Research Priorities to Improve Livestock Production in Asia*

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Summary

Priorities and direction for research concerning more effective use of feed resources by livestock in Asia are discussed in the context of prevailing agroecological zones, animal production systems, land use and types of feeds available (forages, crop residues and agro-industrial by-products, and non-conventional feeds) and opportunities for nutritional interventions to significantly increase animal productivity. Increasing forage supplies will be constrained by inadequate arable land, unless this is extended to forest and woodland areas, and possibly also in food-feed cropping systems. Potentially important possibilities exist for expanding and intensifying the use of fibrous crop residues (FCR) which account for over 66% of the total availability of feeds from all sources, through well researched technologies that can be applied singly or in combination: treatment with alkalis to increase digestibility; rumen manipulation to improve the balance of available nutrients; and supplementation to improve overall digestion, meet nutrient requirements and improve the efficiency of production. The type of supplements include multi-nutrient, non-protein nitrogen mixtures, and bypass protein sources. Data is presented that provide clear demonstrable evidence concerning the impact of supplementation in large scale on-farm studies. Leguminous forages have relatively unexplored potential and their use as supplements can be intensified. Enhancing the efficiency of use of FCR requires both adaptive and applied research. The former includes identification of principal crop residues, sources and preparation of appropriate supplements. The latter involves cultivation or production of protein sources, including processing into bypass proteins, and conservation of biomass for year round feeding. The over-riding need is adaptive work concerning on-farm feed resource utilization which should be seen as a researchable function requiring a multi-disciplinary approach. Equally, there is also a need to address feed resource constraints within crop-animal systems involving both ruminants and non-ruminants. Priorities and direction for research to address these needs are given, which should provide for increasing the contribution from livestock and the development of sustainable systems of production.

1. Introduction

Priorities and direction for more effective use of the feed resources in Asia need to take into account two major issues. One concerns the prevailing agro-ecological zones (AEZ) and the other management and use of the natural resources, mainly land, crops and animals therein. The prevailing AEZ are as follows:-

- Rain - fed temperate and tropical highland system - mainly the Hindu Kush - Himalayan region.
- Rain - fed humid / sub-humid tropical system - mainly countries in Indo-China, South East Asia, South China and the South Pacific islands.
- Rain - fed arid / semi-arid and subtropic systems - mainly countries in South Asia excluding Nepal and Bangladesh.
- Irrigated / humid / sub-humid tropics mainly countries in Indo-China, South East Asia and South China.
- Irrigated arid / semi-arid tropics and subtropic systems - mainly Pakistan and India.

Mixed farmin is the overriding pattern of agriculture in all these AEZ, and is reflective of the traditional form of agriculture in Asia. These mixed farming systems have certain distinctive characteristics across AEZ and are as follows (Devendra, 1995):-

- Diversification in the use of production resources
- Reduction in and spread of risks
- Preponderance of small farms
- Use of large populations of ruminants (buffaloes, cattle, goats and sheep) and non-ruminants (chickens, ducks and pigs).
- Integration of crop and animal farming
- Animals and crops play multipurpose roles
- Low input use and traditional systems, and
- Involves the three main agro-ecosystems (highlands, semi-arid and arid tropics, and sub-humid / humid tropics).

2. Land Use

Table 1 indicates that there exists a total of about 434 million hectares in South East Asia. These include 52% of forests and woodland, 26.5% other land, 17.8% arable and permanent crop land, and 3.7% permanent pasture land. The arable land is already over cultivated, and a significant expansion in this area is unlikely. The area is however an important source of crop residues and agro-industrial by-products for feeding animals. Attention is drawn to the large area of about 226 million hectares under tree crops (coconuts, oil palm and rubber) of which the native herbage understorey is presently under-utilised. Use of the pasture under trees with ruminants is a potentially important production system that has not been adequately explored, and one which can significantly increase the current level of productivity.

Development has hitherto overemphasised the use of essentially lowland irrigated areas to the limits of productivity. Attention now needs to shift therefore to the rain-fed ecosystems mainly because of inadequate arable land in the region. This shift is justified by two main considerations. Firstly, the demand for food outstrips agricultural growth in irrigated areas in the face of increased human needs and also food security. Secondly, these rain-fed areas have large concentrations of livestock whose productive potential have remained at a low level and their nutritional needs have not been adequately addressed.

The rain-fed ecosystems have considerable agro-climatic diversity compared to the irrigated areas, are generally more fragile, and subject to resource degradation. Resource-poor farmers in the upland areas are associated with a complex web of interactions between poverty, agricultural growth and survival in which they perceive short term survival to be more important than environmental protection. Research and development issues thus require to be more needs driven and recognise the complexity of the task.

The complexity of the task is even more compelling when viewed from the fact that research and development has up to the present time mainly emphasised the lowland irrigated areas. Since arable land is limited and already over-extended (Table 1) attention must shift to the rain-fed lowland and upland areas. It will involve strong multidisciplinary effort and systems oriented holistic programmes.

