highly important in the hardness of the final product. For example if the urea percentage is as high as 20 percent, molasses should be reduced to 40-45 percent and the gelling agent needs to be increased. Quick lime produces harder blocks than cement.

Feeding Molasses-urea Blocks to Ruminants

Factors affecting the intake of blocks

The hardness of the block will affect its rate of intake. If it is soft, it may be rapidly consumed with the risk of toxicity. On the other hand if it is too hard its intake may be highly limited.

High levels of urea may reduce intake of the block as well as of straw, urea being unpalatable (Table 2).

Table 2. Effect of urea content on intake of block and straw by lambs

Urea content of block, %	10	15	20
Block intake g/lamb/day	136	112	18*
Straw intake g/lamb/day	441	550	326

*4 out of lambs did not lick any of their block

Source: 621

The level of inanition or imbalance in minerals which lead to pica may result in excessive consumption in a short time also leading to urea poisoning. This has been noticed in at least one case in Senegal. Precautions should be taken to avoid this problem of over-consumption in drought prone countries particularly towards the end of the dry season when feed is scarce. The block should be introduced progressively, and it should be clear that the block, as it is presently formulated, cannot constitute the only feed and a minimum of roughage is necessary.

Where there is a bulk of dry feed the risk of toxicity from overconsumption is not apparent. In India, several thousand buffaloes in village herds have been fed blocks containing 15 percent urea without problems (625) and there is some indication that buffaloes learn to regulate their intake.

Finally, the intake of block obviously varies with the type of animals (Table 3).

Table 3. Intake of blocks for different types of animals fed a basal diet of straw

Type of animal	Animals weight	Block intake per 100 kg LW	Ref.
Lambs	22	400	622
Calves	66	250	623
Young buffaloes	100	380	624
Jersey bulls	300	185	625
Jersey bulls	350	150	"
Zebu heifers	280	110	626

Effects of blocks on intake of basal diet

Feeding blocks usually results in a stimulation of intake of the basal diet. With a basal diet of straw without any supplementary concentrate, the increase of straw consumption due to molasses urea blocks is between 25 and 30 percent. When some high protein concentrate is also given with the basal diet, the increase of straw consumption is less and varies between 5 and 10 percent (Table 4).

Effects of intake of blocks on digestibility of straw and some parameters of digestion

The digestibility of straw dry matter in dacron bags measured after 24 hours in the rumen of lambs increased from 42.7 to 44.2 percent when 100 g of molasses urea block was consumed, and to 48.8 percent by an additional supply of 150 g cottonseed meal.

Ammonia concentration in the rumen of lambs receiving molasses urea blocks increases to levels which are much higher than those generally recommended for optimal microbial development (60 to 100 mg NH3/1 of rumen fluid). This concentration increases with the urea content of the block (Table 5) and when a by-pass protein is added (Table 6). The digestibility of straw in sheep increased even up to 250 mg NH3 - N/1.

Table 4. Effect of block on intake of straw

Type of animals	Animal weight (kg)	Increase in straw intake (%)	Ref
STRAW WITHOUT CONCENTRATE			
Lambs	22	26	622
Jersey bulls	300	29.5	625
Dairy buffaloes	-	24	"
Young buffaloes	100	23	624
STRAW WITH HIGH PROTEIN MEAL SUPPLEMENTS			
Lambs	22(1)	8	622
Jersey bulls	350(2)	6	625
Crossbred cows	- (3)	10	"
"	- (4)	5	"

Preston, Leng and Nuwanyapka, unpublished data, quoted in 576

(1) with 150g cottonseed meal (2) with 1kg concentrates (3) with 1kg noug cake (*Guizotia abyssinica*) (4) with 2kg noug cake

The total volatile fatty acids in rumen fluid is increased when lambs consume the blocks with or without additional by-pass protein. There is a small but significant shift toward a higher propionate and butyrate production, and a lower acetate production.

Effects of blocks on ruminant growth

Dry mature pasture or straw given alone are unbalanced in nutrients to provide for an active and efficient rumen and to ensure an efficient utilization of the nutrient absorbed. Feed intake and the nutrient absorbed from such diets are insufficient to ensure even maintenance requirements and animals lose weight if they do not receive any nitrogen and mineral supplement. Molasses-urea blocks added to such an unbalanced diet allow for maintenance requirements because they ensure an efficient fermentative digestion. When some by-pass protein is added (e.g. cottonseed meal, noug cake) there is a synergistic effect which further improves considerably the average daily gain of ruminants and they become much more efficient in using the available nutrients. In addition total nutrients are often increased because feed intake is increased.

Compared to urea supplied by spraying on straw, urea from blocks give superior results. It is assumed that part of the response may be due to the small amount of supplementary energy supplied by the molasses but also by a stimulatory effect of other ingredients in the blocks on the rumen ecosystem (576).

Effects of blocks on milk production

The use of multinutrient blocks has allowed for a substantial reduction in concentrate in the diet of buffalo cows fed on rice straw. The fat corrected milk yield was not diminished by replacing part of the concentrate with block.

But the amount of straw in the diet and thus the profit per animal per day were greatly increased.

Considerable commercial experience has now been acquired in the use of blocks for supplementing dairy buffaloes fed rice straw under village conditions in India. Reducing the amount of concentrate give to buffalo cows from 5 to 3.5 or 4 to 2.5 kg/day, and distributing blocks, did not reduce milk production but increased fat percentage by about 10 percent and reduced the cost of feeding. In other observations the addition of blocks to the diet increased milk production by about 10 to 25 percent and fat content of milk by 13 to 40 percent. In one village where the initial production level was lower the increase was even grater.

Subsequent trials were conducted in Ethiopia with crossbred cows given meadow hay of low quality with two levels of noug cake. They showed that milk yield was increased by 28 percent when feeding 2 rather than 1 kg of noug cake in the absence of blocks. However, there was no difference between the two levels of noug cake when the cows had access to blocks (containing 10 percent urea). It was then possible to save 1 kg nough cake by providing blocks without lowering milk production.

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The Prickly Pears (*Opuntia* spp., Cactaceae).

Abstract

The prickly-pears (*Opuntia* spp., Cactaceae): a source of human and animal food in semiarid regions. Russell, CE and Felker, P. 1987. *Economic Botany*. 1987, 41: 3, 433-445.

Literature on the uses of *Opuntia* spp. is reviewed. The genus *Opuntia* appears to have its centre of genetic diversity in Mexico where it is widely used as fodder, forage, fruit and a green vegetable. In SW USA, *Opuntia* spp. can be both weeds and valuable forage plants.

During droughts propane torches known as 'pear burners' are used to singe the spines off cactus pads so that they can be eaten by livestock. Although spineless *Opuntia* varieties can be consumed directly by domestic livestock, they are extremely susceptible to herbivory by wildlife. The Cactaceae can be 4- to 5-times more efficient in converting water to DM than the most efficient grasses. Some *Opuntia* strains grow rapidly with fresh fruit yields of 8-12 t/ha year, and DM vegetative production of 20-50 t/ha year.

The Tamaulipan biotic province of South Texas and northeastern Mexico is a semiarid to subhumid environment. Local ranchers maintain that 3 or 4 out of 7 years will be drought years from the standpoint of obtaining a grass crop on rangelands. This unpredictability creates problems for range management that frequently result in rangelands being severely degraded by overgrazing.

Large sums of money are frequently spent to convert coastal plain and chaparral into grassland that can be maintained only for limited periods. Stocking rates based on the estimated forage production of the introduced grasses generally use the average rainfall estimate, which is not predictable for the anticipated growing season.

In light of the known variability of the precipitation regimen, we believe that prickly-pear should be included in any range management scheme in the Tamaulipan biotic province and similar areas of the world. During favorable forage production years, these cacti - protected from herbivory by their spines - would sequester minerals and water while producing carbohydrates and vitamins, which could be made available during drought years more economically than alternative feeds by burning off their spines.

In South Texas, prickly-pear (e.g., *O. lindheimeri*) is widely known as an emer- gency drought feed for cattle. In drought periods when grasses have been over- grazed or have become senescent, this cactus remains succulent and green, with a normal complement of vitamins and carotenoids (precursor to vitamin A). During the drought of the 1950s in Texas, prickly-pear was held in high esteem by cattlemen.

We suggest that prickly-pear can be grown as a fodder crop on land presently deemed marginal for other crops (e.g., maize and sorghum) because of its greater water-use efficiency. This fodder can be of either the spiny or spineless varieties. As an alternative to burning off the spines with pear burners, harvested spiny pads can be mechanically tumbled and chopped to remove the spines for confined cattle in a feed lot or dairy operation.

Finally, prickly-pear can be used to provide greater sustained carrying capacity to drought-prone rangelands. By incorporating it into a more diverse range ecosystem it can assure abundant emergency stock feed during drought seasons.

Nutritional Value of Palms

Abstract

Atchley, A.A. (1984). Nutritional Value of Palms. *Principes*, 28(3), 138-143

A few comparisons of palm nutritional value with that of other crops from tropical and subtropical regions may be instructive. Seed of *Cocos nucifera* has about twice the protein value of, and over fifty times as much fat, as the root of *Manihot esculenta*, and about twice as much protein as the ripe fruit of *Mangifera* indica. The bud of *Cocos nucifera* has over twice as much protein as the average reported for the ripe fruit

of *Carica papaya*, over seven times as much fat, almost three times as much phosphorus, and over twice as much niacin, although it has only about a tenth as much ascorbic acid and presumably, since no data are

reported here has relatively little carotene. (The palms are generally reported to be relatively low in ascorbic acid compared to *Capsicum* spp. and *Carica* spp., as well as many other tropical and subtropical sources of that nutrient.) However, *Elaeis* oil seems to be a source of carotene richer than ripe *Carica papaya* fruit, and at least comparable to the fruit of *Capsicum* spp. as reported by several sources. Interestingly, the bud of *Geonoma edulis* is reported to be over four times as rich in protein as that average ripe fruit of *Carca papaya*.

Such intriguing comparisons, which will it is hoped, become more accurate as the database expands, suggest a potential usefulness of palms in developing countries. Confirming the existence of this potential would appear to require intensive, standardized analysis which adequately explores variation in populations. The full range of ecological factors which influence the variation in time and space of nutritional value must also be investigated.

Extract from table of chemical analysis:

As % of dry matter

	CP	CF	Ash	EE	NFE
***Acrocomia mexicana* F**	**9.1**	**27.8**	**4.4**	**28.6**	**57.9**
***Areca catechu* S**	**6.8**	**18.1**	**1.7**	**12.3**	**79.1**
***Arecastrum romanzoffuznum* S**	**12.8**	**-**	**-**	**64.7**	**-**
***Arenga pinnata* SH**	**1.9**	**9.4**	**1.9**	**3.8**	**92.5**
***Astrocaryum standleyanum* F**	**6.0**	**20.3**	**5.0**	**2.5**	**86.5**
***Bactris guineensis* F**	**5.9**	**10.3**	**5.9**	**1.0**	**87.3**
***Borassus fabellifer* F**	**6.5**	**16.1**	**4.8**	**0.8**	**87.9**
***Butia capitata* S**	**15.7**	**-**	**-**	**-**	**56.5**
***Butia eriospatha* S**	**12.9**	**-**	**-**	**1.8**	**44.1**
***Calamus ornatus* F**	**2.9**	**2.4**	**2.9**	**5.7**	**88.6**
***Chamaedorea* sp. -**	**26.7**	**8.0**	**13.3**	**4.7**	**55.3**

***Chamaerops humilis* S**	**5.0**	**-**	**-**	**8.7**	**-**
***Chrysalidocarpus lutescens* S**	**6.9**	**-**	**-**	**7.2**	**-**
Chrysalidocarpus madagascariensis var. *lucubensis* S	**2.9**	**-**	**-**	**8.2**	**-**
***Cocos nucifera* S**	**6.3**	**11.5**	**1.7**	**67.9**	**24.0**
***Corypha utan* F**	**3.7**	**6.8**	**2.1**	**0.5**	**93.7**
***Elaeis guineensis* F**	**7.9**	**3.9**	**1.7**	**54.4**	**-**
***Erythea* sp. S**	**5.8**	**-**	**-**	**6.6**	**-**
***Euterpe oleracea* F**	**5.8**	**30.5**	**2.0**	**20.7**	**71.5**
***Geonoma edulis* SH**	**27.1**	**12.7**	**11.0**	**2.5**	**59.3**
***Hyphaene thebaica* S**	**4.1**	**10.0**	**3.3**	**6.8**	**85.7**
***Hyphaene turbinata* S**	**8.1**	**-**	**2.3**	**13.4**	**-**
***Jubaea chilensis* S**	**8.2**	**6.8**	**1.0**	**75.3**	**15.5**
***Mauritia vinifera* F**	**11.0**	**41.9**	**4.4**	**38.6**	**46.0**
***Orbignya cohune* S**	**6.9**	**-**	**-**	**52.2**	**-**
***Orbignya speciosa* S**	**9.4**	**-**	**-**	**62.9**	**-**
***Phoenix dactylifera* F**	**2.9**	**6.5**	**5.7**	**1.0**	**90.4**
***Prestoea longepetiolatao* SH**	**24.4**	**6.7**	**15.6**	**2.2**	**57.8**
***Pseudophoenix sargentii* S**	**6.2**	**-**	**-**	**19.2**	**-**

***Pseudophoenix vinifera* S**	**6.4**	**-**	**1.3**	**21.4**	**-**
***Ptychosperma macarthurii* S**	**5.9**	**-**	**1.4**	**1.6**	**-**
***Raphia hookeri* S**	**8.7**	**9.1**	**10.3**	**1.1**	**79.9**
***Salacca zalacca* F**	**1.8**	**-**	**3.2**	**0.0**	**95.0**
***Vetchia merrillii* S**	**4.1**	**-**	**1.5**	**1.3**	**-**
***Zombia anomala* S**	**4.9**	**-**	**1.6**	**1.8**	**-**

F = fruits; S = seeds; SH = shoot or vegetative bud

Strategy for sustainable use of natural renewable resources: constraints and opportunities

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The role of livestock in rural development

Livestock production (ie, all aspects of production systems, their products and by-products) in tropical countries of the less-developed World, has been and must continue to be one of the most important economic and social activities of human culture. In these regions of the world, hundreds of millions of people depend directly or indirectly on livestock-based activities, the analysis of which is complex and multi-sectorial.

