

Chapter 2

## **Identifying priority areas for research on tropical feed resources**

*This chapter provides general guidance on where to look for information and advice on tropical feed resources. It lists some of the promising new areas for research that are emerging as emphasis is directed towards the sustainable use of renewable natural resources.*

It has been intimated in Chapter 1 that future livestock production systems will be predicated not on maximizing the productive rate of a given animal species but in helping to meet the demands of society for the basic necessities of energy, food and shelter. These needs will have to be met with feed resources which will be the by-products and residues of cropping systems designed to optimize production of biomass with minimal external inputs, to maintain biodiversity and to protect the environment.

In such a scenario, livestock must not be in competition with the human population for resources; rather, they should play a complementary and, where possible, a synergistic role.

### **TRENDS IN THE ORIGIN AND NATURE OF FUTURE FEED RESOURCES**

Available feed resources are determined by the way land is utilized. The choice of agricultural systems will reflect the demands of the human population and the nature of the ecosystems which in turn will be determined by available moisture, the nature of the terrain, the fertility of the soil and the pattern of rainfall (FAO, 1993).

**The demands of society**

Human society requires energy (for cooking, light, crop cultivation and transport), food, a source of chemicals, shelter, and employment. There is good reason to believe that human food production can be sustained even with an increasing population. There are local food shortages but world supplies are more than adequate as evidenced by the fact that the major part of the world's cereal grain production is fed to livestock. By contrast, the present global level of energy use is not sustainable, as it depends on finite supplies of fossil fuel. Thus while, in the past, production of food for human consumption has been the priority activity, in the future, provision of energy will begin to take precedence.

Present feed resources for livestock result mainly from activities directed towards human food production. In the future, they will increasingly be derived from the residues and by-products of energy production.

**Natural ecosystems**

Fertile river deltas and valley floors will continue to be priority areas for rice production. However, pressures to increase yields and to reduce agro-chemical inputs will favour the introduction of rotations and associations with high biomass yielding crops that raise soil fertility while still contributing food and fibre. Sugar cane, with its unrivalled capacity for raising soil organic matter, the African oil palm and other multi-purpose trees are likely to become increasingly important components of these ecosystems as the search for renewable sources of energy increases in intensity.

Continuous rice culture as presently practised (with high-yielding varieties and agrochemical inputs) is not sustainable. This is confirmed by the results of a recent study from the International Rice Research Institute (Cassman, 1993) which shows that rice yield response to increasing fertilizer application is falling. Increasing the sustainability of rice production is most likely to be achieved by diversification (e.g., introduction into the rotation of "fertility-raising" crops, and closer integration with livestock). The traditional rice-duck-fish system has already proved to be an excellent biological control mechanism. Livestock manure was, and still is in many areas, the only fertilizer

required if it is supported by diversified restorative cropping. But, as long as fossil fuel is cheap, animal traction (one of the main sources of the manure) will continue to be threatened by mechanization, creating an incentive for increasing use of ago-chemicals. So begins the process of disintegration of the system, and dependence on outside inputs.

The Chinese deep pond and dyke system, sustained for thousands of years in the high water table region along the Pearl river, although demanding of capital (or labour) for its establishment is probably the most productive and highly sustainable way of farming these otherwise difficult (but only in the conventional sense) "water-logged" areas (Chan, 1993). Unfortunately, these systems which have sustained thousands of farmers over generations are also being threatened by the ago-chemical inputs of "modern" technology and the demands of an increasingly "consumer- oriented" society (Chan, 1993).

On hillsides and sloping land at elevations below 2,000 m, sustainable land use requires the cultivation of perennial crops as the basic activity. Systems of agroforestry are the only sustainable alternatives. They offer many options, including associations with short-cycle food crops and with grazing of livestock. But trees, in some form or other, must dominate such landscapes in the future.

Finally, there are the arid and semi-arid regions (less than 400 mm annual rainfall) where the only sustainable option is the cultivation of drought-resistant trees and shrubs, among which the *Prosopis* spp. have already shown their potential (Habit and Saavedra, 1988).

### **FEED RESOURCES FOR TROPICAL LIVESTOCK PRODUCTION**

Four main categories of feeds will be dominant in tropical regions as pressure to carry out sustainable agricultural practices increases. These will be:

- The fibrous residues from crops grown for human food production. Pre-eminent here will be the straws and stovers from cereal grains, mainly from rice but also from sorghum, millet and maize.
- New feed resources derived from crops grown primarily as sources of renewable energy, or as contributors to soil fertility. In this category will be the range of products and by-products derived from

sugar cane, African oil palm, the sugar palm tree, other multi-purpose trees (especially leguminous ones) and aquatic plants. These are rich in readily available energy (the juice from sugar cane and sugar palm, the oil and fruit from the African oil palm) or in protein (the leaves from multipurpose trees and aquatic plants).