Table 1 Land use in south east Asia (FAO, 1993)

Type of Land Use	Area (10^6) (ha)	% of total
Arable land and permanent crops	77.7	17.8
Permanent pasture	15.9	3.7
Forest and woodland	225.5	52.0
Other land	114.9	26.5
Total land area	**434.0**	**100.0**

3. Animal Production Systems

A variety of animal production systems exist which are integrated with crops and involve both ruminants and non-ruminants. The systems vary in relation to type of AEZ and intensity of the mixed farming operations. These systems have evolved over time; have definite economic benefits and have complimentary interactions with individual sub-systems (eg. crops, animals or fish) in which the products are additive. Two good examples of sustainable integrated systems are pig, fish, duck, vegetable systems in Indo-China, Indonesia and the Philippines, and small ruminant, tree cropping systems in South East Asia and the Pacific (Devendra, 1993).

It has been recognised in recent years that the emphasis must swing to the development of sustainable small farm systems, which considers multiple crops, multiple animal use with integration within or between crops and animals. The small inexpensive, plastic biogas digestor is now considered by the Grameen Bank as being a central pivot for integrated sustainable farming systems, with the use of the mineral rich effluent for aquatic plant propagation or algae production to feed fish. The aquatic organisms reclaimsnutrient losses (N.P.K.) from the farming system.

Ruminant production systems in Asia are divided into three categories as follows:-

Extensive systems

Systems using biomass from:-

- the byproduct of arable cropping
- roadside, communal and arable tethered or grazing systems
- cut-and-carry feeding

Systems integrated with tree crops such as coconuts or oil palm.

These production systems are unlikely to change in the foreseeable future. New proposed systems and returns from them would have to be demonstrably superior and supported by massive capital inputs and other resources (Mahadevan and Devendra, 1986; Devendra, 1989). However, it is quite predictable that there will be increasing intensification and a shift within systems, especially from extensive to systems combining arable cropping, induced by population growth and the fact that population density and intensity of land use are positively correlated (Boserup, 1981). This situation is increasingly likely with decreasing availability of arable land, which will occur in many parts of South East Asia.

An analysis of these systems lead to the conclusion that the principal objective should be to maximise the use of the available feed resources, notably crop residues and low quality roughages, and also various leguminous forages as supplements in appropriate feeding systems to maximum advantage. This conclusion is consistent with the finding in the recently concluded global consultation to define the agenda for livestock research (ILRI, 1995) that feed resources and nutrition, was the most important constraint affecting animal production across regions (Asia, sub-Saharan Africa, west Asia and north Africa, and Latin America and the Caribbean).

4. Feed Resources

Four main categories of feeds are identifiable: forages include grasses, legumes and browse; crop residues; agro-industrial by-products (AIBP), and non-conventional feed resources (NCFR). Crops grown specifically for livestock, including grasses and legumes represent a relatively small component of the available resources for ruminants because of the unavailability of arable land. The exception to this is the production of legume crops grown as a cash crop at the end of the wet season and prior to the onset of the dry season.

Crop residues are mainly fibrous crop materials that are by-products of crop cultivation. Because of the emphasis and intensity of crop production in Asia, these form a high percentage (over 66%) of the total volume of feeds produced. These crop residues have low crude protein content, have low digestibility and are often deficient in minerals.

AIBP refer more to by-products from the industry, are less fibrous, have relatively more digestible nutrients and are often relatively high in protein. Good examples are copra meal, rice bran, cottonseed meal and palm kernel cake with effluent from refining palm oil and molasses being low protein by-products high in minerals and fermentable substrates. NCFR are identified separately and refer to all those feeds that have not been traditionally used in animal feeding. In Asia, NCFR represent diversity and include coco pod husks, pineapple waste, distiller solubles and poultry litter. It has been estimated that the total availability of feed resources other than grasses from traditional sources and NCFR was 1996 x 10^6 MT, of which about 47% were NCFR (Devendra, 1992). Additionally, it was also estimated that approximately 80% of the total feed availability is potentially best suited for feeding ruminants. The most important function of these animals in the Asian and Pacific region is therefore the utilisation of carbohydrate resources in fermentative digestion which are not sufficiently digestible by monogastric animals to support their production..

4.1 *Supplements for ruminants*

Almost all the carbohydrate resources fed to ruminants in the tropics are low in total nitrogen and protein and are also often deficient in some essential minerals. Supplements that can be used to provide these different nutrients are discussed below.

4.1.1 Oil seed meals

Much of the increased requirements for protein meals in some parts of Asia can be met from the reduction in export of by product vegetable protein meals to Europe and North America. In many regions the available protein resources are prioritized for feeding to pigs and poultry. Often the need is therefore to find or produce a suitable protein resource for ruminants. One approach concerns, leguminous forages and there is at present, a concerted, perhaps over-emphasise initiative, to develop these throughout the region.