Many technical and economic endeavours, at national and international levels, have attempted to increase animal production and animal productivity in the tropics but results in general have been meagre. Of the many explanations of this phenomenon, perhaps the most pertinent is the lack of understanding of the ecological, socio-economic and cultural limitations inherent in these countries and which constrain severely the application of conventional development models.

Paradoxically, there are also incredible opportunities for sustainable development, thanks to the enormous cultural and biological riches of the tropics, the rational exploitation of which could support sustainable production in the medium and long term, but which have not been considered seriously in previous attempts to develop the livestock sector in these regions.

The role of livestock in developing countries is quite complex and extends beyond their traditional uses to supply meat and milk as is invariably the case in the industrialized countries (Sansoucy 1995). They are certainly multi-purpose. They are valued for one or several (sometimes all) of the following traits: capital, credit, traction, milk, meat, hides, fuel and fertilizer. Thus, for families without land, livestock are primarily a means of increasing the family income. For the crop farmer especially in Asia, but increasingly in Africa and Latinamerica, the large livestock - cattle and buffaloes - are primarily sources of traction and power. In many societies the dung is used for fuel and to a lesser extent as fertilizer. For the transhumant grazier livestock may be most valuable as a capital resource and a source of credit. Production systems must take into account these varied roles, and must be adapted to specific local situations.

If, as expected, fossil fuel prices increase in the long term at rates exceeding average inflation in the industrialized countries, then one increasing role will be the use of livestock as sources of power in agriculture. This is already the case for many countries in Asia with low GNP and low international purchasing power (eg: Bangladesh and Vietnam).

The other issue, which perhaps relates more specifically to Latinamerica, and parts of Africa, is that the principal livestock production system is extensive grazing by large ruminants, the establishment of which has mostly been

through the destruction of the natural ecosystems of the tropical rain and cloud forests. These systems have consolidated the position of the medium to large landowner/cattle rancher and, by so doing, minimized opportunities for the small scale farmer.

Despite the privileged role accorded to extensive cattle ranching - witness the supporting research and development efforts over more than three decades by both international and national institutions - these production systems have become increasingly less profitable, due to increased prices of animals, feeds and other inputs, as well as increasing land prices due to competition with other end use patterns. The result has been their conversion into secondary activities kept in place by support (subsidies!!) from industry and commerce.

Livestock are enormously important to the economies of the less-developed countries as a whole. According to Brumby (1987) when, to the direct economic value of animal products, the value of livestock in providing rural transportation, draught power for cultivation, manure for crop production and their ability to utilize non-arable land and the agricultural residues is added, livestock accounts for about half the total agricultural production. Livestock also play a critical role in maintaining a cash flow for poor farmers who grow their crops essentially to provide food for their own household. Milk, meat and hides will always be sought after by those segments of society that have the necessary purchasing power to acquire these products. To the farmer-producer these products represent opportunities for generating income.

Economic growth and renewable natural resources

It is becoming a matter of increasing concern (Daly 1993) that the present rate of economic growth is already outstripping the capacity of the earth's ecosystems: (i) to produce the required resources; and (ii) to absorb the pollution caused by present levels of economic activities. The impact of the expected doubling of the human population by the mid-term of the next century, most of which will take place in developing countries, coupled with the aspirations of the present and future under-privileged majority, poses a threat that can in no way be described or predicted.

It is quite clear that future scenarios of resource utilization must be predicated on:

- **Optimizing the capacity of the earth's ecosystems to produce biomass, as the only renewable source of energy, chemicals, and food, without compromising the biological diversity on which the survival of all ecosystems depends.**
- **Minimizing waste through recycling, which reduces the need for raw materials and helps to protect the environment.**

For livestock to play a symbiotic role in such a scenario, it will be necessary to give priority to species that combine efficiency of conversion and productivity, produce low emissions of methane (a major "greenhouse" gas), and have the capacity to use by-products and residues from other primary industries.

Pigs and scavenging poultry undoubtedly are the preferred animal species in this scenario, but there will be an increasing role for the small, as opposed to large, ruminants and for the small non-ruminant herbivores (Cardozo 1993). High reproductive rate is what gives the competitive edge to these species. Aquatic systems with multiple production of fish, ducks, geese, water plants and other animal and plant species, will also find an increasingly important niche in the new livestock development model. The large herbivores will have a primary role as sources of power and fertilizer for agriculture, which they will achieve by recycling the residues from the crops they help to produce. Increasingly they will be expected to combine these activities with milk production and reproduction. The use of castrated males for work is a luxury which future pressures on resources will make increasingly less attractive. As with the plant kingdom, the need for biodiversity per se will justify the domestic use of the widest possible range of livestock species.

Among the largely unexplored possibilities of the diverse animal species present in tropical ecosystems, the natural wildlife - mammals, birds, reptiles, fish and crustaceans - can also make a contribution to sustainable livestock production systems, especially because of their adaptation to the ecologically fragile zones and their contribution to biodiversity (Cardozo 1993).

Sustainable use of natural renewable resources

The World Commission on Environment and Development (Brundtland Report 1987) defined sustainability as "ensuring that development meets the needs of the present without compromising the ability of future generations to meet their own needs". To this can be added the need to respond to the pressures increasingly coming to bear in both industrialized and developing countries to safeguard natural resources (see Brown *et al.* 1991). In livestock-based agriculture, production systems must take into account these issues. In practical terms this means measuring the "sustainability" of the system according to its effects on:

- **The economy**
- **The environment**
- **The need for energy (especially from fossil reserves)**
- **Animal welfare**
- **Food quality and security**

Economic constraints:

The prerequisite of any livestock system is that it should be profitable to the producer. In all industrialized countries, the costs of livestock production have escalated mainly because of the increase in the cost of labour caused by rising expectations (standard of living) and competition from other industries. The situation is exacerbated in those countries where farm size is small and therefore unit costs of mechanization are high. Faced with such situations, governments have resorted to subsidizing agriculture through guaranteed support prices and other forms of financial assistance. The total cost of this support amounts to a staggering 75% of the total value of agricultural production in Japan, 40-50% in the European Economic Community and up to 25% in the USA.

Producers are supported in industrialized countries through subsidies and protected markets. These supports have two important consequences: (i) they increase the price of food to the domestic consumer; and (ii) they reduce the economic growth of many developing countries unable to export primary and secondary commodities against the

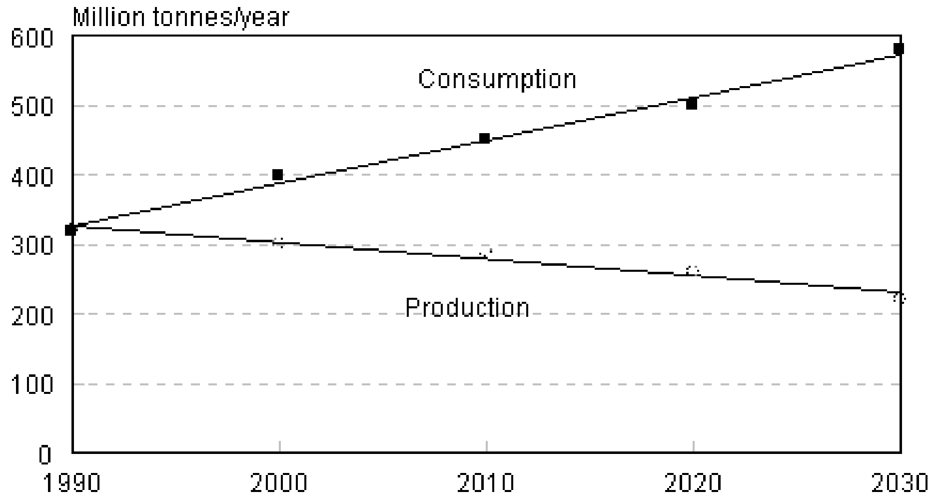
barriers of tariffs and quotas.

Such policies in the long term are not sustainable. They are inefficient in resource utilization since they direct expensive resources (often produced with cheap fossil fuel) into products which could be produced elsewhere with fewer resources. The production of wheat and milk in some oil-rich countries, which is only made feasible with massive inputs derived from fossil fuel (in fertilizers, irrigation and machinery) is an example of this misguided policy.

For the world economy to grow at an optimum and more equitable rate, it is essential that there is free trade in basic commodities. The objective of GATT (General Agreement on Trade and Tariffs) is precisely to promote the concept of "comparative advantage", whereby commodities are produced in the areas/countries which use least resources for that purpose. Unfortunately, the free movement of capital means that the principal beneficiaries from the exploitation of "comparative advantage" are likely to be the large multi-national companies. An even more worrying issue is that comparative advantage can also mean advantage gained by not paying the environmental cost of a given production activity.

Another world trend likely to have considerable economic impact is a likely cutback in the availability of cereal grains for livestock feed. Two factors will contribute to this trend. On the one hand, the rising human population in low income countries will increase the demand for cereal grain which usually is the cheapest staple either to produce locally or to import from world markets. On the other, state subsidies and protection, although still at high levels in the industrialized countries, will gradually be reduced as a result of the GATT agreement. Grain prices will rise as a consequence. Increasing cost of agro-chemicals and fossil fuel through environmental pressures will lead to cutbacks in the use of these inputs which in turn will lead to lower crop yields and increased costs of production.

Figure 1: Predicted trends in production and consumption of cereal grain in China (1990-2030)(Source: Brown 1994)



The case of China puts this in perspective. Presently there is a balance between production and consumption of feed grains at about 300 million tonnes annually. However, consumption for animal feed, now approximately 20% of the total, is increasing fast in pace with the increasing aspirations of the people for more animal products in their diet. At the same time the arable area is steadily decreasing due to the inroads of economic development through construction of roads, factories and houses. It has been predicted that, with present trends, by the the year 2030 China could face an annual cereal grain deficit equal to the present rate of production of 300 million tonnes.

For the poor small scale farmer, in a less-developed country where subsidies on the scale presently employed by the industrialized countries are out of the question, the priorities are food security and to maintain their life style (eg: as with pastoralists and indigenous peoples). The essential steps to achieve this are to produce first for family consumption, using an integrated production system involving crops, forestry and livestock, and which ensures self-reliance by making maximum use of renewable natural resources with minimal dependence on inputs from outside.

This is a more economical and ecological way of improving their standard of living, as compared with the

developed country models which have used fossil fuel to achieve this end.

Environmental issues

The productivity and efficiency of livestock production per animal unit in the least-developed countries is considerably less than in the more-developed world. But 'productivity' and 'efficiency' are references that relate specifically to temperate agricultural practices. In the tropics, livestock activities are different -- how does one measure the efficiency of survival, or livestock as a form of credit? These and other productive traits are achieved with minimum inputs of fossil fuel. The biomass availability and the potential to produce more biomass in those countries which are in the tropics is many times higher than in the major industrialized countries which are exclusively situated in temperate zones. But we have only just begun to recognize the potential of tropical feed resources, let alone devise ways of exploiting them in a way which will be sustainable.

Another factor likely to become increasingly important in the future is the potential for tropical soil-based ecosystems, derived from decaying biomass, to foster atmospheric nitrogen fixation (Patriquin and Moncado 1991), sequester carbon (Hall *et al.* 1991) and oxidize methane (Keller *et al.* 1990; Mosier *et al.* 1991). Threats to the environment come from:

- **Atmospheric contamination (global warming)**
- **Deforestation**
- **Accelerated erosion**
- **Soil and water pollution**
- **Loss of biodiversity**
- **Excessive human aspirations and lack of awareness of the finite nature of renewable resources**

Global warming

Livestock production is intimately linked with build-up of atmospheric carbon dioxide and methane since: (i)

emissions of carbon dioxide are caused mostly by burning fossil fuel and tropical deforestation; (ii) some 20% of methane emissions arise from digestive fermentation in the gut of herbivores, the methane itself contributing to some 15% of total greenhouse gases.