- Other by-products and residues.
- Natural pastures, although their role is decreasing, will provide, for some time, the bulk of ruminant feed. However, there is a wealth of data on grasses and conventional forage crops. There will be little to be gained by doing more research with these feed resources.

A wide range of by-products and residues results from other food crops and cropping systems. In general, information exists on the nutritive value of by-products of oilseed and cereal milling. It is more important to know where the existing information can be found, which is the next point to be discussed.

## **SOURCES OF INFORMATION ON TROPICAL FEED RESOURCES**

### **The electronic highway**

It is a logical corollary to the discussions in Chapter 1 and above that little of the information required in order to promote sustainable livestock-based rural development will be found in the classical text books and journals, and even less so in the standard texts on "how to feed livestock" (e.g., the bulletins of NRC, ARC, INRA, Australian Feeds and similar sources). These sources relate neither to the tropics nor to sustainable development.

Information both on tropical feed resources *per se*, and the interpretation of this information in the light of developing sustainable solutions, is in a rapid and dynamic state of flux. One example will suffice to demonstrate this. The first literature citation indicating the enormous potential of the fruit of the African oil palm, as opposed to the by-products of oil extraction, as the basis of an intensive system of pig production has only just appeared (Ocampo, 1994b, published in the computerized journal *Livestock Research for Rural Development*, Volume 6, Number 1). If it had been submitted to a traditional scientific

journal, it would be "in preparation" (and therefore largely inaccessible) for a minimum of 12 months and perhaps even longer.

The first step in the search for information is for researchers to join an electronic mail network and contact the person or institution working in their areas of interest. Through this same network, the researcher will be able to access relevant scientific articles, abstracts, notes and observations from practising farmers, relating to what is happening "now", not what was researched 2-3 years ago - before sustainability became an issue.

Guidance on how to join one or more of the appropriate electronic mail networks serving developing countries is given in Chapter 13.

### **Tropical feeds**

The most useful information on tropical feed resources is found in the computerized database "Tropical Feeds 1994", available from the Feed Resources Group at FAO HQ in Rome. The most recent version of this program contains new data on fibrous crop residues and alternative "high biomass" crops such as sugar cane, multi-purpose trees and water plants. The decision to complement the compositional and descriptive information on feeds with a discussion on their use in practical feeding systems is especially commendable. Abstracts - where appropriate - of the original papers have also been included. The programme is now available in the three principal working languages of the UN system: Spanish, French and English (Tropical Feeds, 1994).

### **Computerized international journals dealing with tropical feed resources and sustainable development**

The computerized international journal "Livestock Research for Rural Development" is now in its sixth year. It is available 'on-line' via the APC (Association for Progress in Communication) Networks (GreenNet in the UK; EcoNet in USA). Information on how to obtain the journal by email can be obtained from Andrew Speedy in the UK (speedy@vax.ox.ac.uk), from Gordon King in Canada (gking@aps.uoguelph.ca) and from René Sansoucy in FAO (rene.sansoucy@fao.org).

Three new journals publishing information on tropical feed resources have recently been launched in computerized format. These are:

- "Indice Venezolano de Investigaciones en Producción Animal", produced by the Instituto de Producción Animal, Universidad Central de Venezuela, Maracay;
- "Revista Latinoamericana de Investigación en Pequeños Herbívoros No-rumiantes", published by the Universidad Nacional Experimental Ezequiel Zamora (UNILLEZ), Guanare, Portuguesa, Venezuela.
- "Revista Computadorizada de Producción Porcina", published by the Instituto de Investigaciones Porcinas, Habana, Cuba.

Information on how to obtain these journals can be obtained from Andrew Speedy in the UK ([speedy@vax.ox.ac.uk](mailto:speedy@vax.ox.ac.uk)) and from Rene Sansoucy, FAO, Rome ([rene.sansoucy@fao.org](mailto:rene.sansoucy@fao.org)).