4.1.2 Leguminous forage proteins

The main thrust to date has been to provide protein (and energy) from forage legumes in pasture or as protein source in fodder banks. Biomass and protein production have been the criteria for selection. Little consideration has been given to the form of protein in such forages. Proteins present in green forages are usually highly soluble enzyme proteins which are easily fermented in the rumen with the amino acids largely converted to ammonia, and therefore provide little or no essential amino acid to the animal. It has been demonstrated that in many situations the leguminous forage, in small quantities, functions to stimulate rumen fermentative efficiency and in this way they give no extra benefit over that provided by a molasses-urea multi nutrient block (MUMB). Research on forages should be continued, but it is equally important to find ways to protect the proteins, which may be accomplished to some extent by simple sun drying (Leng, 1995).

The most important component that is effective in protecting the protein in fresh legume forages is the presence of tannins at 1-3%. Tannins protect the protein from rumen degradation as occurs in *Lotus* sp. (Barry, 1983).

Unfortunately in tanniniferous forages, tannins are present in concentrations that are extremely variable both between and within forage/foliages. The factors that influence tannin content and, its irreversible or reversible binding of protein needs considerable research. The important factors that influence tannin levels in a foliage source include plant growth conditions, stage of growth, damage from insect or herbivores; harvesting methods and feeding techniques for the forages. There is considerable doubt as to whether tannins in effect reversibly bind proteins (see Van Soest, 1994). .

Trees and shrubs that contain tannins often react quickly to foliage damage by increasing their tannin content up to 300% and this often happens quickly after a tree is damaged (see Van Hoven, 1985). The factors that influence tannin levels is critical in identifying the range and variety of species that could be used for ruminants. Selection of forage legumes containing tannins that are high in protein could be particularly important to further enhance the use of protein banks.

There are attempts to use recombinant DNA technology to introduce tannin synthesis into forage legumes that were previously devoid of these compounds (CSIRO Plant industries, Canberra).

4.1.3 Fodder tree/shrub proteins'

Some emphasis is being focussed on fodder tree plantations (Devendra, 1990). Trees require more emphasis because they are multipurpose and therefore readily fit into an integrated farm approach. They also meet many of the requirements for sustainability of farming systems and can be used in grazing systems or where cut and carry grass is used to feed housed/ tethered animals. They also provide fuel resources for households, often reducing the need to purchase other fuels.

The attributes of trees in farming systems include:

- They provide high protein leaf forage and some, large quantities of fruits or pods, which can be used as a relatively high energy concentrate feed.
- They are perennial and often drought resistant
- Many species are legumes and/or also mobilise unavailable P through root associated fungi. They are also deep rooted and uptake minerals from deep soils that are not exploited by grasses and crops.
- They provide sustainability when planted in pastures, protecting the soil against wind and water erosion and recycling nutrients from deeper soil layers with the fixation of N in leaf mulch on the soil surface.
- They store carbon dioxide from the atmosphere reducing atmospheric build-up.
- They provide fuel, (an ever increasing problem for the poor), the replacement of fossil fuel energy by wood energy again contributing to lowering of carbon dioxide emissions into the atmosphere, and
- They also provide numerous other advantages and uses, e.g. shade, fenceposts, medicants etc. and importantly are a critical fodder reserve during drought.

4.1.3.1 ***Fodder*** tree ***species*** In grazing systems on a neutral to alkaline soils, *Leucaena leucocephala* has already proved its usefulness but insect infestation (psyllid) has reduced the areas where it can be grown.

Many fodder trees are known to indigenous peoples who feed them to their livestock. Pods as well as leaf foliage are often sought after as ruminant feeds - *Acacia niolotica* pods are used extensively for feeding to goats in India and *Prosopis juliaflora* pods are finding their way into concentrate feeds in a number of countries, particularly in Brazil (Dutton, 1992).

Useful species include *Leucaena, Tagasate, Acacia, Glyricidia, Erythrina, Calliandra, Prosopis* and *Tricantera.* The last mentioned is fed to pigs and poultry in South America. There is a continuing need to identify useful trees to fit with the local environment and soil conditions. However, for livestock, tree foliages are especially important as these will essentially provide supplements to pasture or other biomass and will be fed at low levels in a diet. Often the level of inclusion in a diet is below that where deleterious, constituent, secondary plant compounds have an effect. This then broadens the scope for the use of different species. The foliages with secondary plant compounds are often rejected at the first screening level for useful plants.

4.1.3.2 ***Need for processing of proteins/secondary plant compounds from trees.*** There has been little research to process tree foliages and fruits or pods to maximise their nutritional value as supplements.

Heat, chemical or physical treatments to develop protein supplements from trees/shrubs that are rumen-protected but are intestinally digestible are recommended for priority research. Simple mixing of high-tannin and low tannin foliage may result in better utilisation of tree fodders. Sun drying tree foliages appears to increase their nutritional value as supplements, suggestive of protection of the protein from rumen degradation (Norton, 1994).