Forests and high biomass producing crops are important sinks for carbon dioxide (one ha of sugar cane is a permanent sink on average for some 80 tonnes of this greenhouse gas). Decaying biomass in contact with soil appears to be an important ecosystem where anaerobic micro-organisms oxidize methane (Keller *et al.* 1990; Mosier *et al.* 1991). Use of animal traction reduces the burning of fossil fuel; and permanent (as opposed to slash and burn practices, which provide for natural regeneration of the forest) tropical deforestation is mostly caused by activities leading to establishment of pastures for extensive ruminant livestock production.

Alternative methods of livestock production using high biomass-producing crops, fed mainly to monogastric animals and small herbivores, in partial or total confinement, will lead to increases in the size and number of sinks for both carbon dioxide and methane.

Deforestation

Livestock production parameters in extensive grazing systems in tropical developing countries are notoriously poor. The average fertility rate in the Latinamerican tropics rarely exceeds 50% and is often less; average stocking rates are less than one mature cattle unit per ha; slaughter age for 450 kg live-weight steers is more than 40 months; mortality rates frequently reach high figures in many regions due to contrasting food supply situations caused by long droughts and dry periods (Salazar and Torres 1981).

The recent evaluation of a dairying project in Costa Rica provides further confirmation of the unsustainability of tropical pasture-based livestock systems (Holman *et al.* 1992). Rain forest (4,000 mm rainfall annually) was cut down and burned in 1979-84 to establish Brachiaria pastures for family-farm resettlement. In 1992, it was revealed that incomes had deteriorated (to less than the minimum wage), soil fertility had decreased, weeds had taken over from the Brachiaria and concentrate usage had increased. The authors concluded that tropical pasture milk

production was not sustainable and that research was needed to facilitate transition to other systems of land use.

The contrast with Asian livestock production systems is interesting. In Vietnam, for example, erosion is not a serious problem and even the areas desiccated by defoliants during the war are regenerating vegetative cover. The reason for the environmentally-friendly role of livestock in Vietnam is that there is no recognized pasture-based beef industry. The role of cattle and of buffaloes is to supply the power needed by agriculture. They are therefore kept in the cropping areas and are fed almost exclusively on fibrous crop residues and by grazing on fallow and common lands (Preston T R, unpublished observations).

Erosion

Africa's grazing systems are characterized by agro-pastoralism and transhumance. Such systems were apparently sustainable in times of low population density, with little pressure on the natural resource base and with opportunities to move from degraded lands to new territories or to adapt the pastoralist practice (eg: to herd camels and goats instead of cattle); but they have been destabilised by "development" practices, which have removed former "density-dependent" constraints (eg: through veterinary care, reduction in tribal raiding), or added new constraints (eg: reduction of range land area due to encroachment of crops and settlement of pastoralists; and increasing herd sizes) (see Ellis and Swift 1988).

The impact of this destabilisation was clearly seen in the Dodoma region of Tanzania (Christiansson *et al.* 1987; Chritiansson 1988)). Explosive growth of the population resulted in increasing areas of range land being diverted to cropping. At the same time, the livestock herds of the pastoralists were also increasing. The outcome was uncontrolled over-grazing of the non-cultivable areas, leading to severe land degradation, threatening total ecological collapse of the region. The seriousness of the situation resulted in the initiation of a far reaching, and in some respects unique programme - The HADO Project (Hifadhi Ardhi Dodoma - Dodoma Region Soil Conservation Project).

The HADO project was started in 1973 and was initially concerned with arresting the accelerating land degradation

occurring in parts of Dodoma Region through physical soil conservation measures. However, it quickly became apparent that the terraces, bunds, cut-off drains etc. that had been constructed were not having the desired effect due to their destruction by grazing animals, and also due to uncontrolled water run-off from higher slopes denuded by over-grazing. As a result, a decision was taken in 1979 to close the most severely affected area, of over 1,200 km - the so called Kondoa Eroded Area - to all livestock, which involved the eviction of over 85,000 cattle, goats, sheep and donkeys.

A review of the Kondoa area, 10 years after the decision to de-stock (Preston T R 1989, unpublished data), showed that the regeneration of the vegetation, and the arrest of ecological degradation generally in these areas had been dramatic. Honouring the promise to the farmers that some form of livestock keeping would be allowed when the land had recovered, the government in 1990 with help from SAREC and SIDA introduced a zero grazing scheme for milk production with improved crossbred and local cattle. Results have surpassed expectations (Ogle *et al.* 1993), with milk yields of up to 10 litres daily being achieved on locally available feed resources, and with major participation of women in the feeding and management of the cows and the use and sale of the milk.

Soil and water pollution

The problem of soil and water pollution has arisen due to excessive use of chemical fertilizers and insecticides in "green revolution" agriculture. Loss of soil organic matter, which increases the need for fertilizer inputs, through monoculture of exploitive crops such as cotton and cassava has been a contributory factor.

A related issue is the effect that excessive chemical fertilizer application and burning of crop residues has had on natural ecosystems. There is increasing evidence that high levels of nitrogen fertilization decreases fixation of atmospheric nitrogen in the rhizosphere of, for example, sugar cane (Patriquin 1982); and that it increases emissions of nitrous oxides and decreases oxidation of methane (Mosier *et al.* 1991). By contrast, leaving post-harvest cane trash on the soil as a mulch, instead of burning it, increases sugar cane yields (Mendoza 1988; Phan Gia Tan 1994; Nguyen Thi Mui *et al.* 1995) and soil fertility (Phan Gia Tan 1994).

The integration of livestock with crops provides both nutrients for the plants and organic matter as an energy source for soil micro-organisms to aid soil fertility. On a specialized crop farm there may be little incentive for planting break crops of legume forages. But if livestock are present then such forages can be turned into income by feeding them to animals. Planting of multi-purpose nitrogen-fixing trees in association with cash crops as in "Alley farming" systems is also more attractive to the farmer if some of the foliage can be used to give added value to livestock (Attah Krah 1991).

Loss of biodiversity

Genetic selection for livestock of ever increasing productive potential has inevitably lead to decreased biodiversity at the animal level. Intensive feeding systems for monogastric animals, almost exclusively tied to use of cereal grains and soya bean meal, have encouraged replacement of indigenous ecosystems and local strains of cereals with 'more-productive' hybrids. Emphasis on specialized grazing systems in the tropical savannahs has created vast expanses of pasture monocultures of *Brachiaria* spp. In both cases plant biodiversity has been reduced.

The positive side of increasing affluence is the opportunity to choose more on quality and less on price. In Colombia, eggs from scavenging 'local' poultry were preferred and brought higher prices that those from 'battery' birds (Solarte *et al.* 1994a). Local chicken command a higher market price than "broilers" in Vietnam (Luu Trong Hieu 1994, personal communication). Meat from an indigenous pig breed had a better taste than that from imported 'improved' breeds and was preferred by local inhabitants in Guadeloupe (Depres *et al.* 1994). The meat from non-ruminant herbivores living in natural ecosystems is considered to be a delicacy (and therefore worthy of a higher price) in many tropical countries.

The search for alternatives to cereal grains and protein-rich oilseed and animal by-product meals (Sansoucy 1995) is already leading to the identification and promotion of a wide range of indigenous (to the tropics) crop and water plants, trees and shrubs. Biodiversity will be enhanced by these practices which should be encouraged (eg: by more research).

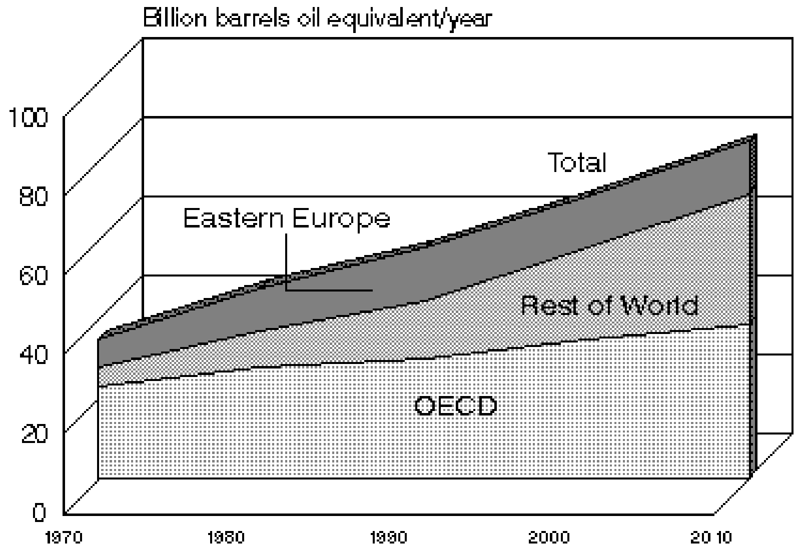
Human aspirations and the resource base

The economic strength and the standard of living of the industrial countries is directly linked with their consumption of fossil fuel (Figure 2). The aspiration of the less-developed countries is to follow a similar route.

But reserves of fossil fuel are finite and have a lifetime measured in decades not centuries. Hydro and nuclear power pose serious threats to biodiversity and to contamination with hazardous wastes, with fewer opportunities for employment.

The only sustainable solution is to promote life styles, and goods (of which energy is a priority), which are derived from activities associated with the development and management of natural biologically-based resources. For the researcher in a tropical country, responding to this challenge should be a privilege and source of satisfaction, long since absent from the agenda of their colleagues in industrialized countries for whom agriculture is of declining importance.

Figure 2. The demand for energy (mostly as fossil fuel) will increase most rapidly in the least-developed countries as they aspire to the living 'standards' of the industrial countries (source: the Economist, June 18 1994).



Renewable and non-renewable (fossil) energy

The close link between livestock policies and fossil fuel use has been mentioned. Three examples put this in perspective. On the 30,000 ha sugar estate in the Dominican Republic (La Romana), some 18,000 oxen haul the sugar cane from the fields to pickup points on a railway system leading to the sugar mill. This system is highly sustainable since the energy for the oxen is derived from the carbohydrates in the cane tops; nitrogen and minerals in the tops are returned to the soil in their excreta, since the animals eat and rest in the recently harvested areas.

By contrast in Cuba, some 80% of the sugar cane is harvested mechanically by diesel-driven combines and loaded onto trucks which transport the stalks and attached trash to cleaning centres. Here, electrical power is used to blow off the trash, and the stalks are elevated onto rail wagons or trucks for continued transport to the factory. This system is not sustainable. At the time of writing this paper the problem of de-mechanization of Cuba's agriculture was the subject of keen debate and the re-introduction of draught oxen a matter of high priority for the Government (Rena Perez, 1995, personal communication).

The example of Vietnam has already been mentioned, where agricultural power is supplied almost exclusively by buffaloes and oxen, and bicycles are the major means of personal transport. Vietnam's rating in terms of GNP may be one of the lowest in the world but if it were assessed in terms of sustainable agriculture it would be among the leaders. By contrast, in most tropical countries in Latinamerica, oxen have been replaced by tractors and forests are burned to develop pastures for beef cattle. These policies are highly unsustainable.

A specific problem of less-developed countries is the provision of domestic fuel for the more than 2,000 million families that use firewood from woods and forests for this purpose. In Colombia, it is estimated that 29% (240,000 ha) of the annual rate of deforestation (800,000 ha) is caused by domestic fuel wood consumption, half of which is in rural households, a third in poor urban communities, the remainder divided between charcoal production (9%) and rural handcrafts (11%). The amount consumed varies from region to region, but it is calculated that a rural family of 8 persons uses 18 cubic metres (about 3.6 tonnes) of firewood annually solely for cooking. If this is purchased then it may cost (in Colombia in 1990) up to US$70.00/tonne. When cut from the forest it is estimated that 50 work days are expended annually for this purpose, to a value of US$147.00 (Solarte, L, Personal communication). The situation in much of Africa and in parts of Asia is similar.

Several solutions have been proposed which involve livestock. They are complementary and depend on natural and economic resources available and on cultural acceptance of the technology on offer.

- **Biogas digesters**
- **Establishing energy plantations**
- **Use of crops that fractionate easily into "feed" and "fuel" components**

Biogas technology was first developed in India and China. The mixture of methane and carbon dioxide (biogas), produced by the anaerobic fermentation of livestock and human excreta, has found major uses in cooking. Biodigesters are intimately linked with livestock production, as they depend for substrate on the excreta of animals. Thus, use of this technology strengthens the arguments for partial or full confinement of animals, and thereby forms part of the strategy against uncontrolled grazing. The major constraint to the popularization of

biodigesters has been cost and availability of suitable materials for their construction. The recent development of low-cost (less than US$50/family unit) biodigesters using standard polyethylene tubular film (Botero and Preston 1988) has had a major impact in Vietnam (Bui Xuan An *et al.* 1994) and Cambodia (Than Soeur 1994) where the even lower costs (less than US$30.00/family unit) put the technology within reach of the majority of families.