## **PRIORITY AREAS FOR RESEARCH IN TROPICAL FEED RESOURCES**

### **Feed resources and sustainable development**

Cereal grains are the staple food of the bulk of the world's population. The areas devoted to their cultivation, and the yields obtained, have steadily increased, mainly through the use of inputs derived from fossil fuel. Cultivation of cereals at these extremes of the yield response curve is not sustainable viewed in the context of the long term. However, cereal crops can be part of a sustainable cropping system, in which other crops are grown to restore the fertility exploited by the cereals. Ley (rotational) farming was introduced into Europe in the 18th century for this very purpose. The livestock farming network based around the rice crop, coordinated by IRRI (Carangal, 1993) is an example of this approach. Similar initiatives are needed in the other tropical continents.

In temperate regions of the world, cereal production exceeds what is needed for human consumption. The surpluses are fed to livestock and considerable amounts are exported. In contrast, most tropical countries (Thailand and Vietnam are the exceptions) import part of their needs of cereal grains for human consumption and many of them also import grain for feeding to livestock. In tropical countries, promoting the use of alternative feed resources, derived from crops which are more "environmentally friendly", will lead to more sustainable development and will increase self-reliance (Sansoucy, 1995). The major objective of

this manual is to encourage the use of these alternative feeds and, through research, to improve the efficiency of their utilization at the level of small-scale farmers.

It should also be stressed that for many new "alternative" feed resources, learning how to grow them will have a higher priority initially than characterizing their nutritive value; which is a way of emphasizing that researchers concerned with developing sustainable livestock-based production systems in the tropics must be prepared to approach the problem in a multi-disciplinary fashion. For agronomic knowledge will often be an essential prelude to being able to use a particular plant as a livestock feed.

### **Cereal grain substitutes for monogastric animals**

Considerable advances have been made in the development of feeding systems using the products and by-products of sugar cane and the African oil palm (Figuerola and Ly, 1990; Sarria *et al.*, 1990; Perez, 1994; Ocampo *et al.*, 1990a,b; Ocampo, 1992; Ocampo, 1994a,b,c), crops that with appropriate management have proved to be sustainable, as judged by the indicators set out in Chapter 1. The principal nutritional elements in these feed resources are sugar and oil respectively. There is insufficient knowledge about both these nutritional fuels, how best to complement them with protein and other support nutrients, and what their effect is on the composition and nutritional quality of the products when they are the basis of the diet. Much work has been done with the cassava plant, designed to promote its use in livestock feeds (Buitrago, 1990). However, the major emphasis has been on producing a dry meal from the roots that could be used in conventional mixed feeds. This suited the interests of exporters (e.g., Thailand and Brazil) and feed millers and compounders in the developed countries, but the added processing costs usually put the dry product outwith the financial means of small-scale farmers, who were usually the original growers of the crop. Future research with cassava and other root and tuber crops should be directed to simple ways of on-farm processing and conservation, so that the growers can also be the major beneficiaries.

A relatively new feed resource, especially appropriate for the dry and semi-arid ecosystems, is the fruit from trees such as *Prosopis* spp.

Many of these tree fruits are rich in soluble sugars and gums. There is little documented information on their nutritive value or on ways in which they are being used or how they could be used better if managed in the most appropriate way.

In general there is an urgent need to promote feeds and feeding systems that are farm-based, rather than relying on purchases of a "balanced" and "expensive" feed from a factory.

## **ALTERNATIVE SOURCES OF PROTEIN FOR MONOGASTRIC AND RUMINANT ANIMALS**

### **Oilseeds and pulses**

The traditional sources of protein in the diets of monogastric animals are the by-products from oilseed milling and the processing of livestock, including fish. Although village-based processing is still the norm in some countries, the process of "development" has led to intensification and scaling-up of poultry and pig production in vertically integrated enterprises encompassing all aspects of the production cycle. This has made it difficult and costly for independent small-scale producers to acquire these feed resources.

There is an urgent necessity to develop protein sources that can be produced and processed on the farm. There is scope for the cultivation of traditional protein crops such as soya bean, groundnut, sunflower, as components of integrated and associated cropping systems. Unconventional legumes such as *Canavalia ensiformis* and *Canavalia gladiata* have received attention from researchers in Africa (Udebibie, 1991), and especially in Latin America (Anon, 1993) but, as yet, there is little impact at the level of the commercial farmer.

### **Multipurpose trees**

Multi-purpose trees are essential features of sustainable development in all less-developed countries, but especially those in the tropics. Thanks to the enormous biological diversity within tropical trees and the accumulated experience of indigenous communities it is possible to advance rapidly in the identification, nutritional characterization (including the presence of secondary plant compounds), cultural needs and growth patterns in associations with other species. There are

hundreds of species in more than 40 botanical families and, within species, a wide range of provenances, many of which are already proving their "sustainability" (Molina, C. and Molina, E., personal communication, 1994). To be able to take advantage of these "indigenous" riches is a stimulating challenge for researchers in the less-developed countries.