4.1.4 Research needs for fodder tree

Both forages and tree fodders require continuing research. The areas include:-

- Selection of species and how to manage plantations
- Harvesting and/or grazing management
- Special studies of secondary plant compounds; the influence of tree management, harvesting, soil fertilisation and water regimens.
- The effects of secondary plant compounds in the animals, and
- Foliage and fodder processing to ameliorate adverse effects of secondary plant compounds and enhance the utilisation of protein.

The major issue with fodder trees is where to grow them, as the available cropping land is low. The integration of fodder trees in difficult lands (because of topography, aridity, acidity, salinity, etc) or with plantation crops appears to warrant considerable research.

4.1.5 Aquatic plants

Aquatic plants are a further resource that can be produced on presently under-utilised areas of water and again fit into a farming systems approach aimed at sustainability. Most research has focused on the use of

Azolla with lesser emphasis on *Pistia sp* (water lettuce) and water hyacinths *(Eichornia spp)*. All water plants are low in dry matter, low in fibre but variable in protein.

Members of the *Lemnacae* (duckweed) have recently been singled out for attention because of the very high protein content, high biological value and low fibre which makes them very suitable as a protein or food source for pig, poultry and fish and as a potential N or protein source for ruminants. It is also a source of P when grown on water of high P content (see Skillicom et *al.*, 1993, Leng et *al.*, *1994).*

Under ideal conditions duckweed may have 45% protein (more usually 30-35%) in the dry matter and up to 1.5% P which appears to be totally available and is extremely high in vitamin A (Leng et al., 1994). It has the potential to produce 9- 18 tons. of protein/ha/ year under good conditions. Considerable research is now needed on aquatic plants with emphasis on growth conditions to maximise protei n and. minimise fibre contents. Feed processing such as drying (as the plant is 6-8% DM), preservation of wet materials and retention of the high biological value of the protein preserved wet or dry are also needed. Treatment to ensure protein protection, if it is to be fed to ruminants, may also be needed.

There is considerable scope to set up duckweed and *Azolla* farming on sewerage and industrial waste waters high in phosphorus. However, they are more suited to small integrated farming systems to provide a mechanism to recycle a high protein supplement for animals and at the same time recycle P, N and K specifically, but also a number of other minerals in solids or effluents from animal production.

4.2 Feed resources for pigs / poultry

4.2.1 Availability of feed grain

Inevitable fuel cost increases will set an upper limit on food crop production with its multiplier effect on all costs of crop production. The constraints imposed by rising fuel costs, together with plateauing genetic improvement in cereal yields, increasing land degradation and decreasing land size per head of population with increasing population growth, indicates that inevitably intensive pig and poultry production based on cereal grains and as practiced in industrialised countries, will become unacceptable or uneconomic in most developing countries other than where these industries supply the wealthier markets such as tourists and urban middle class.

At the present time, intensive pig and poultry industries are the major growth areas providing meat and eggs for the Asian region even though there is enormous potential to increase total meat and milk production from ruminants.

There must be serious doubts about the sensibility for supporting continuation of growth of the intensive pig and poultry industries in Asia. The production systems based on inexpensive oversupply of world grain are often peri-urban and are produced at considerable cost to the environment. The developments of this industry and the research technology that will be transferred from industrialised countries will be undertaken by entrepreneurial business men and should therefore be left to the private sector. However, the small scale production of pigs and poultry based on alternative feeds/management should be progressed as part of the traditional and integrated farming systems of Asia (Devendra, 1995). Increased research and development on these systems can significantly increase the current level of output from these systems.

There is a school of thought (Mitchell and Ingco, 1994) supporting earlier predictions (Alexandrous, 1988) that there will be a continuing availability of surplus cereals on world markets at competitive prices for pigs and poultry production to meet urban middle class markets. This scenario is based on the view that increasing income will change diet selection and reduce human requirements for grain consumption; increase grain supply due to increased inputs into production in the grain exporting countries; and competitive low cereal prices. These factors are expected to favour increased pig and poultry production. On the other hand China alone is projected to require to import 300 x 10^6 MT of feed grain by year 20 10 (Lester-Brown, 1994). This is almost double the predicted surplus at that time.

Thus it appears that the dependency on grains for extenions of pig and poultry production is at the best a precarious option. A collapse of burgeoning and established pig and poultry industries because of increased costs of grain could be devastating for many countries and therefore for heightened food security alone, there is a need to build onto and develop alternative small farmer systems. If it appears there is a need to concentrate on improving ruminant production because of the large feed biomass that will always be available and to develop unconventional feeds and appropriately modify traditional feeding systems for monogastric animals in Asia.

A responsible issue for ILRI to consider therefore appears to be the development of integrated farming systems based on local and non- conventional feeds, including ruminants fed crop residues and alternative production systems for pig and poultry that are sustainable.

4.2 Village pig-poultry production

Throughout Asian countries there exists a massive unstructured village level pig and poultry (including ducks) industry, that is largely unserviced by research, that is based on scavenging feeds from the farms and household. The production of ducks on rice fields or in lagoons is often sophisticated and traditional systems in Indonesia are highly efficient particularly in egg production. In general however, scavenging pigs and poultry are inefficient enterprises limited by poor nutrient and hygiene, disease and lack of housing. These systems have received little attention, perhaps because of the difficulties of researching such diverse systems and in addition the research has been under resourced and poorly designed and often has not included on-farm participatory activities.

