# Goat Production and Research in the Tropics

**Proceedings of a workshop held at the University of Queensland, Brisbane, Australia, 6–8 February 1984**

*Editor:* **J.W. Copland**

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The Australian Centre for International Agricultural Research (ACIAR) was established in June, 1982 by an Act of the Australian Parliament. Its mandate is to help identify agricultural problems in developing countries and to commission collaborative research between Australian and developing country researchers in fields where Australia has a special research competence.

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# Foreword

ACIAR was established to help identify priority problems requiring agricultural research in developing countries and to support collaboration with Australian research institutions who have a demonstrated capacity to assist in their resolution. Workshops are one of the primary avenues for identifying where ACIAR might most effectively implement this mandate.

The aims of the workshop Goat Production and Research in the Tropics were: firstly, to identify the major problems facing the goat industries in developing countries; secondly, to understand Australia's comparative advantage in goat research; and finally, to identify potential topics, operating institutions and scientists around which ACIAR might develop collaborative research proposals.

Data on goats are not as good as they are for other animals. In the mid-1960s FAO estimated that there were 380 million goats in the world. The figure may currently be close to 500 million. There were about 28 cattle and 28 sheep for every 10 goats.

The Far East contains about 25% of the world's goat population and Africa has about 30%. Hence, the countries represented at the workshop together comprised more than 50% of the world's goat population. The Far East region has the greatest animal pressure on grazing land; 0.3 ha/animal unit compared with 2.9 for the Near East and 4.7 in Africa. This suggests that research on management and nutrition should have high payoffs, especially in the Far East.

In Australia, goats are kept for milk, skin, cashmere, and mohair production and are managed on individual holdings. In South and Southeast Asia they are primarily kept for meat and milk purposes and have a particular significance for subsistence farmers and for landless households. They often make effective use of land and vegetation that is unfit for cropping and generally do so more efficiently than sheep and cattle. Hence, research on goats can have considerable equity as well as productivity implications in developing countries. However, goats often roam and browse on land that does not belong to owners or herders. This fact can condition the type of Australian research that will be relevant to goat herders or owners in developing countries, especially in fields such as nutrition and management. Because of the complex nature of goat rearing and management in developing countries, it would seem desirable not only to consider projects that have a biological focus but also those having a socioeconomic component to properly understand the constraints that operate on goat producers.

Conclusions reached at the workshop have been valuable in developing ACIAR's collaborative research activities with goat researchers in the developing world. ACIAR would like to thank Dr Barry Norton and his colleagues at the University of Queensland for making the arrangements for the conduct of the workshop. It is obvious that they set the stage for a most useful interaction amongst goat scientists. We would also like to thank Jack Mertin and Janet Lawrence for helping with the editing of the proceedings.

**J.G. Ryan,** *Deputy Director*
Australian Centre for International
Agricultural Research

# Priorities for Goat Research in the Tropics: Workshop Recommendations

J.W. Copland*

DURING the workshop it became clear that the research needs of different countries in the region varied in such factors as the relative economic importance of goats, land use and management practices, and the countries' traditional experiences with goats. Variation occurs within and between countries so the following summary is presented on a country-by-country basis as discussed on the final day.

In general, all participants agreed that production from goats and their utilisation was low in all countries represented at the workshop, due mainly to high mortality, slow growth, poor production, inefficient marketing systems and low availability of capital. It was considered that access to a resource group of technical and development research personnel would be of great value to the various countries of Southeast Asia and the Pacific. In some cases, technical surveys were needed to identify component research priorities but emphasis should be given to practically oriented research consisting of both technical and sociological inputs which would lead to a package of activities relevant to the village environment. Successful packages could be expected to attract increased development support. The background papers cover in detail many of the research needs while specific priorities for research and other attention were identified after discussion as follows:

## Indonesia

Goats contribute an important proportion (38%) to the total ruminant population. Twenty percent of farmers keep goats for a range of purposes: meat, milk, hide production, manure, crop residue utilisation, family employment and such sociological factors as financial security and ceremonial uses.

The program of priorities for improvement consists of research on nutrition, breeding, disease control, management and marketing. Significant aspects are:

### Nutrition

There is insufficient quantity, quality, distribution and availability of feedstuffs to meet nutritional requirements. Quantity is inadequate due to seasonal variations, cropping patterns and insufficient land for feed production. Plant and crop residues are of poor quality and the supply and distribution systems are unstable.

### Breeding

Low inherent productivity is seen to be due to the lack of sound and continuous selection programs for goat products and a lack of knowledge of the best types of available animals to use.

### Disease

In the areas where goats are important there is little knowledge of the distribution prevalence and incidence of disease, and a lack of expertise in methods of epidemiological investigation and control at both the village and regional levels.

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* Research Program Coordinator, ACIAR, G.P.O. Box 1571, Canberra A.C.T. 2601, Australia.

### Management and Marketing

There is little understanding of marketing mechanisms, price information, trading and market structures. In addition, there is a need for information on aspects of land use, climate interactions, and of the farmers' needs and perceptions in relation to their goat-raising enterprises. Also, the role and potential of goat production in the total farming system requires clarification.