Research efforts should be concentrated on: (i) identification of the secondary plant compounds in the leaves and how these are affected by soil, climatic and cultural practices; (ii) developing ways of neutralizing those compounds that have anti-nutritional effects (e.g., by simple ensiling and other fermentation methods); (iii) increasing the availability to digestive enzymes of the amino acids in plant material consumed by monogastric species; and (iv) finding combinations of leaves which maximize "by-pass" characteristics of the protein for ruminants.

### **Water plants**

Where rainfall and/or irrigation are adequate, water plants are highly productive sources of protein-rich biomass and are ideal complements for fibre-free basal diets such as molasses, sugar cane juice and palm oil in pig and poultry feeding systems. As with the trees there are many species to choose from, each of which has its special characteristics which makes it more or less suitable for a given ecosystem. They satisfy the sustainability indicators (Chapter 1) and fulfill a particular niche because of their capacity to decontaminate water excessively charged with organic matter and plant nutrients.

The leaves of most water plants are more digestible than the leaves from trees and, generally, they appear to have low concentrations of anti-nutritional factors. The problem in practice has proved to be more in the area of agronomy than in nutrition. It is almost certain, that at the present time, learning how to grow water plants in continuous culture has a higher priority than characterizing their nutritive value.

### **Unicellular protein**

It is time to return to this subject but from the point of view of natural ecosystems rather than the fossil-fuel based schemes which have largely failed because of health-related issues (e.g., yeasts using petroleum derivatives as substrate) or cost (e.g., torula yeast from sugar cane derivatives). *Spirulina* has the potential to reproduce at a high rate on

biodigester effluents (Ho Thi Kim Hoa *et al.*, 1994), and has an amino acid pattern ideally suited to complement low-protein, energy-rich feeds derived from tropical resources such as sugar cane and African oil palm. Recent developments on the growing of *Chlorella* and *Snedecus* algae show promise as the basis for a low-cost method of harnessing solar energy and atmospheric nitrogen fixation to produce high-quality protein; potential rates of productivity of 9,000 kg protein/ha/year were reported by Chowdhury *et al.* (1994).

### **Worms, insects and larvae**

Cultivation of the Californian Red Worm on livestock excreta has proved to be a commercially viable method for producing concentrated organic fertilizer (humus) on farms in Colombia (Rodriguez, L. and Cuellar, P., 1994, personal communication). The worms, which are really a by-product of this process, are a source of high quality animal protein which has potential as a supplement for poultry, especially at family farm level (Arango *et al.*, 1994).

This same medium (livestock excreta) can be used for cultivation of a range of insects and larvae. Peasant farmers on the Pacific coast of Colombia are skilled in disseminating termite mounds in the forest and harvesting the contents as feed for poultry (Solarte *et al.*, 1994a,b).

There is much to be researched in this category of unconventional protein-rich resources.

### **Silage from animal and fish by-products**

In industrial countries there are well developed technologies for recovering by-products of animal and fish processing and converting them into protein-rich meals. However, such facilities are rarely found in tropical less-developed countries, especially at the level of small towns and villages where slaughtering and processing of fish are done in rudimentary conditions and where by-products often become contaminating wastes. In such situations, the ensiling of the by-products, using molasses and crude syrups derived from sugar cane, is a simple and appropriate method of conservation (Perez, R., personal communication). The results of using this method to preserve mixtures of blood and shrimp heads in Vietnam are described by Lien *et al.* (1994).

## **UNDER-RESEARCHED LIVESTOCK AND LIVESTOCK SYSTEMS**

### **Small non-ruminant herbivores**

Cardozo (1993) lists the following species as priority candidates for research and development: rabbits (*Oryctolagus cuniculus*), guinea pigs (*Cavia porcellus*), geese (*Anas anser*), iguanas (*Iguana iguana*), picture (*Dascyprocta* spp.), capybara (*Hydrochaeris capybara*) and snails (*Pomacea* spp.).

The advantage of the majority of species in this category is their high reproductive rate and their capacity to select and utilize plants which would not normally be fed to domesticated livestock. Rabbits, snails and guinea pigs, are traditionally managed in confinement. In fact, such a practice is essential in the case of rabbits and snails which rapidly become serious pests of food crops if allowed to proliferate without control. Geese are efficient grazers and their management should probably be based on some form of scavenging system. For the other species, domestication is almost certainly undesirable, and their exploitation in natural habitats is the preferred approach.