The recent introduction of a small amount of attenuated Newcastle disease virus in a feed supplement has effectively immunised poultry under village production systems in South East Asia increasing survival rate enormously (Spradbrow 1992). This raises the issue of how feed resources and feeding systems can be developed to keep up with the increased survival rate.

Identification of the order and magnitude of nutritional deficiencies in traditional pig and poultry production systems and supplementation of the limiting nutrients could have a major impact on production if major disease problems are controlled simultaneously (see Spradbrow, 1992).

In Vietnam, there is a traditional system of duck raising which includes lagoon production of duckweed. The lagoons were fertilised with excrement from humans, ducks, pigs and cattle; freshly harvested duckweed was mixed with rice polishings and cassava wastes as the main protein resource for raising ducks and the run off water is used in irrigation. This is an excellent example of traditional systems that require study.

4.2.3 Local feed resources for pigs and poultry.

4.2.3.1 Sources of carbohydrate/energy There are many alternative carbohydrate sources which can be used particularly by pigs. Cassava roots, sweet potatoes, reject banana fruits, cereal brans, molasses and sugar cane juice, food waste from urban communities, or where available inexpensive vegetable oils (Preston and Margueitio, 1992). The opportunity cost of using any of these depends on a number of factors, but there are many combination of food that can lead to moderate levels of pig production.

Diets based on urban household waste for pigs, traditional in Europe in the 1940's and Molasses-based diets have been used in recent years in Cuba and South America (Figueroa and Ly 1990). Fractionation of sugar cane into juice and fibre and the use of juice for pigs and the fibre and residual sugar for ruminants respectively have been shown to be feasible on small to large scale production units (Preston, 1980). The use of high levels of oil (40-50%) from oil palm in the diet of pigs has recently been reported to support reasonably high levels of growth (Ochampo, 1995).

4.2.3.2 Sources of proteins Oilseed extracted protein meals, chicken offal meals, hydrolysed feather meal, seeds, foliage of some food crops, fly larvae, duckweed, azolla and other aquatic plants and earthworms have all been researched in a rather superficial way as protein sources in diets for pigs.

Improved village or backyard pig production systems based on non-conventional foods, could be very effective in increasing meat availability that would benefit a large number of poor people.

5. Priorities for Nutrition Research

The major emphasis on agriculture in Asia will continue to be on food production, but as the middle class expands with increasing standards of living, animal products must assume an increasing component in overall primary production output. Most animal industries other than the high technology pig and poultry industries are secondary to, but interrelated with crop production. The secondary nature of animal products for small farmers has resulted in ruminant production being under resourced and characterised by low growth rates, late maturity and extended interbreeding intervals. To increase ruminant productivity substantially does not appear to be a major task from its present low base. It is however important to understand that for crop farmers their priorities in terms of ruminants are usually targeted at continuing draught power needs and not increased meat and milk production.

The areas of priority for nutrition are governed largely by the availability of digestible biomass. Although forests and woodlands and other lands in South East Asia combined represent 78.5% of the total, as a source of fermentable biomass, this possibly provides less biomass than that from the arable and permanent crops (which is 17.8% of the total) and permanent pastures are almost negligible in terms of their total biomass production relative to cropping lands.

The main objective is to increase ruminant production within the cropping areas based largely on crop residues, agro-industrial by-products and non conventional feeds. The use of biomass under plantation management however is a largely unexploited resource for ruminant production that deserves some considerable emphasis.

5.1 The major issues in nutrition research

5.1.1 Ruminants

- Identification of the major conventional and non-conventional biomass resources available in sufficient quantities to be the basal diet for ruminants.
- Consideration of their nutrient composition and digestibility and where appropriate establish economic treatment processes to improve digestibility.
- Identify the appropriate supplements to provide . feed nutrients deficient for optimal microbial growth.

. nutrients to increase protein supply for absorption of the intestine (bypass protein) and other nutrients required by the animal (P, Ca., etc).

. potential protozoa1 toxins to remove the anti nutritional effects of protozoa (See Bird, 1995).

- Establish response relationships to supplements in ruminants fed biomass or biomass treated to increase digestibility.

5.1.2 Monogastrics

- Identify alternative carbohydrate resources or feeds.
- Identify potential supplements to balance diets based on non-grain based feeds or scavenging monogastrics
- Measure response relationships to graded inputs of protein meals, minerals etc.

For both ruminants and monogastrics it will be necessary to monitor and take advantage of the effects of any inputs into animal production on nutrient flows within the integrated farm and how these effect crop yields, fuel supply and production from other animals.

5.1.3 Research : feed resources

- Where protein resources are scare the priority will be to produce on farm protein sources which may be conventional (e.g. legumes and tree foliages) or non-conventional (e.g. azolla, duckweed).