Cereal crops are easily separated into grain and straw. The latter is burned on open fires (with low efficiency) for fuel in many developing countries. But increasingly in industrialized countries, especially those with strong legislation against uncontrolled burning, it is used as fuel in boilers designed for this purpose. In Denmark whole villages are heated in the winter using this technology. In tropical countries, there are even greater opportunities for applying this principle. Production of sugar from sugar cane is one of the few agro-industrial activities which is self-sufficient in energy (and can even be an exporter of energy). In Vietnam, the growing of enough sugarcane to feed four pigs (with the juice) produced fibrous residues (the pressed stalk) sufficient to cover half the fuel needs of a family of six (Nguyen Thi Oanh 1994). The concept of the multi-purpose biomass refinery, in which the juice is the basis of animal feed or chemicals and the fibre is converted to synthesis gas to power gas turbines for electricity generation (Preston and Echaveria 1991), promises to be more viable, economically, sociologically and ecologically, than the single-purpose production of alcohol as in the Brazilian model. Multi-purpose trees can also be fractionated easily into feed (the leaves) and fuel (the branches and trunks) and can thus be part of the same "integrated" model.

Energy plantations are important for the arid and semi-arid regions as they are complementary to pastoral-forestry schemes. Many species that can be used also fix atmospheric nitrogen and produce edible foliage and/or fruits. They include: Acacia, Prosopis, Leucaena, Gliricidia, Guazuma, Inga, Albizia, Cassia, Pithecellobium and Alnus spp. They may be sources of food, feed, fuel, timber and protection against erosion and desertification. These systems can also be the basis of biomass refineries as described above.

Thus the promotion of sustainable systems of agricultural production, in which livestock play a fundamental role, can also contribute to the solution of the domestic energy crisis. The use of multipurpose crop plants and trees, and the recycling of livestock excreta, provide not only much needed domestic fuel, but also control erosion,

reduce contamination and act as sources of fertilizer.

Ethological issues

Animal behavior studies were originally conceived as a means of exploiting livestock more efficiently through greater understanding of their habits and activities in different environments. The approach today is quite different. Behavior studies are done so as to develop less exploitive methods of animal production. The aim is to reduce stress to the animal and the attendant so that the quality of life of both is improved (Fox 1988).

The deliberate promotion of contentment through natural means can be reflected in higher productivity. The calf, lamb or kid, that is suckled by its mother will grow faster, be healthier and have a better feed efficiency than if it receives its milk from a bucket. The dam will also respond to the more natural environment of having her offspring present at milking, and having it suck the residual milk from the udder. Milk yield will be higher and udder diseases less than if calves are weaned permanently soon after birth (Preston 1983; Preston and Vaccaro 1989). Calves suckled naturally do not have the urge to suck the navels of their neighbours and thus can be managed in groups instead of being confined to individual pens. Sows fed fibrous feeds during gestation are less prone to develop anti-social behavior (eg: biting of tails and ears) than when high nutrient density feeds are given. They can then be managed in (more social) groups rather than in separate individual stalls.

Stressful systems of livestock management, such as raising animals in cages and stalls, are already being legislated against in many countries in Europe. Practices such as debeaking of birds housed in cages, amputation of the tails of pigs and castration, reduce productivity and invite cannibalism.

Embryo transplants have been heralded as a means of increasing beef cow profitability by inducing multiple births and thus raising prolificacy (King 1989). However, this technology can result in a high degree of stress in both the cow and her attendant. The long term effects are likely to be reduced lifetime fertility. Stimulation of cow milk yield by injecting recombinant growth hormone appears to reduce longevity and to increase stress (Kneen B, 1994 Personal communication) through accelerated partitioning of nutrients from body tissues into milk. The welfare of

these cows is certainly decreased and cannot be considered to be sustainable.

The direct economic cost of stressful systems of management will ultimately be reflected in the market place with premiums for products from contented and well cared-for animals and penalties for products of animals that are ill-treated.

The transformation of both extensive cattle ranching and the highly intensive methods practiced in monogastric animal production, into more integrated systems in which the livestock play a symbiotic and complementary role rather than being the primary goal, will bring with it related advantages in terms of animal welfare.

Wholesome (natural) foods

In an increasing number of supermarkets and stores in the industrialized countries, premiums are paid for food produced in "environmentally-friendly" farming systems. Crops that are grown according to "organic" farming principles are in this category; as are animal products (eg: meat and milk) derived from such cropping systems.

The ban on imports to EU countries of beef from cattle treated with synthetic hormones shows how this concern for more natural food translates into economic criteria.

Inappropriate models derived from industrialized countries

The issue here is that, in contrast with crop production, livestock systems in tropical developing countries have been highly influenced by practices developed in the industrialized countries, most of which are in temperate climatic zones. For example, most "modern" methods of pig, poultry and dairy production in tropical countries are almost exact copies of those practiced in industrialized countries, using the same germ plasm and feed resources. The term 'assembled' is often used to describe the products derived from such systems to emphasize their dependency on imported inputs.

Such practices have been justified by the need to respond to the aspirations inherent in a 'better standard of living' through increased consumption of food of animal origin. In fact, they exacerbate the basic problems since they result in:

- **Minimum employment opportunities.**
- **An increase in the foreign exchange deficit, due to high imports (some countries import 100% of their feeds for industrial-scale pig and poultry production)**
- **More pollution as usually the animal population in such units is high and there are no associated crops for recycling the excreta.**
- **Impoverishment of the small scale farm family which cannot compete in the purchase of the required inputs and may not have the skills for the more sophisticated management that is required.**
- **Countries such as Nigeria and Venezuela, which built up sophisticated intensive animal industries in times of high oil revenues, found that these were not sustainable when oil prices fell and agricultural subsidies had to be reduced.**

Indicators of sustainability

Indicators of sustainability are derived from measurements which describe the effect of the system on the sustainability of the resource. While this topic is presently the subject of much discussion, the following parameters are proposed as criteria on which the sustainability of resource utilization can be measured. The items (not in order of priority) include:

- **Total biomass yield**
- **Soil organic matter content**
- **Soil pH**
- **Soil content of P, N, K, and Ca**
- **Degree of diversity of animal genetic resources and their use at the level of small scale users**
- **Water quality**

- **Production and use of renewable energy**
- **Energy balances**
- **Diversity in fauna and flora at plant and soil level**
- **Greenhouse gas emissions and sinks (carbon and methane)**
- **Employment generation**
- **Involvement of women and children**
- **Food security.**
- **Maintenance of lifestyle of households in rural areas**
- **The catalytic role of livestock in the integration of crops, livestock and forestry.**
- **Protection against erosion and desertification**

Using the above criteria it has been the experience in several tropical countries that the production and use of feed resources derived from sugar cane (small scale - not industrial), African oil palm, sugar palm, forage trees and shrubs, and most water plants, can be sustained. The use of cereal crop residues (but not always the production) is also a sustainable feeding system as the primary product will always be produced for human consumption. By contrast, cultivation of cassava, cotton and "introduced" tropical pasture species is unsustainable due to negative effects on soil fertility and, in the case of tropical pastures, due to negative effects on socio-economic indicators (eg: employment, and persistence of households in rural area). The issues here are that exploitive crops which are not sustainable as monocultures should be rotated with crops that restore soil fertility.

Conclusions

The issues discussed in this paper provide a conceptual basis for the sustainable use of renewable natural resources in livestock-based farming systems for the tropics. The interpretation of this strategy in the form of practical farming systems has profound implications both for the type of feed resources that will be on offer, the species of livestock most suitable for their utilization, the most appropriate way to evaluate them and the manner in which such feeds should be incorporated into the diet of the animal. These themes are the basis of "research into the better use of tropical feed resources for livestock" which is the primary theme of this conference.

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Prosopis juliflora

Andrew Speedy

(Editor)

Extract from FAO Tropical Feeds Database

***Useful reference*: 563**

A tree up to 10-15 m high, typical of arid and semi-arid regions, with a green-brown, twisted stem; flexible branches with long, strong thorns, bipinnate leaves; pale-yellow flowers arranged in spikes; flattened fruit, nondehiscent with hardened epicarp, multi-seeded and curved (approx. 4 mm thick, 1 cm wide and up to 15 cm long). The fleshy mesocarp is rich in saccharose (20-25%) and 10-20% reduced sugars. The root system includes a tap root that grows deeply downwards in search of water tables.

***P. juliflora* is native to Peru, Chile and Argentina and has spread to Mexico, the southern USA, NE Brazil, Bolivia, Colombia, El Salvador, Nicaragua, Uruguay, Venezuela, the West Indies and the Bahamas. It is also now found in Iran, India, S Africa and Australia.**

Pod harvest is an easy but costly, manual operation. Pods are stored in wood-lined or brick-built houses or in layers of sand (`colca'). Pods may be stored for several years but are very prone to insect attack, requiring fumigation of the storage houses with bisulphide or phosgine.

Pods have long been used as feed for cattle, horses, sheep and goats. Stock poisonings recorded from pods eaten after exposure to rain. Only ripe pods should be fed, as the green pods are bitter and have little feed value. The foliage is good-quality fodder but its use is not widespread; direct browsing of the foliage has been used but may limit tree development and it is not particularly palatable.

In Peru, Chile, Argentina and Uruguay, the pods are used in concentrate rations for dairy cows at a ratio of 40-60%. They are also included in rations for beef cattle, mules, pigs, sheep and fowls. In Hawaii, it is also much valued for cows, but also for fowls and pigs. The following experimental studies are all cited in reference 563. Studies in Brazil showed that *P. juliflora* pod flour could replace up to 60% of wheat flour in rations for lactating cows and that DM intake, weight gain and milk production increased with increasing proportion of pod flour. Total replacement of

wheat flour by ground pods was also favourable for beef cattle.

In Mexico, trials with sheep showed that replacement of sorghum flour with PJ pod flour increased LW gain up to 45% but not at 60%. In Brazil, replacement of sugarcane molasses with PJ pods at 0, 15, 30, 45 and 60% was most effective in terms of LW gain at the 30 and 45% levels. In another trial, it was found that intake by sheep was not influenced by grinding or heating but ground pods fed with elephant grass (*Pennisetum prupureum*) were eaten in greater volume than the whole pods.

References to pig feeding are scant but, in Peru, pigs have been fed 1-3 kg pods. Pigs fed on rations containing 70% sun-dried PJ seeds in Hawaii gained 595 g per day. Kiln-dried seeds gave lower gains. PJ flour was used to replace up to 100% of wheat bran in rations for chickens with no effect on intake, FCR or egg weight (564).

As % of dry matter

	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref
Seeds, Brazil	88.4	35.8	6.1	3.7	4.5	38.3	-	-	563
Pod flour, Brazil	89.2	59.0	1.7	4.9	8.9	15.0	-	-	"
Fresh flowers, Sudan	30.0	21.0	15.5	10.0	3.2	50.3	1.31	0.40	64
Fresh leaves, Sudan	41.2	19.0	21.6	8.5	2.9	48.0	2.08	0.22	"
Pods, South Africa	93.7	13.9	27.7	4.8	3.0	50.6	-	-	193
Fruit pulp	-	7.7	12.0	2.3	0.6	77.4	-	-	234
Seeds, Sudan	-	65.2	2.8	5.2	7.8	19.0	-	-	"
Pod husks	-	4.3	54.3	3.4	0.6	37.4	-	-	"

Digestibility (%)

	DM	CP	CF	EE	NFE	ME	Ref
Pod meal, Peru	82.6	80.1	70.9	91.0	83.2	-	563

Amino acid composition as % of crude protein

Pod flour Ref 563

Arg	Cys	Gly	Hys	Iso	Leu	Lys	Met	Phe	Thr	Try	Tyr	Val
13.3	1.2	4.4	2.7	2.7	6.6	4.0	1.0	3.5	2.4	1.1	2.3	3.5

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Introduction to the First FAO Electronic Conference on Tropical Feeds and Feeding Systems

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Background

Livestock production constitutes a very important component of the agricultural economy of developing countries, playing, in particular, a key role in food security. In fact, the animal product part of the total food production is increasing at a much higher rate than that of cereals and other crops. Actually, the contribution of livestock goes far beyond direct food production (milk, meat and eggs) and includes multipurpose uses, such as: draught power (contributing to crop production, transportation...), skins, fibre, fertilizer and fuel, as well as capital accumulation. Furthermore, livestock production is closely linked to the social and cultural lives of several million resource-poor farmers for whom animal ownership ensures varying degrees of sustainable farming and economic stability.