### **Multi-purpose cattle and buffaloes**

The concept of multi-purpose use of large ruminants is gradually gaining acceptance, not least because of the technical and socio-economic failures of most projects that aimed to exploit specialized breeds and management systems. Two main focal points can be identified: the mainly dual-purpose management of crossbred *Bos indicus* x *Bos taurus* breeds for milk and beef production and the triple-purpose management of buffaloes and mainly *Bos indicus* breeds for work, milk and beef. Much more research needs to be done with these breeds and production systems. From the animal nutrition standpoint, interesting areas of work relate to selection, offer level and quality of the predominantly fibrous feeds, the efficient use of which is the prerogative of these breeds and systems. The comparative advantage of the buffalo (mainly the "swamp" variety) is still not well understood and even less well documented. Equally the advantages of restricted suckling of the calves, although highly appreciated and well understood by tropical farmers, poses questions to researchers concerning interactions between animal behaviour (or greater animal contentment), productivity and feed utilization efficiency, as this affects both dam and offspring.

The effect of work on productive traits of cows is highly correlated with nutrition (Zerbini and Gameda, 1994). However, much of the research in this area has been done with the aim of characterizing nutrient requirements rather than understanding how best to manipulate the system in order to optimize use of local feed resources and 'catalytic' supplements. This is a fertile area for study.

### **WHERE TO DO THE RESEARCH: ON-FARM OR ON-STATION?**

In part, it is a question of choosing horses for courses. Most animal feeding research in the tropics, aimed at providing solutions to the complex problems detailed earlier in this manual, is probably done more effectively and more economically on commercial farms than at the experiment station. It is rare to find an experimental station that manages well either crops or livestock. The results then become site-specific (good or bad according to the management) and replication within the station may be of limited value. If management is a component of the hypothesis being posed, then validation should be done on a range of commercial farms.

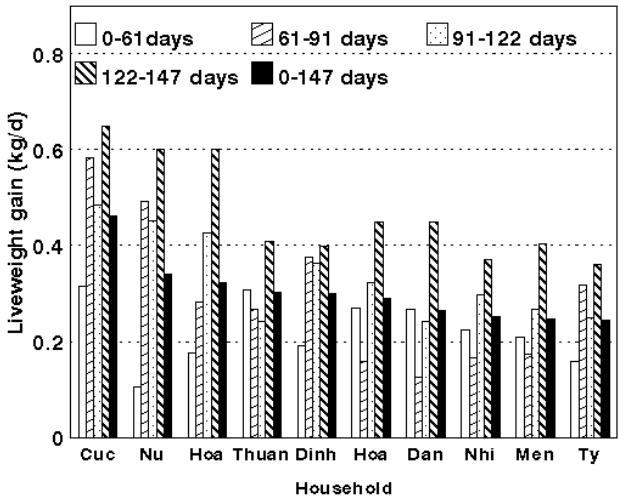
The screening of potential feed resources should also begin on-farm or in-village. For, in many communities in the tropics, livestock farmers often have no land of their own. It is these latter farmers, usually women, who have developed particular skills in identifying trees, shrubs and plants that have specific nutritional properties (Rangnekar, 1994). In a recent encounter with such resource people on the Pacific coast of Colombia, more than 20 plants were identified by the farmers as sources of feed for their livestock (Solarte *et al.*, 1994ab).

On-station research is indicated when a problem, identified in on-farm activities, requires a form of analysis (usually chemical or biological) which calls for a laboratory or other facilities for which an experiment station is equipped.

On-farm research methodology is different from that applied on-station. It will rarely be possible, or even desirable, to have replications of a treatment on the same farm. Rather the farm itself will be a replicate, for the objective frequently will be to measure the range of variation encountered among farms in which similar interventions are

made. The data in Figure 2.1 demonstrate such a response to introduction of sugar cane juice feeding of pigs in villages in Vietnam.

**Figure 2.1: Growth rates of pigs fed sugar cane juice diets on family farms in villages in Tuyen Quang Province in Vietnam (Source: Preston, T.R., 1993, Unpublished data).**



The question that such a response raises is: what is the cause of the variation? A detailed analysis of the activities on each farm, especially those at the extremes of performance levels, will often yield valuable insights into the strengths and weaknesses of a given technology, which would not have come to light under the more controlled conditions of the research station.