6. Nutritional Strategies to Increase Productivity from Animals

6.1 Intensifying the use of crop residues

There is a real and obvious desire by scientists to progress beyond the boundaries of present knowledge in animal production and ILRI has a mandate for long term research to service animal production at least 10 years from now. However, substantial increases in total animal productivity could be achieved if the established nutritional knowledge were to be applied widely throughout the region. Enormous research effort has targeted improvement of ruminant production from crop residues (straws) and high biomass agro-industrial by-products (e.g. sugar cane bagasse, molasses, etc.). The key need is to determine, under the prevailing regional and socio-economic conditions, the appropriate applications of inputs to feed crop residues to ruminants that can substantially lift production to a level and the product to a quality that are acceptable by local, national and international markets.

The major research needs are those that:-

- Identify economical and appropriate technologies to improve the potential digestibility of crop residues
- Develop the most appropriate strategies to enhance rumen function and the means to administer these supplements.
- Develop appropriate means of manipulating net rumen microbial growth efficiency
- Identify and/or develop the feed resources to provide bypass nutrients.
- Demonstrate to farmers the profitability of the responses to appropriate packages of technologies.
- Provide or ensure post production facilities for efficient marketing of the products which should have added value wherever possible.

6.2 Enhancement of the utilization and digestibility of straws through alkali treatment

There is now a major developmental model for the use of supplementation strategies and the technologies of straw treatment to improve ruminant productivity. Under the auspices of FAO, a pilot project was set up in southern China to develop cattle feeding systems using straw and cottonseed cake (Dolberg & Finlayson, 1995). The success of the project is indicated by the statistics of straw treated and fed to cattle in the region (Table 2).

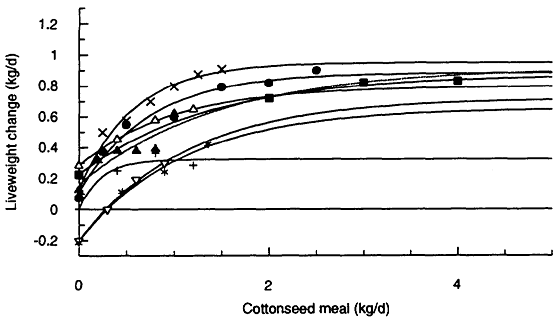
Table 2 Development of beef production systems based on ammoniated straw in S. China (Dolberg and Finlayson 1995)

	Year	*Farmers (x 10^6)*	*Straw Quantity Tonnes (x 10^6)*
	1985		0.003
	1986		0.042
	1987		0.148
	1988		1.480
	1989		1.830
	1990		2.570
	1991		3.870
	1992	2.2	6.000
(estimated)	1993	3.3	11.000

6.3 Strategic supplementation

The success has been achieved through local research that defined the nutritional supplements needed within the socio-economic realism of the area. For example, growth response relationships in cattle fed ammoniated straw to cottonseed cake inputs were developed. These results, together with a number of response curves for cattle fed low quality forage and supplemented with cottonseed meal are shown in Figure 1. The effects of various treatments for adding ammonia to straw to effect treatment were also evaluated. As the technology is taken up by more and more farmers, alternative sources of protein will be needed and research may pay off where the cottonseed cake protein is further protected to reduce the inputs necessary. When carcase composition and quality becomes a major market criteria, further studies to alter carcase composition (eg. feeding protected fat) may also be needed.

Figure 1 The response in liveweight gain of cattle fed basal poor quality forage supplemented with cottonseed meal (after Leng, 1995). Data for cattle fed ammonia-treated straw in China are show as filled circles (●) and filled squares (■).



The above example of a research and development strategy demonstrates the way ahead for most rapid development of ruminant production systems in cropping areas; that is, to adapt and extend the already known technologies to use local biomass resources; to demonstrate the benefits of supplementation of crop residues fed to small or large ruminants and show the additional benefits from alkali treatment (urea ensiling) of straw for small farms.

The lack of appropriate supplements or the infrastructure for manufacture and distribution of supplements are primary limitation. Cash flow for purchases of supplements and knowledge of how to use these are also critical constraints to their use, particularly by the small resource-poor farmer.

7. Research Requirements to Establish Appropriate Supplements for Low Quality Forages for Ruminants

The supplements needed to balance low digestibility roughages for feeding to ruminants have been discussed above. They are now classified according to their role as:

- Nutrients essential for efficient microbial growth in the digestive systems of ruminants, which include :-
  - Multi-mineral sources, eg., molasses or residues from molasses fermentation (spent liquor), chicken litter or poultry manure made into loose mixtures, liquid mixtures or the same mixes solidified into blocks.
  - Non-protein nitrogen sources include urea, chicken manure/litter and soluble proteins from leguminous forages, seeds and agro-industrial by-products (e.g. soyabean curd)
- Supplements that increase protein digested in the small intestines (i.e. bypass or escape protein or rumen non-degradable protein).
  - Bypass protein sources; which include protein meals that have been (i) heat treated in process ing, (ii) contain a low level of tannins (1-3%), (iii) have simply been dried, or are (iv) have been heated with reagents that make the protein insoluble (some protective agents include xylose, glucose, formaldehyde gluteral dehyde etc).