## Malaysia

The needs for goat research in Malaysia have their foundation in the special significance of goats in the rural and village communities, and their role in producing meat, milk and other products.

Goats serve as a source of supplementary income to farmers who generally keep them as a reservoir of ready cash. They serve an investment function and also confer on their owner social standing within the community. On a production basis, goats are kept primarily for meat which brings amongst the highest prices. Milk is generally unimportant for human nutrition but is clearly a prime factor of maternal ability in does.

Breed improvement is an important goal of government policy and efforts are aimed at gaining knowledge on the potential benefits of introduced types in relation to local goats, for increased size and fecundity.

There is a small knowledge base which would allow the adoption of relevant technological procedures and emphasis is placed on the need for the design of suitable production systems at the farmer level. Such systems would include the choice of breeds, efficient feeds and by-product utilisation, management practices, alleviation of reproductive problems and the identification of health and disease problems.

A research priority exists for investigations with a farming systems perspective for integrating goat raising with plantation crops which would involve the consideration of both production and economic aspects.

## Philippines

The vast majority of goats are raised by small farmers or people who own no land. As these people are not able to develop the industry nor to stimulate improved production and living standards, government policy is directed to research priorities which emphasise: (a) improved breeding, nutrition, health, housing and management; (b) development and evaluation of technology packages at the farmer level; (c) integration of goat raising with use of crops and marginal lands; (d) improvement of processing goat products; and (e) studies of socioeconomic aspects of goat raising and marketing.

To service these general needs, six project areas have been identified. They are: breeding; herd management, nutrition and health; product utilisation and marketing; socioeconomic studies; on-farm trials; and goat farm modular system.

## Thailand

The major area for goat production is southern Thailand, especially in the Muslim areas of the border regions. Priorities for research into goat production in the area involve: (a) identification of present productivity and management constraints at village level; (b) intensive breeding at a central site of improved goats; (c) evaluation of breeding and production programs at the village level; and (d) distribution of improved or crossbred animals to village producers.

## Solomon Islands

It is planned to develop goat production in the Solomons. However, several problems related to research were evident: first, the lack of adequate skilled manpower in goat management and production techniques; second, the problem of internal parasites which will require a cost-effective control program. Studies will also be needed on the economics of grazing goats in association with other agricultural activities, such as coconut production, and evaluation of the impact of goats on tropical environments such as atolls.

## Fiji

Although most goat raising is done by small farmers, commercial farms for grazing goats exist. The principal product is meat and a successful breeding project has been carried out based on crossbreeding with Anglo-Nubians.

Priority problems requiring a research input range from low productivity due to nutritional problems to poor management and severe internal parasite infections.

Management packages are required for about five different typical situations. The main technical research problems are disease, especially internal parasites; early mortality; improved nutritional management; housing and yard designs for commercial farms and marketing and management systems.

# The Problems of Goat Production in Malaysia

**Mohd Khusahry Mohd Yusuff***

In the Malaysian economy, agriculture contributes 23% to the total foreign exchange earnings and provides employment to 40% of the total workforce. Within the agriculture sector rubber and palm oil predominate and account for 50% of the country's gross income. In both commodities Malaysia's share of world exports has exceeded 45 and 60% respectively. In contrast, livestock contributes only 11% of the gross value of agricultural output or about 3.5% of the Gross Domestic Product.

The levels of sufficiency for the various animal products are estimated at 51, 18 and 6% for beef, goat meat and mutton, milk and dairy products, respectively. As a remedial solution the country has to rely on imports to meet the growing demand for protein. In 1980, Malaysia's import bill of livestock products amounted to MR 480 million (MR = Malaysian Ringgit; 2.2 MR = $1US at time of writing). Thus, there is a need to devise suitable systems of animal production which are more effective and efficient than those presently practiced, for increased production of animal protein is important.

In recent years, more attention and interest has focused on the development of the goat industry in Malaysia. This paper attempts to outline the current status of the goat industry in Malaysia, problems and constraints faced in goat production, current research findings and future prospects and strategies for continued development of the goat sector in Malaysia.

## Status of the Industry

### Economic Significance

The goat industry in Malaysia is characterised predominantly by small backyard type of operations. Goats are mainly kept for meat production although milk, mainly fresh, is sometimes consumed in estates and urban fringe areas. In 1980, its estimated contribution to the overall gross turnover of animal products was 0.4% amounting to MR 5.5 million. Its meat is preferred by about 12% of the population with a per capita consumption of about 3.4 kg. The present local production level is about 800 metric tonnes, approximately 5% of a total 16 425 metric tonnes, and overall supply of goat meat has in fact declined at a rate of 2.7% annually (Devendra 1983).

It is therefore not surprising that the supply of goat meat is always short of the market demand. From 1976 to 1981 self-sufficiency levels for goat meat and mutton have fluctuated with levels of 18% in 1976, 25% in 1978 and 18% in 1980. With the government's projected demand for goat meat and mutton to increase from 5648 metric tonnes in 1980 to 11 107 metric tonnes in the year 2000, greater dependence on imports is envisaged if efforts to increase production are not intensified. Already the value of import for this commodity has doubled during the last 10 years from MR 5605 million in 1970 to MR 11 911 million in 1981. Inevitably this has led to greater hikes in prices of local goat meat, despite imported mutton being 20–30% cheaper than local meat. In 1972 the average price per kilogram of local goat meat was MR 4.55 while in 1982 the value was MR 9.40/kg. During the same period, the price of imported mutton has increased from MR 3.13 to MR 7.34.