The target group of FAO programmes is that of the small farmers. The main problems which presently limit the productivity of the small farmers' livestock are shortage and low quality of feed, and in some cases, high disease incidence and subsequent mortality of livestock. These problems are further aggravated by the lack of substantial capital investment, lower technological inputs and slow transfer of appropriate technologies. Despite the repeated efforts regarding animal health and genetics, during the past decades, the productivity has not increased due to the neglect of the feed component. This has particularly been the case in numerous developing tropical and sub-tropical countries where the main purpose of maintaining livestock is draught power and organic fertilizer, rather than for livestock products.

In order to feed the growing human population, it will be necessary to devote more land to food and cash crops and therefore the land available for pasture and fodder will be reduced as has already occurred in Asia. Wherever the rate of population growth is high, grain production will be more and more destined to satisfy the food needs of these populations and less or no grain will be made available for animal feeding. On the other hand, increased food and cash crops will produce more crop residues and agro-industrial by-products, many of which represent valuable animal feed resources.

Therefore, there is a need to promote new feeding systems taking advantage of sources of energy and protein which are not directly challenged by the food demand and which can be integrated in a sustainable agricultural production system. Several such systems are already known and have been tested under different tropical and sub-tropical conditions. Their aim is to utilize all available local resources, such as natural grasslands and high yielding crops (sugarcane, palm oil, cassava tubers or sugar palm trees) as providers of energy and locally-grown soya or other legumes, multipurpose trees, animal and fish wastes, and aquatic plants as providers of protein.

There is a large number of different feeds available in the tropics (more than 600 are mentioned in the FAO publication "Tropical Feeds"). However, information on their nutritive value and their potential role as ingredients in local sustainable feeding systems is quite insufficient in most cases.

The major objective of the livestock development policies in developing countries is to ensure the optimum contribution of livestock to agriculture, in order to achieve food security, through an increase of the domestic production, and an improvement of income and welfare of the small farmers. The priorities of the developing countries favour production systems which are sustainable and environment-friendly, and which promote rural employment and reduce dependency upon imports. Livestock should be kept on feeding systems which do not require food demanded by people.

Why An Electronic Conference on "Tropical Feeds and Feeding Systems"?

On the occasion of the presentation of the document "Livestock and Improvement of Pasture, Feed and Forage",

the FAO Committee on Agriculture (1993) recommended "the development of means for rapidly disseminating information on various feed resources by modern techniques (computer diskettes, CD-ROM, electronic mail)" and that "further efforts and research be devoted to this initiative". The need was also emphasized to disseminate the results coming from on-farm and on-station feed research on techniques suited to smallholder systems.

The Feed Resources Group (FRG) of the FAO Animal Production and Health Division has been very active in the production of publications in electronic format and supporting key database in recent years. It has been involved since the early eighties at the inception of the electronic journal LRRD "Livestock Research for Rural Development" published by CIPAV (a Colombian NGO) which focusses on the role of livestock technologies in rural development in the developing countries (Preston and Speedy, 1989). This journal is now distributed to about 1500 scientists in over 100 countries, (free of charge in developing countries). The FRG has continuously been involved in the editorial advisory board, the collection of contributions, the distribution, diffusion and FRG is also now cooperating with the editorial work. Moreover, LRRD has become the main vehicle of information for two FAO regional projects since it includes their news bulletins.

The first publication of the FAO book "Tropical Feeds" by Bo Gohl in 1975 has been much appreciated by scientists all over the world. A second edition was issued in 1981, and the book went out of print in 1990. For economic reasons, and also to take advantage of the tremendous progress made in electronic publications, the first computerized version of Tropical Feeds, revised by Andrew Speedy (Oxford University) was issued in 1991. This has greatly facilitated the updating of the information contained in this book. However much more information is still needed on tropical feeds, fodder plants, trees and shrubs. In order to better respond to the users' needs, more data should also be compiled on practical utilization aspects and feeding systems for the main domestic animal species.

In 1994, a prototype of an electronic book (APH 102: Legume trees and other fodder trees as protein sources for livestock) was produced which constitutes the first step towards an electronic library to be made available through an Internet server. Six recent publications from the FRG should be transferred in the near future under the electronic format for inclusion in the electronic library. Savings gained through this new publishing policy could

be devoted to the updating of previous publications and their transfer to this new format for distribution. This approach would greatly expand the potential readership throughout the world.

In developing countries, computers can now be found almost everywhere and electronic mail and INTERNET services are more and more available. This communication system is rapidly expanding since it has been recognized as the most cost-effective means of exchanging, circulating and updating information. It is the fastest way of getting inputs and distributing outputs from and to a huge audience. Since 1989, the FRG has been using Electronic mail to correspond on a regular basis with more than 50 countries (33 of them are developing countries) from the five continents. This network is currently enlarging very quickly, in particular with the help of trust fund network projects in Asia, Near-East and North Africa, and Latin America and the Caribbean.

Through electronic mail, the FRG has started to establish a small informal "Panel of Experts" (from Botswana, Colombia, Cuba, Denmark, France, India, Tunisia, UK, Vietnam...), which is regularly consulted for advising on identification of consultants, preparation of the programme of activities, technical matters, etc... This has proven to be a more efficient (prompt response) and cheaper way of receiving advice than the traditional FAO Panels of Experts.

From November 1992 to April 1993, the first electronic conference on Livestock Research and Development has been successfully organized by the Winrock International Institute for Agricultural Development (USA), the International Forum on Sustainable Land-use Systems (INFORUM, USA) and the International Development Research Centre (Canada) with the participation of a few scientists from developing countries. At that time, however, this conference had difficulties in reaching scientists from the South. With the rapid progress of technology and the reduction of costs of equipment it has, at present, become much easier for developing countries to join the various electronic networks.

These developments are fully in line with the need for FAO to spare money on traditional publications and international meetings without jeopardizing its recognized leadership as a major repository of information, a major source of norms and a neutral international forum. In particular, the FRG could better comply with its

responsibility for selective dissemination of feed information, related to the better use of available resources in new feeding systems, rather than just supporting the further collection of data and information per se.

Prospects

The objective of the FRG is to boost the exchanges of information and experience in the field of tropical feeds and feeding systems among developing countries. Many of them are currently suffering from the so-called `book famine', which is a major constraint to effective development. On the other hand, other developing countries are overflowed with often `non appropriate' information coming from industrialized countries. At the same time, due to the lack of an effective vehicle, very relevant information which is increasingly being generated in the developing countries is still not widely disseminated to other developing countries where this information would be most useful.

This unfortunate situation can now be improved in a cost-effective and sustainable manner thanks to the development of electronic publications, mail, and conferences. The latter are some of the fastest and most powerful tools for exchanging information and experiences. They will soon become essential instruments which will give access to a large range of information from which scientists and extensionists can choose options suitable for local conditions. Amongst other things, they will permit developing countries to spare the often scarce resources devoted to research, by sharing results and avoiding duplication.

One of FAO's primary functions is to collect, analyse, process and disseminate information. Another important role is also to act as a forum for its member countries. Electronic communications are a particularly appropriate tool for accomplishing these two functions.

This electronic conference on "Tropical Feeds and Feeding Systems" is the first of its kind organized by FAO. It should contribute to providing important material for updating its database and to facilitate the exchange of data among developing countries. For those interested who do not yet have access to electronic mail it is planned to distribute the proceedings on diskette, or possibly on paper.

The main object of this conference is that it should be the first step towards establishing a global network on "Tropical Feeds and Feeding Systems" which should allow for a continuous flow of information exchange and discussions among scientists all over the world. Although it appeared appropriate to start with tropical feeds as they concern most developing countries towards which FAO devotes the majority of its efforts, this network should eventually extend its scope to all feeds available throughout the world.

The Development of the FAO Tropical Feeds Information System

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Background

FAO Tropical Feeds first appeared in 1975, the result of a considerable amount of work by the author Bo Göhl. At that time, published information on the nutritive value of feeds in general was scarce, particularly for tropical feeds. Bo Göhl reviewed some 600 references and produced descriptions and tables for 600 feed materials, including grasses, legumes, fodders, cereals, oilseeds, fruits and vegetables, animal by-products and miscellaneous materials.

At about the same time, FAO agreed to participate in an International Network of Feed Information Centres, designed to provide a means of collecting and disseminating data on the composition and nutritive value of feeds and information on their use. While much effort was put into systems of nomenclature, classification and coding, the INFIC system (which was run from centres in Australia, Canada, the Netherlands and the United States.) failed to add significantly to the value of the earlier work, with its focus clearly on tropical materials.

In a report to FAO in 1991, Speedy (1991) concluded that large scale feed information databases were of limited value for use on small scale projects in developing countries. INFIC had concentrated on detailed analysis of feed composition and the compilation of data from laboratories. However, it paid undue attention to cereals, conventional protein supplements (soya, groundnut, etc.) and much less on the local feed resources of Africa, India, SE Asia and Latin America (alternative crops, by-products, forages and tree foliages).

It became clear that INFIC has failed to realize its objectives as a comprehensive system of feed information for use in developing countries. Indeed, emphasis has changed towards sustainable systems of livestock production based on locally available feed resources (rather than imported grains and supplements), with greater notice given to the biodiversity of plant materials and their role in integrated farming systems. Data is required on the diversity of feeds rather than more detail on the limited range covered by the traditional computer databases of the INFIC system.

Tropical Feeds, however, provided a much wider range of materials and highlighted information that was unavailable elsewhere. While the analytical data was limited, it focused on feed description, including the use of materials for different classes of livestock and the practical problems and limitations. This was achieved by emphasizing text descriptions rather than tabular data.

Hence the decision was taken to develop Tropical Feeds as a computerized database which could be easily used and cheaply distributed worldwide. Initially, the text of the original Tropical Feeds was electronically scanned and converted to computer text with Optical Character Recognition (OCR) software. Then a special program was written to enable selection, viewing and printing of the text and data. Finally the program and data were commited to a single floppy disk, in compressed format, which was distributed by the Feed Resources Group, FAO Animal Production and Health Division.

The key features of the Tropical Feeds Diskette which has made it widely accepted and acclaimed by users include:

- **focus on local feed resources of tropical countries, including legumes, fodders, fruits and vegetables, oilseeds,** crop residues and agro-industrial by-products (plus grasses, cereals and conventional feedstuffs).

- text description including botanical and physical characteristics, processing, antinutritional factors, uses and limitations for different classes of livestock
- limited data with emphasis on composition of different components and botanical stages (seeds, fruits, immature and mature stages, etc.)
- full references to sources of information and published articles
- simple and effective software to search, view and print the text and data

Development of Tropical Feeds 1991-92

Futher work on the system (Speedy, 1992) achieved the following results:

- improved software
- assemblage of 638 references on tropical feed data from AGRIS, AGRICOLA and CABI databases on disk in WP notebook form.
- New entries to tropical feeds were written on the following topics: Sugar cane, whole sugarcane, sugarcane tops, sugarcane juice, molasses, filter mud, maize, *Gliricidia sepium*, *Prosopis chilensis, Prosopis juliflora, Prosopis tamarugo, Acacia nilotica,* cottonseed, *Coffea arabica* (text received from R. Bressani), molasses-urea blocks (edited text from Sansoucy et al., FAO Animal Production and Health Paper 72).
- Revision of entries on rice straw, sweet potatoes and cassava.
- Addition of data on Dry Matter degradability (provided by Dr E.R. Ørskov, Rowett Research Institute) and additional data on degradability compiled from published information, mainly from Animal Feed Science and Technology. Where necessary, a standard equation was fitted to published data to provide tables of solubility, degradability and rates. DM and nitrogen degradabilities have been included where possible. A total of 90 items on rumen degradability were added.
- New data on amino acid composition, obtained from the Brazilian national research centre (EMBRAPA) for swine and poultry (CNPSA) have been added.

Proposals for further development of tropical feed information 1992

The report of de Jong and Preston (1992) proposed a scheme for the further development of tropical feed information based on the FAO Tropical Feeds diskette system. In particular, their conclusions and recommendations proposed the following:

- **increased use of local natural resources, based on sustainable livestock systems within integrated crop-livestock systems on small and medium-scale farms;**
- **emphasis should be on resources that can be grown by the farmer and processed and used on the farm;**
- **the need to collect and interchange information on tropical feed resources, especially those that offer promise as alternatives to cereal grains and protein meals**
- **data should include chemical composition (including *in sacco* degradability), physical description, secondary plant compounds and special considerations (toxicity, etc.)**
- **how the feed can be used in production systems and for which animal species it is most appropriate, plus the possible role of the feed resource in relation to the sustainability of the production system.**

They detailed a scheme which would categorise information by on-farm production systems which in turn would be determined by the target animal and the nature of the basal diet. They listed the four major fields by animal groups as:

- **ruminants (cattle, buffaloes, sheep, goats and camelids)**
- **non-ruminant herbivores (rabbits, guinea-pigs, horses, donkeys)**
- **pigs**
- **poultry, ducks, geese**

They suggest that selection of a particular feed resource would direct the reader to the animal group where it is cited.