The best preparation and sources of supplements depend on locality. For example, recent studies have demonstrated that simply drying leaf foliages has an

Table 3 Comparison of the effect of tree foliage supplements fed fresh or after drying to goats fed a basal diet of rice straw (Norton 1994).

Foliage supplement	Forage intake (g/kg LWt/d) Tree foliage Fresh	Tree foliage Dry	Basal diet	Dry matter digestibility (%)	Growth rate (g/d)
Albizia chinensis	7.5		18.5	51	0
		7.5	16.5	44	54
Calliandra calothysus	7.5		18.5	47	24
		7.5	18.5	44	48
Glyricidia sepium	7.5		18.5	56	12
		7.5	15.5	47	42
Leucaena leucocepha	7.5		15.5	49	-18
		7.5	18.5	47	0
Sesbania sesban	7.5		14.5	53	0
		7.5	17.5	52	54

effect on how the material is viewed as a supplement (Table 3), fresh it appears to enhance only rumen fermentative digestion but the nutritional value of the dry leaf meal appears to be enhanced which may be due to insolubilisation and thus its content of bypass protein.

7.1 Draught animalpower

Animals are often critical in cropping areas since they provide a means to recycle nutrients to crops and also increase the fertility of land. The draught animal plays this role in many small farms providing fertiliser for crops such as ricee, but pigs and other animals can be important in places (e.g. pigs in Vietnam - see Xuan, 1995). Although in places draught animals are starting to be replaced by motorised equipment, at the present time the dependency on work animals (cattle, buffalo, horses and donkeys) predominates in Asia. The continuation of draught power into the foreseeable future seems assured on many grounds, especially socio-economic and any price increases for fossil fuel in general is accompanied by a return to the work animal both for their contribution of manure and for transportation and cultivation. In terms of their nutrition there is considerable wisdom in most countries where specialist cattle producers raise draught animals. For example in India 20 million cows are kept to produce replacement bullocks. In general, research needs include nutritional studies to:

- ensure attainment of potential adult liveweight
- ensure maximum nutrient extraction from the diet.

These two requirements may be achieved through supplementation of their poor quality forage diets to create optimum rumen fermentation conditions (see Preston & Leng, 1986; Preston, 1990).

8. Production from Small Ruminants

8.1 General considerations

Although the nutritional principles of using agro-industrial by-products and other sources of biomass are the same for both large and small ruminants, there are some advantages in using sheep and goats. These include:

- Some sheep and goat breeds are prolific and therefore can rapidly increase ruminant populations.
- Given the opportunity, they have the ability to select a more nutritionally valuable feed from mixed sources of nutrients and they depend on different feeds to sheep and cattle in mixed pastures.
- The goat has a capacity to detoxity some anti-nutritional secondary plant compounds largely in the liver. This broadens their feed base and in the semi arid areas, this increases the available biomass including high-protein shrub and tree foliages that may not consumed by cattle and sheep.
- There are breeds of goats and sheep that are highly efficient dairy animals and fit well into small integrated farming systems.

There are also a number of other advantages in small ruminants which include:

- The skin of goats is often as valuable as the meat
- They require relatively small investment to purchase breeding stock and to feed
- They can be managed by women and children
- Unlike the large ruminants in Asia, the male is as valuable as the female
- They are the preferred meat in many areas and their small size means that refrigeration for storage of meat is often not necessary and there appear to be no significant taboos against them for human food
- They are highly suited to grazing under plantation crops; in agro-forestry development or in special combinations of fodder trees/shrubs in pasture, particularly where intestinal parasite control is effective.

Multiparous goats/sheep that breed twice per year have the potential for highly efficient conversion of biomass to animal product. The role of the multiparous goat or sheep could be more analogous to the pig in industrialised countries and they have the major advantage that they need not compete for human food and that the production of their forage resources is achieved without excessive energy inputs.

With the already available technologies, i.e. disease/parasite control/supplementary feeding and the use of various forages and a variety of other feed sources of moderate to high digestibility there is potential for substantial productivity from small ruminants. One female goat well managed, could produce say 6 kids per year weighing at slaughter 20-30kg each. This is to be compared with the production of 50-100kg LWt from buffaloes/cattle largely over a 2 year period that would consume at least 16 times the basal feed resource in that time. There is particularly a great opportunity to develop sheep and goat production from forages growing under tree crops.

8.2 Research approaches

8.2.1 Adaptive and applied research for small ruminant production

- Identify feed resources and protein supplements and establish growth trials with response relationships to the most critically deficient supplement fed with either treated or untreated biomass or in grazing situations.

- establish the effects of supplementation of multiparous small ruminant on their fecundity and fertility.

8.2.2 Basic research

- Identification and study of genotypes for multiple ovulation (prolificacy) and ability to breed year round aiming at development of strains with high or medium prolificacy to fit the appropriate farming situation.
- Studies of the interaction of nutrition, disease and reproductive performance, including ovulation rate, conception rate and the survival of young.
- Studies on how to manipulate reproductive capacity to improve efficiency of production of total off spring, and
- Studies on the mechanism of detoxification of secondary plant compounds in liver or rumen.

9. Specialist Livestock Husbandry

The secondary nature of ruminant production to the priority for cropping on small farms in Asia is directly the cause in the present universal low ruminant productivity. It may be opportune now to develop systems where milk and meat become a focal issue within the farm but still integrated into the farming system of a village.

A new approach, might involve the encouragement of specialist animal producers outside the integrated farm, in which the specialists purchase the inputs (eg. straw etc) and sell the residues (eg manure to the crop farmer). This is a strategy that could be developed for the landless rural people who are increasingly underprivileged. The reason behind these suggestions is that it is doubtful whether traditional farms with crops as their major output can input into ruminant systems sufficiently to meet increasing quality control that is being demanded by more discerning markets. The potential to create “animal farms” closely associated with crop farms will depend mainly on the development of quality markets and sustainability of the system. Separate cattle production units would fit into the intensive rice farming systems where increased removal of rice straw from paddy fields now appears to be necessary to lower soil carbon and nitrogen pools (Fischer 1995).

10. Environmental Issues

Future animal productivity and environmental considerations within aide agencies and government legislation are likely to have a large impact on the direction of future research. Considerations which will come into play include the need to control gaseous pollution of the atmosphere and pollution of surface and ground water. The pressures will be applied largely through inter-government interactions and aide agencies anxious to ameliorate anticipated world problems. The issue of sustainability of the farms, however, has to be the uppermost consideration which in every situation will be difficult to monitor because of the long time period over which measurements are needed. Traditional systems are generally sustainable and therefore there should be a concerted effort to build on such systems or at least identify them, monitor them for implementation particularly where traditional systems have been perturbed beyond sustainability.

11. Institutional Considerations

In the Asian region, the issues are mostly associated with small farm enterprises and therefore integrated farming. Five key requirements are essential if new research programmes are to be accepted and implemented to increase the value of livestock production. These include:

- Commitment to inter-disciplinary research within integrated systems.
- Consideration of pollution control and recycling of nutrients as areas for study.
- Formulation of research programmes that are farm oriented and participatory, not laboratory oriented and take into consideration post primary production components.
- Establishment of effective, both ways, information transfer with farmers and scientists.
- Determination of effective means of monitoring the potential sustainability of farming systems.

11.1 Basic /Institutional research

There are well founded arguments that have established that future improvements in animal production require research aimed at understanding to develop the more fundamental aspects of animal production. Currently, biotechnology, in particular, recombinant -DNA technology has shown some promise for future application. There are good arguments for the development of such studies, particularly where the boundaries for research are established according to the needs or the peculiarities of developing countries and therefore are unlikely to receive attention in the industrialised world. However, the nature of such research requires extensive laboratory facilities and it is undoubtedly expensive relative to “on farm” or applied level research (Leng, 1990). There are a large number of possibilities for the direction of such research but, the pay off in relation to increased sustainability, profitability and productivity of animal farming will remain a major gamble. However, it would be inappropriate not to outline in this consultation some areas of research that might apply to ruminants fed poor quality forages and pigs and poultry fed non-conventional feeds.

Within the area of ruminant nutrition, the most appropriate areas for understanding and manipulation, centre on improving feed utilisation through manipulation of the rumen microbes or the feed. A brief summary of these is given below.

- Enhancement of microbial-fermentative digestion of cellulosic biomass.
- Enhancement of microbial growth efficiency and improving microbial flow or protein relative to energy from the rumen. This includes control of protozoa using feed additives and/or immunisation techniques.
- Prevention of protein degradation by rumen microbes; development of novel methods of protection of protein in plant materials - such as the use of immunisation techniques to inhibit proteolysis.
- Detoxification of anti nutritional factors in feeds by the rumen microbes or by treatment of plant material, or manipulation of the plant, and
- Screening of plants for high protein yields and secondary plant compounds that promote rumen bypass of the protein.

For pigs and poultry, again the major areas for manipulation are these that alter the non-conventional feeds to support higher feed conversion efficiencies and include :

- Simple methods to detoxify a range of seeds particularly from trees and forages.
- Simple methods to remove secondary plant compounds from agro industrial byproducts such as gossypol in cottonseed meal, and
- Treatment of high fibre protein meals to lower the fibre content and increased incorporation rates into non-conventional feeds.
- Simple methods to prevent aflatoxin problems associated with protein meals (e.g. binding with bentonite).

12. Overview

In most countries of Asia the major constraints to ruminant productive are associated with slow growth which results in delayed maturity and long intercalving intervals. Large improvements in production result from research that establishes feeding strategies that increase growth rate lower the age of puberty and ensure that a mature cow has one calf annually. For Asia non-conventional feeds for pigs and poultry must be research but the overriding issues are those that pertain to the production of all animals within the farming systems.

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