Within the animal groups, the main categories of:

- **grasses (grazed and fed in confinement)**
- **cereal straws**
- **sugarcane and by-products**
- **cereals and derivatives**
- **roots, tubers, fruits and derivatives**
- **oilseeds and derivatives, etc.**

were listed with different emphasis in each animal category.

Besides the data and description, they therefore placed increased emphasis on the feeding system, including:

- **how the material is fed**
- **amount and method of offer**
- **kind and amount of supplementation**
- **main role (as fermentable N, by-pass protein, etc.)**
- **recommended form of processing**
- **levels of production that can be expected**

Finally, they listed requirements for future research to include:

- **list of researchers working actively on the particular feed resource**
- **list of institutions working actively on the particular feed resource**
- **key references for further reading**

They recommended that the FAO Tropical Feeds diskette system should be developed in this way.

Interpretation of the 1992 recommendations in the development of Tropical Feeds 1993

In further developing Tropical Feeds, the above recommendations have been taken into account, with particular emphasis on the incorporation of feeding systems information.

Hence a different approach has been taken to collect more information on feeding systems from the published literature. As well as writing new entries on water plants (*Azolla* and *Salvinia* spp.), the editor has searched the available literature from two major sources:

1. A detailed search of abstracts published in the FAO AGRIS bibliographic database relating to feeds and feeding systems in the tropics.

2. Extraction of key papers from the electronic journal Livestock Research for Rural Development relating to feeds and feeding systems.

This produced some 607 abstracts from AGRIS and 85 papers from Livestock Research for Rural Development.

The new system with access to published information on feeds and feeding systems

The recommendations of de Jong and Preston (1992) envisaged categorizing feeds by livestock species and also referring to their use within feeding systems. The most effective way to do this has proved to be by allowing access from the basic feed description to published articles as abstracts and summaries. The advantage of this approach is that the published reports can provide additional information in the following ways:

- **details of feed composition, digestibility, degradability - including comparative data on several feeds under the same laboratory and experimental conditions**
- **details of feeding systems including feed mixtures, amounts, animal intake and performance, also on a comparative basis.**
- **where more than one feed is cited in a reference (which is usually the case), the reference may be accessed from several locations, thus allowing the reader to see the comparative value of alternatives**

- **details of feed preferences by animals, again on a comparative basis**
- **details of mixtures either sown or as natural vegetation with indications of performance of specific mixtures (particularly relevant to grasses and grass-legume mixtures)**
- **details of appropriate and effective supplements, again particularly relevant to tropical grasses and low-quality forages where supplements such as molasses, molasses-urea blocks, protein supplements, etc. have been provided. Such references are also accessible from both the basal diet component species and from the supplementary feed descriptions.**
- **specific reference to the livestock involved, including different species, breeds, ages, starting weights, live weight gains, milk production, etc.**
- **details are given of authors and institutions with respect to published material, as well as the source of the full articles and addresses for contact.**

The abstracts/summaries give comparisons, details of feeding systems and animal production details under the specific experimental conditions. In some cases, there are a number of references under each category, allowing the reader to compare results and to browse actual data on the feed material in which they are interested. They appear on a separate menu on the feed description page, under the heading 'ADDITIONAL' for additional information.

In addition, the exercise produced 180 new feeds which were not previously included in Tropical Feeds but on which there was published information in the years 1984-1993.

The new feeds have been described on the basis of published material. Latin names and common names were included in the indices and a brief description written for each species, together with a table of composition where available. In addition, two new feed groups were added: Water plants and Toxic plants. However for many of the new feeds information is still very scarce. It is hoped that scientists working in tropical countries will contribute to provide the missing information.

The new computer program

In 1993-94, there was further improvement of the computer software used for compiling, searching, viewing and printing the information from Tropical Feeds (Speedy, 1993, 1994).

The program maintains its previous simplicity of use and general 'feel' but has been completely rewritten using new object code throughout to achieve greater speed, reliability and efficiency. There are two versions, for MSDOS and Windows and the complete system now fits in compressed form on one 1.44 MB 3.5 in. HD floppy disk which is installed to the user's hard disk with an appropriate installation program included in the diskette.

Although twice the size of the previous version of Tropical Feeds, it has been felt appropriate to move to high-density diskettes for distribution as disk drives of this type are now universally available throughout the world.

Graphics capabilities

Tropical Feeds, the book, contained some excellent line drawings which depicted the appearance of plants, including details of leaves, flowers, seeds, pods, etc. This was a useful aid to field workers in identifying materials, particularly with reference to grasses, legumes and other fodder plants. However, the use of computers with colour monitors enables even greater use of pictures, including real photographs which can improve both the appearance and utility of the database. The program was therefore modified to include graphics and 57 colour pictures were obtained from various sources. To make these available requires one additional HD diskette.

French and Spanish versions of Tropical Feeds

Besides the development of the English version, it was decided to produce versions of Tropical Feeds in French and Spanish languages. The two original books: *Piensos Tropicales* and *les Aliments du Bétail sous les Tropiques* have also been converted to electronic format and additional entries added.

Future development - Tropical Feeds as an electronic library

The direction of development of Tropical Feeds permits new possibilities for its future progress. The general concept of the index leading to feed description leading to more detailed articles on the feed, comparisons and systems will permit a system to be developed whereby new publications can be easily incorporated into the database structure. In addition, articles may be commissioned on specific feeds and specific aspects of comparisons and systems and added to the Tropical Feeds library on disk.

Furthermore, continuous updating of the feeds and supporting articles will be undertaken. It is a feature of the computer system and the Tropical Feeds software in particular, that a new edition may be released whenever new information is added. Hence the system can be continuously updated as new material is published and becomes available.

In conclusion. Lessons learned in the compilation of Tropical Feeds

Tropical Feeds is recognized as a valuable book for scientists and development workers operating with feeding systems in developing countries where the emphasis is on local resources, sustainable systems and integrated farming. The diskette version has been widely acclaimed as an efficient and cost-effective way of distributing the information more widely in developing countries. In addition, it is shown to be a good way to operate a continuously updated source of information in the area of tropical feed resources. The process should continue and further develop.

A number of lessons have been learned from the compilation of the new edition. In the work, a large number of sources of information were identified from the literature. However it was clear that there was considerable bias in the numbers of publications relating to different types of feed. Of the 351 feeds referred to in relevant literature sampled from 1984-1993, the statistics applied:

Number of references	Number of feeds
>50	2

45-49	2
40-44	0
35-39	0
30-34	3
25-29	1
20-24	4
15-19	4
10-14	14
5-9	25
0-4	296

The most popular subjects of research were: *Gossypium* spp. (53), *Leucaena leucocephala* (52), *Arachis hypogaea* (49), *Panicum maximum* (48), *Digitaria decumbens* (34), *Pennisetum purpureum* (34), *Zea mays* (34), *Manihot esculenta* (25), *Cynodon nlemfuensis* (23), Molasses (23), *Cynodon dactylon* (23), *Brachiaria decumbens* (22). 199 species had only one reference to them in the 10 year period.

This is not an accurate reflection of all the literature as it is after some selection by the editor. However, it is clear that there is much emphasis still on a relatively small number of common feed materials and not enough attention is being given to alternative species.

An important objective for the future is to emphasize the role of biodiversity in feedstuffs and to consider alternatives to the traditional feeds, not only maize and soya, but also the other common tropical materials which have been much studied.

In particular, it is clear that there are many alternative legume tree species and other fodder plants and yet there has been almost total concentration on *Leucaena leucocephala* at the exclusion of other, potential candidates.

Future objectives

In the future, a proactive attitude should be adopted towards encouraging new publications on more diverse alternatives, particularly in the area of fodders and legumes, but also in the alternative oilseeds, fruits and the various by-products.

Tropical Feeds should be seen as a vehicle for publishing new research, especially from developing countries, on these categories of feedstuffs. Action should be taken to contact laboratories and research centres to request data and suitable articles for inclusion. It should be stressed that the material required should include: feed comparisons, animal feeding system descriptions, animal performance data and details of antinutritional factors and other problems associated with new alternatives.

Many of these data probably already exist. For example, on a recent visit to Venezuela, it was indicated that a large number of projects do not get published in the literature (approximately 1.5% of projects reach publication). The problem of publishing results from developing countries should be addressed with urgency. Tropical Feeds may be an ideal vehicle to provide a useful method of compiling unpublished data and directing research to more local alternatives in the field.

The objective is to establish a network of research workers in developing countries with interests in the area of alternative feed resources. The following steps are being taken:

1) Compile an address list of workers and institutions (based initially on known FAO sources plus the extensive list of young research workers funded by IFS, the International Foundation for Science).

2) Distribute Tropical Feeds to all workers on the above list.

3) Request publications on alternative feeds and feeding systems associated with the lesser-known materials.

4) Establish network communications by:

a) diskette transfer

b) electronic mail and data interchange

In this way, Tropical Feeds can begin to be a medium for data interchange with particular emphasis on local feed resources and on biodiverse alternatives in tropical areas.

The FAO Electronic Conference on Tropical Feeds and Feeding Systems

As a start to the process of developing a 'Tropical Feeds Network', this conference has been started and employs a number of electronic communication methods to reach as many scientists, development workers and other interested persons. These include:

FTP (File Transfer Protocol)

Files are lodged on a computer which is accessible via the Internet and can be downloaded on the users computer. The files available include discussion papers on methodologies, feed descriptions, articles on sustainable production systems, utilities to read the articles and finally, the Tropical Feeds diskettes.

Gopher

A method of transferring the above information over the Internet in text format from a menu index.

World-Wide-Web

The new method of transferring text and graphics over the Internet (developed at the European Particle Physics Laboratory (CERN), Switzerland) and using software such as Mosaic or Netscape on the user's computer. All articles, the Tropical Feeds database and other relevant material is now established on the WWW server at the University of Oxford and on the WAICENT site at FAO.

UUCP (Unix-to-unix-copy-program)

For sites in developing countries, contact has been established using direct telephone connections to central machines in the country. The Oxford computer dials these sites daily and passes electronic mail and files rapidly by UUCP. Connections are in operation to Laos and Vietnam using this method. Local networks are established so that users can exchange mail and obtain the files from the central national site.

Listserver

Discussion of the papers in the conference took place by electronic mail using a listserver program which automatically passed all messages to registered subscribers. An initial list was compiled in consultation between FAO headquarters and the Listserver operators and members were invited to introduce new interested colleagues as the conference proceeds.

Proposed outcome of the conference

The electronic conference enabled contributions from a wide range of participants to the future development of Tropical Feeds. It will be published as an FAO Animal Production and Health paper, as well as providing additional material for the database. Furthermore it gave experience of the operation of the new medium of the electronic conferences and data interchange, and serves as a model for future Expert Consultations.

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Aquaculture Feeds and Feeding in the Next Millennium: Major Challenges and Issues

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The Dilemma: What Approach

If aquaculture is to play a major role in the food security of low-income developing countries (LIDCs) as a much needed and affordable source of high-quality animal protein then it is essential that the farmed species be produced en masse using low-cost sustainable farming methods. In this respect China (an LIDC) stands out alone in that it has been producing food fish for home consumption for over 3000 years!; China being the world's largest producer of aquaculture products (58.7% of the world total of 22.63 million metric tonnes (mmt) in 1993),

including farmed finfish (58.4% of the world total of 11.19 mmt in 1993). The Chinese finfish farming system is based on the polyculture of complementary freshwater herbivorous/omnivorous fish species at low fish stocking densities within closed (i.e., static water) integrated fish farms; aquaculture usually being the predominant farming activity and combined with the production of farm livestock and crops. Within these semi-intensive farming systems (SIFS) fish growth and production is achieved through the integrated use of low-cost locally available nutrient inputs in the form of pond fertilizers and low-protein agricultural by-products. India, the second largest aquaculture producer in the world (total aquaculture production of 1.44 mmt in 1993, including 1.39 mmt of finfish) also employs similar polyculture farming techniques (both these countries producing over 65% of total world aquaculture production). In fact it is interesting to note that whereas only 46.2% of world meat production (ie. cattle meat, pigmeat, poultry meat, sheep meat, goat meat etc.) was produced within developing countries in 1993, over 85.0% of total world aquaculture production by weight (70.7% by value) was produced within developing countries, including 86.7% of all farmed farmed finfish.

In marked contrast to China and India, Japan (the third largest aquaculture producer in the world, and the largest aquaculture producer of the developed countries with a total production of 1.43 mmt in 1993) employs high-cost intensive farming methods for the production of food fish. The farming system is based on the monoculture of high-value (in marketing terms) marine carnivorous fish species at a high stocking density within open (ie. high water exchange) intensive pond, tank, raceway or cage-based farming systems; Japan producing 342,000 mt of finfish in 1993. Within these intensive farming systems (IFS) fish growth/production is achieved through the use of high-cost nutrient inputs in the form of high-protein nutritionally-complete diets or in the form of a natural foodstuff of high nutrient value such as fresh or frozen trash fish or shellfish.

Although both of the above mentioned farming systems operate as economically viable operations within their respective countries they both have their share of advantages and disadvantages; depending upon one's viewpoint (ie. economic, socio-economic, environmental, technical, or biological) and position in society (ie. resource-poor farmer, resource-rich farmer, private investor, politician, government official, scientist, environmentalist, conservationist, angler, or layperson). However, whether these and other alternative farming strategies will continue to be sustainable in the coming decade or the long-run is another matter. For example,

due largely to population pressure for resources (including land and water) there is now an emerging global trend in agriculture towards intensification of farming systems, and aquaculture is no exception to this. However, although the intensification process may increase production per unit area and bring short term economic gains in terms of increased profits or a faster return on investment, intensification by its very nature is dependent upon increased resource inputs (including feed) and as such has its drawbacks and risks. The aim of this paper is to highlight some of major issues and challenges related to aquaculture nutrition and feed development which will dictate the future sustainability or not of SIFS and IFS within developing countries.

Major Issues and Challenges

1.Dependency of aquaculture on agricultural and fishery resources as fertilizer and feed inputs and the increasing competition of aquaculture with humans and the traditional animal livestock production sector for these resources

Availability and increased demand for feed resources

All finfish and crustacean farming systems are dependent upon the market availability of `feed resources' for the provision of nutrient inputs, either in the form of fertilizers, agricultural wastes and by-products as supplementary feeds, or formulated pelleted aquafeeds. It follows therefore that if the finfish and crustacean aquaculture sector is to maintain its current growth rate (increasing by 11.2% from 10.90 mmt to 12.12 mmt from 1992 to 1993) then it will have to compete with other users (ie. humans and/or farm livestock) for these feed resources. Although the aquaculture sector may have been successful in the past in obtaining the necessary fertilizer and feed inputs, this may not be so in the future as farming systems intensify and the demand for a finite pool of valuable feed resources increases. It has been estimated that the total world production of manufactured compound animal feeds exceeded 550 mmt in 1994 (valued at over 55 US$ thousand million), of which poultry feeds constituted 32%, pig feeds 31%, dairy feeds 17%, beef feeds 11%, aquatic feeds 3%, and others 6%.

Dependency upon fish meal and other fishery resources as feed inputs

At present the production of carnivorous finfish species (1.26 mmt or 11.3% of total farmed fish in 1993) and marine shrimp (0.80 mmt in 1993) is totally dependent upon the use of fishmeal and fish oil as the sole or major source of dietary protein and lipid within farm-made or commercial aquafeeds; these two fishery products generally constituting about 70% by weight of compound aquafeeds for most farmed carnivorous fish species and about 50% (together with shrimp meals and squid meal) by weight of compound aquafeeds for marine shrimp.

Although the production of carnivorous fish species and shrimp species will continue to be profitable for those countries with ready access to fishery feed resources and/or international credit facilities, this will be only possible as long as fishmeal and fish oil stocks last and prices remain stable or within competitive limits. However, an unknown factor which could upset the balance is the growing global interest and demand for health foods (primarily within `developed' countries) and the recognition that fish and fishery products (including fish oils) could play a key role in the diet of `modern man'; the latter either driving up the market price of fish and fishery products (including small pelagics) or diverting the use of small pelagics for direct human consumption rather than for rendering into fishmeal.

2. Need to sustain and further increase aquaculture production in the face of increasing feed and farm production costs, and increasing degradation of the aquatic environment

Increasing raw material and farm production costs

Increasing raw material and farm operating costs, coupled with an often static and/or decreasing market value for many farmed species (ie. and in particular the high-value carnivorous fish and shrimp species) necessitates that the farmer reduce production costs so as to maintain profitability. Since food and feeding (including fertilization) usually represent the largest single operating cost item within SIFS and IFS, particular attention must be focused on the development of research and farming strategies aimed at reducing fertilizer/feed costs and improving on-farm fertilizer/feed management techniques. A logical step therefore is to make a detailed appraisal of the fertilizer and feeding strategies currently employed by the fish farming community within the country in question (through the use of farm questionnaires and field visits) so as to identify the fertilizer/feeding deficiencies and

constraints; these in turn serving as the subject of future on-farm field research investigations.

Furthermore, so as to ensure the applicability and rapid transfer of research data to farmers it is recommended that where ever possible that fertilization and feeding/nutrition-based research trials be conducted *in situ* on representative fish farms and that the data generated from these on-farm research studies be also evaluated from an economic, socio-economic, and environmental impact viewpoint. Emphasis within government/public aquaculture support staff (including researchers) must be placed on trying to find local solutions and improvements for the existing problems of the aquaculture sector within member countries by supporting on-farm research (participatory systems approach) rather than just conducting pure or fundamental research within the laboratory. However, the key to the success of on-farm research is the participation of the farmers themselves, not only assisting in the identification of research needs and priorities (usually overlooked), but also in the actual implementation of on-farm research programmes. Sadly, in many instances the aquaculture R & D programmes of public agencies are aimed more on the particular research interests of individual government scientists and/or donor agencies rather than to the farmers or existing farming community they are there to support.

Choice of cultured species: herbivores, omnivores or carnivores?

At present all IFS and SIFS for carnivorous finfish species (ie. salmonids, eels, marine fish species - seabreams, yellowtail, seabass, grouper etc.) and penaeid shrimp are net fish protein `reducers' rather than net fish protein `producers'; the total input of fish and fishery resources as feed inputs far exceeding the output of new fish protein by a factor of 2 to 5 depending upon the farming system and fishery resource used (ie. fishmeal-based diets or `trash fish' as major feed inputs). This is in sharp contrast to the net fish protein producing status of the majority of SIFS and IFS employed by farmers for the production of herbivorous/omnivorous fish and prawn species; the culture of herbivorous/omnivorous fish species being generally realised by `developing' countries (the two largest producers being China and India) and constituting 88.7% of total finfish aquaculture production in 1993. It is also of interest to note here that whilst the average increase in global production of cultivated carnivorous finfish species (ie. rainbow trout, Atlantic salmon, yellowtail, Japanese seabream etc.) was 9.37% from 1992 to 1993, the average increase in production of the non-carnivorous fish species (ie. silver carp, grass carp,

common carp, bighead carp, milkfish, rohu, nile tilapia, catla, mrigal carp, crucian carp etc.) has remained higher at 13.35% from 1992 to 1993. On a country basis, it is perhaps of interest to also compare the recent statistical data on aquaculture production from China and Japan; finfish production in China (97.9% of total being omnivorous/herbivorous fish species) reportedly increasing by a staggering 21.4% from 5,387,107 mt to 6,536,620 mt from 1992 to 1993 and finfish production in Japan (94.5% carnivorous fish species) decreasing by 2.7% from 353,140 mt to 343,714 mt from 1992 to 1993 (FAO, 1995).

It follows from the above that if aquaculture production is to maintain its current high growth rate and continue to play an important role in the food security of developing countries as an `affordable' source of high quality animal protein, that herbivorous or omnivorous finfish/crustacean species (feeding low on the aquatic food chain and therefore being less demanding in terms of feed inputs) be targeted for production rather than high-value carnivorous fish/shrimp species; the latter being less energy efficient in terms of resource use and dependent upon the use of high-cost `food grade' protein-rich feed inputs. In this respect it is also high time that we learn from our terrestrial counterparts whose farming systems are based on the production of non-carnivorous animal species (ie. poultry, ducks, pigs, sheep, rabbits, goats, cattle).

Absence of information on nutrient requirements and importance of natural food organisms

Despite the fact that silver carp, grass carp, common carp, bighead carp, and the giant tiger prawn were the top five cultivated fish and crustacean species in the world in 1993 (totalling 5.97 mmt or 49.3% of total farmed finfish and crustacean production), and are all mainly cultivated within SIFS, little or no information exists concerning their dietary nutrient requirements under practical semi-intensive pond farming conditions; the majority of dietary nutrient requirement studies to date having been performed under controlled indoor laboratory conditions (these in turn only being restricted to common carp and the giant tiger prawn). Whilst the information generated from laboratory-based feeding trials maybe useful for the formulation of complete diets for use within IFS this information cannot be applied to the formulation of diets for use within SIFS since the fish/shrimp also derive a substantial part of their dietary nutrient needs from naturally available food organisms; this is particularly true for those species which are capable of filtering fine particulate matter from the water column (ie. bacterial laden

detritus, phytoplankton, zooplankton etc.), including silver carp, bighead carp, catla, rohu, mrigal carp, kissing gourami, Thai silver barb, milkfish, nilem carp, and last but not least marine shrimp.

For example, despite the dietary essentiality of vitamins for *Tilapia* sp. under indoor laboratory conditions, field studies in Israel have shown no beneficial effect of dietary vitamin supplementation with Tilapia sp. in ponds, cages or concrete tanks at densities of 100 fish/m2 with yields of up to 20 tonnes per hectare. Moreover, crustaceans researchers have recently been able to reduce feed costs by half using lower dietary protein and micronutrient levels with no loss in the growth and feed efficiency of shrimp within pond-based SIFS. Unfortunately, in the absence of published information on the dietary nutrient requirements of finfish/crustaceans within SIFS almost all of the commercially available aquafeeds produced for these farming systems are usually over formulated as nutritionally complete diets irrespective of the intended fish stocking density employed and natural food availability. Clearly, this situation will have to be rectified if farmers are to reduce production costs and maximise economic benefit from their semi-intensive pond farming systems.

Polyculture and use of natural pond food resources

At present the bulk of world finfish and crustacean aquaculture production within developing countries is realised within pond-based SIFS. However, although the nutritional and economic importance of natural food organisms within the diet of pond raised finfish has been well recognised and utilized by farmers in China with the development and use of complex polyculture-based farming strategies, with the possible exception of India, such practices have not met with the same degree of success outside China. Polyculture-based farming systems are based on the stocking of a carefully balanced population of fish species with different (ie. non-competitive) and complementary feeding habits within the same pond ecosystem and so maximizing the utilization of natural available food resources (ie. phytoplankton, zooplankton, bacterial-laden detritus, macrophytes, benthic algae, invertebrate animals etc.) and available water resources (ie. surface, mid- and bottom-water) with a consequent increase in pond productivity and fish yield per unit area. For example, polycultures in China commonly include the use of filter feeding fish species (ie. silver carp, bighead carp; 26-52% of total fish stocking weight), herbivores (ie. grass carp; 30-37% of stocking weight), omnivores (ie. common carp, crucian carp, Chinese bream, tilapia; 18-

25% of stocking weight), and carnivores (ie. black carp; 0-11% of stocking weight); stocking weights and patterns varying with the financial resources of the farmer. Thus, within low-productivity provinces (ie. low-income provinces/resource-poor farmers; net fish yields averaging 3.3 mt/ha/yr) fish stocking densities are low (initial stocking weights averaging 444 kg/ha) and the proportion of filter feeding fishes is high (52%), whereas in the high-productivity provinces (ie. higher-income/resource-rich farmers; net fish yields averaging 7.9 mt/ha/yr) fish stocking densities are about three times higher (initial stocking weights averaging 1,481 kg/ha) and the proportion of `feeding fishes' (ie. herbivores, omnivores and carnivores) are the dominant species stocked.

Importance of farm-made aquafeeds within SIFS

As mentioned previously the bulk of world aquaculture production within developing countries is currently realised within SIFS and is small-scale in nature with nutrient inputs supplied in the form of fertilizers and supplementary `farm-made' aquafeeds; the latter ranging from the use of fresh grass cuttings, cereal by-products, to sophisticated on-farm pelleted feeds. In contrast to industrially produced compound aquafeeds (more commonly used within IFS), farm-made aquafeeds allow the small-scale farmer to tailor feed inputs to their own financial resources and requirements, and facilitate the use of locally available agricultural by-products which would otherwise have limited use within the community. In addition to their ability to use locally available waste streams, farm-made aquafeeds are also potentially much cheaper for farmers than commercial aquafeeds (although farmers whose initial success was based on farm-made aquafeeds often shift over at a later date onto commercial feeds).

Need for increased environmental and social compatibility

Particular emphasis has been placed on the environmental compatibility and central role played by polyculture-based integrated farming systems in aquaculture development within developing countries and the need to carefully balance exogenous supplementary feed inputs with the endogenous supply of natural food organisms (achieved through the use of fertilizers) within the pond ecosystem. Furthermore, as mentioned previously, in addition to their minimal effects on the environment, in terms of resource use SIFS are less dependent upon high-

cost `food grade' exogenous feed inputs (ie. fishery resources), facilitate maximum use of locally available agricultural resources (ie. by-products and wastes), have lower production costs, are less prone to disease problems, and are usually net fish protein producers and more energy efficient compared with IFS.

By contrast, the negative reported impacts of aquafeed usage within IFS on the aquatic environment have been largely due to the use of poor on-farm husbandry and management techniques (including on-farm feed management practices) and lack of appropriate aquaculture planning measures limiting the size of existing farms or groups of neighbouring farms to the `environmental carrying capacity' of the water body or coastal area in question. Despite this, increasing attention is now being given by farmers, feed manufacturers, and researchers alike to the development of farming systems and feeding strategies which maximize nutrient retention by the cultured fish or shrimp and minimize nutrient loss and negative environmental impacts.

It is also important to mention here the critical role played by nutrition (ie. undernutrition) and farm management (ie. on-farm feed, water and pond management) on fish/shrimp health and the incidence or not of disease outbreaks within IFS (and to a lesser extent SIFS) and the need to satisfy not only the dietary nutrient requirements of the farmed species for maximum growth but also to satisfy their additional dietary requirements for increased immunocompetence and disease resistance.

Finally, the dietary value and importance of aquaculture products in human nutrition as a much needed source of `affordable' animal protein should not be overlooked; fish being one of the cheapest sources of animal protein within rural and coastal communities. For example, at present freshwater aquaculture (ie. mainly cyprinids and tilapia) offers one of the cheapest sources of high quality animal protein within the major rural inland communities of Asia, including China, India, Indonesia, and the Philippines.

Need for information and training

Finally, but not least, one of the major factors limiting aquaculture development in most developing countries is the lack of ready access to up-to-date information, either through publications within libraries and electronic

bibliographic databases, or through in-country training opportunities (ie. for farmers, extensionists, researchers, or the trainers) on aquaculture, and in particular concerning aquaculture nutrition and feed technology. Clearly, since information and training (ie. the dissemination of information and knowledge through education) are fundamental to any research, learning or development process, it is essential that this issue be addressed if farmers (the ultimate beneficiaries) are to improve their skills and farming operations. Sadly, information is often overlooked as being an integral part of the learning or research process; the net result being the re-invention of the wheel and the unnecessary duplication of research effort rather than building upon the knowledge base already available and learning from past mistakes and experiences.

Closing Remarks

Despite the fact that China has the longest history and experience in aquaculture development the sector has recently faced serious difficulties with the `intensification' phenomenon and the shift of the more resource-rich provinces and farmers from traditional farming practices to more `Western-style' market-oriented farming practices; farming practices shifting from the use of low-cost and low-input (and therefore low output) polyculture-based SIFS (aimed at the mass production of `food fish' for local consumption) at one end of the spectrum to the production of high-cost and high input (and therefore high output) monoculture-based IFS (aimed at the production of high-value (in marketing terms) `luxury food fish' (ie. carnivorous fish/shrimp) for export at the other end of the spectrum. The particular case in point is the spectacular `rise and fall' of the shrimp farming industry, with shrimp production collapsing from a high of about 200,000 mt between 1988 and 1992 (China then being the largest producer of farmed shrimp) to under 50,000 in 1994. The collapse of the shrimp farming sector in mainland China was almost identical to that which had occurred in Taiwan five years earlier in 1988 and was largely due to the progressive degradation and deterioration of the aquatic and pond environment (due to pollution, poor feed and pond management, and inadequate planning and concern for the environment) and consequent massive disease outbreaks.

It is evident from the above economic and environmental disasters that although `intensification' and modern `high-tech' high-input and high-output IFS (ie. feedlot systems) can bring considerable economic gain to farmers

with access to resources (ie. finance, land, water, trained manpower, feed and other off-farm inputs) these farming systems are highly `stressed ecosystems' whose stability is entirely dependent upon `human factors' and `the farmers control and use of resources' rather than by natural `ecological factors' as in the case of low-input polyculture-based SIFS. Despite this, whether we like it or not, intensification and IFS are here to stay and aquaculture (like all other forms of animal production) will increasingly be constrained by increasing competition for land and resources, including feed. For example, at present China's economy is one of the most dynamic and fastest growing economies in the world (GDP growth in 1993 being 13.4% and the highest amongst Asian countries), in which livestock and farmed fish production is increasing at double digit figures. By contrast, cereal and oilseed production (used as feed for humans and livestock) is only increasing at an average annual growth rate of 2-3% per year (China being a net importer of cereals for one-quarter of a decade). Coupled with an average annual population growth rate of 1.3% per year and a huge population resource base of 1.2 billion people, it follows that, if China (like the majority of other developing countries) is going to sustain and improve the nutritional and economic welfare of it's people, traditional farming systems will have to be improved and/or upgraded.

Clearly, if the intensification process from extensive and semi-intensive to intensive farming systems is to proceed in a sustainable manner, it is essential that research be aimed at developing farming systems which produce more fish or shrimp, but that the production be based on the use of sustainable ecological/environmental balances and the efficient `integrated' use of resources rather than just on a purely economic basis. It follows therefore that, for the survival of the industry the overall efficiency of resource use should be improved and that the aquatic environment be preserved, thus ensuring that long term sustainability prevails over the desire for rapid gains and short term profits.

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The Palmyra or Toddy Palm (Borassus flabellifer L.)

Abstract

Morton, J.F. (1988) Notes on Distribution, Propagation, and Products of *Borassus* Palms (Arecaceae). *Economic Botany* (1988) 42(3): 420-441

The palmyra palm is a large tree up to 30m high and the trunk may have a circumference of 1.7m at the base. There may be 25-40 fresh leaves. They are leathery, gray green, fan-shaped, 1-3 m wide, folded along the midrib; are divided to the center into 60-80 linear- lanceolate, 0.6-1.2 m long, marginally spiny segments. Their strong, grooved petioles, 1-1.2 m long, black at the base and black-margined when young, are edged with hard spines.

It grows wild from the Persian Gulf to the Cambodian-Vietnamese border; is commonly cultivated in India, Southeast Asia, Malaysia and occasionally in other warm regions including Hawaii and southern Florida. In India, it is planted as a windbreak on the plains. It is also used as a natural shelter by birds, bats and wild animals.

Each palm may bear 6-12 bunches of about 50 fruits per year. An average crop of B. flabellifer in Ceylon is 350 fruits.

The coconut-like fruits are three-sided when young, becoming rounded or more or less oval, 12-15 cm wide, and capped at the base with overlapping sepals. The outer covering is smooth, thin, leathery, and brown, turning nearly black after harvest. Inside is a juicy mass of long, tough, coarse, white fibers coated with yellow or orange pulp. Within the mature seed is a solid white kernel which resembles coconut meat but is much harder. When the fruit is very young, this kernel is hollow, soft as jelly, and translucent like ice, and is accompanied by a watery liquid, sweetish and potable.

Toddy

The chief product of the palmyra is the sweet sap (toddy) obtained by tapping the tip of the inflorescence, as is done with the other sugar palms and, to a lesser extent, with the coconut. The sap flows for 5-6 mo - 200 days in

Ceylon - each male spadix producing 4-5 l per day; the female gives 50% more than the male. The toddy ferments naturally within a few hours after sunrise and is locally popular as a beverage; it is distilled to produce the alcoholic liquor called palm wine, arrack, or arak. Rubbing the inside of the toddy-collecting receptacle with lime paste prevents fermentation, and thereafter the sap is referred to as sweet toddy, which yields concentrated or crude sugar (gur in India; jaggery in Ceylon); molasses, palm candy, and vinegar.

Palmyra palm jaggery (gur) is much more nutritious than crude cane sugar, containing 1.04% protein, 0.19% fat, 76.86% sucrose, 1.66% glucose, 3.15% total minerals, 0.861 % calcium, 0.052% phosphorus; also 11.01 mg iron per 100 g and 0.767 mg of copper per 100 g. The fresh sap is reportedly a good source of vitamin B complex.

Seedlings

The peeled seedlings are eaten fresh or sun-dried, raw, or cooked in various ways. They also yield starch, which is locally made into gruel, with rice, herbs, chili peppers, fish, or other ingredients added. It has been proposed for commercial starch production.

Fruits

Small fruits are pickled in vinegar. In April and May in India, the shell of the seed can be punctured with a finger and the sweetish liquid sucked out for refreshment like coconut water.

Immature seeds are often sold in the markets. The kernels of such young seeds are obtained by roasting the seeds and then breaking them open. The half-grown, soft-shelled seeds for the hollow jelly-like kernels are sliced longitudinally to form attractive loops, or rings and these, as well as the whole kernels, are canned in clear, mildly-sweetened water, and exported. Tender fruits that fall prematurely are fed to cattle.

The pulp of mature fruits is sucked directly from the wiry fibers of roasted, peeled fruits. It is also extracted to prepare a product called punatoo in Ceylon. It is eaten alone or with the starch from the palmyra seedlings). The

fresh pulp is reportedly rich in vitamins A and C.

Proximate analyses of leaves, fruit, seedlings, immature seed, and "seed" of B. flabellifer have been assembled from various sources by Atchley (1984) (see below).

Folk Medicine

There are innumerable medicinal uses for all parts of the palmyra palm. Briefly, the young plant is said to relieve biliousness, dysentery, and gonorrhea. Young roots are diuretic and anthelmintic, and a decoction is given in certain respiratory diseases. The ash of the spadix is taken to relieve heartburn and enlarged spleen and liver. The bark decoction, with salt, is used as a mouth wash, and charcoal made of the bark serves as a dentifrice. Sap from the flower stalk is prized as a tonic, diuretic, stimulant, laxative and anti phlegmatic and amebicide. Sugar made from this sap is said to counteract poisoning, and it is prescribed in liver disorders. Candied, it is a remedy for coughs and various pulmonary complaints. Fresh toddy, heated to promote fermentation, is bandaged onto all kinds of ulcers. The cabbage, leaf petioles, and dried male flower spikes all have diuretic activity. The pulp of the mature fruit relieves dermatitis.

Chemical analysis

As % of dry matter

	CP	CF	Ash	EE	NFE	Ca	P	Ref
Leaves	13.3	38.0	7.4	4.6	74.7	-	-	*
Fruit	6.5	16.1	4.8	0.8	87.9	0.22	0.24	*
Immature Seed	5.1	7.9	1.7	0.6	92.7	0.17	0.18	*

Shoot	**8.9**	**7.2**	**3.3**	**0.7**	**87.2**	**0.06**	**0.46**	*****
Fruit	**3.1**	**-**	**3.1**	**0.9**	**93.4**	**-**	**-**	*****
Seed	**8.1**	**-**	**3.5**	**1.4**	**85.1**	**-**	**-**	*****

***Atchley (1984)**

Reference

Atchley, A. A. 1984. Nutritional value of palms. *Principes* 28(3):138-143.

Colombian Forest Plants

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Local people on forest farms in the Choco Region of Colombia use a large number of adapted species which fit into sustainable systems in the forest.. This list was prepared and presented by the author at a lecture given at Oxford in November 1994.

Local name	Botanical name	Uses
Chontaduro	*Bactris gasipaes*	Edible fruits
Yarumo	*Cecropia* spp	Leaf litter [org. mat. recycling]

Balso	*Ochroma* spp	Leaf litter; wood
Sandé	*Brosimum alicastrum*	Medicinal latex, wood, shade
Nato	*Mora megistrosperma*	Wood for canoes
Tangare	*Carapa quianensis*	Wood for canoes
Higuerón	*Ficus* spp	Shade trees
Jobo	*Spondiasmombin*	Edible fruits, shade tree
Totumo	*Crescentia cujete*	Containers and collanders
Palo de cruz	*Brownea* spp	Wood, medicine
Caimito	*Chrysophillum* spp	Edible fruits
Caimo	*Bellucia* spp	Edible fruits
Mango	*Mangifera indica*	Fruits
Punta de lanza	*Viomia* spp	Leaf litter
Cumare	*Astrocanjum* spp	Fibres
Milpesos	*Jessenia polycarpa*	Edible fruit
Coconut	*Cocos nucifera*	Edible fruit
Cuesco	*Attalea* spp	Edible fruit
Zapote	*Matisia cordata*	Edible fruit
Borojó	*Borojoa patinoi*	Fruit pulp for beverages
Papaya	*Carica papaya*	Edible fruit

Avocado	*Persia americana*	Fruit
Pacó	*Grias cauliflora*	Fruit
Guamo	*Inga* spp	Fruit
Uvo	*Pourouma* spp	Fruit
Cacao	*Theobroma cacao*	Edible seeds
Palmito	*Euterpe* spp	Edible young leaves
Bijao	*Calathea* spp	Leaves for packaging
Zapotolongo	*Pachira acuatica*	Edible seeds [nuts]
Nacedero	*Trichanthera gigantea*	Fodder, medicine
Achiote	*Bixa orellana*	Spice, food colouring
Sugar cane	*Saccharum officinarum*	Sugar, animal feed
Mafafa, Papachina	*Xanthosoma* spp	Tubers and fodder
-	*Colocassia* spp	Tubers and fodder
Ortiga	*Urera* spp	Edible leaves and medicine
Pineapple	*Ananas* spp	Fruit
Banana	*Musa* spp	Fruit
Plantain	*Musa* spp	Fruit
Iraca	*Carludovica* spp	Fibres [packaging, hats]

Name	*Dioscorea alata*	Tuber
Cassava	*Manihot esculenta*	Tuber