### Population

The population of goats in Malaysia is about 348 746 animals. Out of the total about 83.6% are found in Peninsular Malaysia, 5.9% in Sarawak and 5.5% in Sabah. As a percentage of total ruminants, goats are important next to cattle, accounting for 31.3% of the total ruminant population. Goats represent the major ruminant species kept in Sarawak and are second largest in number in Malaysian Peninsular.

In Peninsular Malaysia, concentration of goats is highest in the northwestern states (48%) with 30% of the population found in the southern states and the rest (22%) found in the east coast. Distribution in Peninsular Malaysia is shown in Fig. 1. Distribution patterns show high concentrations of goat populations in the poorer states of the country, which invariably means that goat keeping is traditionally in the hands of the

* Malaysian Agricultural Research and Development Institute, Kuala Lumpur, Malaysia.

rural poor and small farmers, and thus associated with various cropping patterns. Thus goats form an integral part of the overall farming activity of a majority of the farmers and are kept as a source of supplementary income.

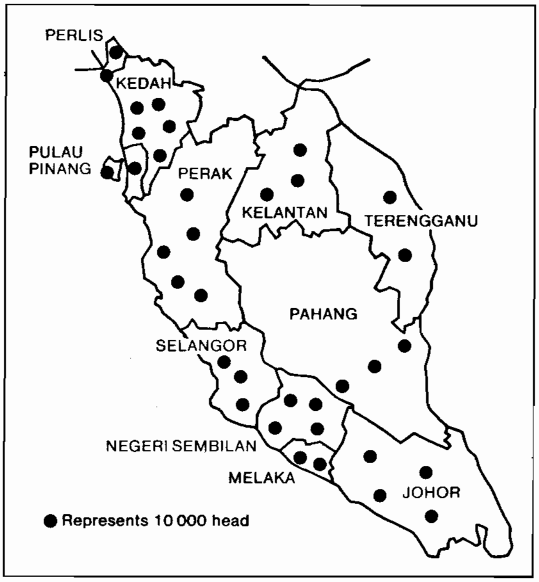


**Fig. 1.** Distribution of goats in the various states in Peninsular Malaysia, 1982; from Devendra 1983.

The livestock census records of the years 1948–80, as shown in Fig. 2, illustrate some alarming trends. During the 1950s and early 1960s there was a steady increase in population. Estimated annual growth rate up to 1970 was 2.3% (Devendra 1983). But from 1970 onwards a 0.9% decrease in growth rate was seen. Overall growth rate for 32 years was approximately 1.2%. The relationship between population growth and extraction rate is also illustrated in Fig. 2. Rate of extraction was highest during the 1950s but has since shown a steady decline. Possible reasons for the slow growth rate are: 1) increasing slaughter rate especially

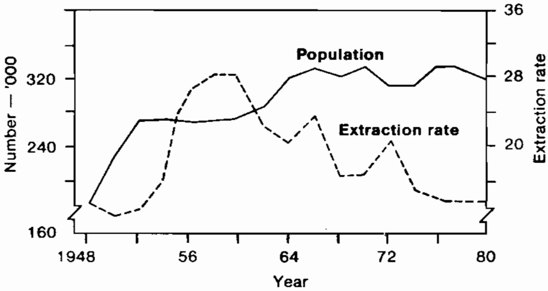


**Fig. 2.** Development of the goat population and extraction rate in West Malaysia from 1948 to 1980 (source: Livestock Statistics, Ministry of Agriculture).

of females; 2) increased demand for meat; 3) inadequate breeding replacements; 4) lack of legislation against uncontrolled slaughter; 5) relatively high kid mortality (Devendra 1983).

## Breeds of Goats

The goat population comprises three types of animals: 1) the indigenous Kambing Kacang, 2) the local or crossbred goats of various grades, and 3) the exotic purebreds.

The indigenous Kacang has been described as a small and compact type of goat with relatively poor growth rates (40–50g/day) but renowned for its prolificacy and fecundity traits. Average mature weights vary from 20 to 25 kg. This breed is adapted to a wide range of management conditions and feeding regimes. It is usually black with patches of white in the middle of the body or underside of the belly. Several reports have indicated that colour variation exists in this breed ranging from black to white with predominant colour variations of either black and white or black and brown making up about 60–70% of the population (Nishida et al, 1975; Devendra 1983). The development of the breed hitherto has been left to chance, resulting in a large variation found in its performance.

The crossbred goats are of various grades and are genetically heterogeneous animals. Numerically these 'local' animals are more important than the Kacang. The heterogeneity of these animals is associated with the degree of exotic blood in the cross as a result of indiscriminate crossing and upgrading. Although not distinctly identifiable, these grades of animals are somewhat stabilised and their distinctiveness in terms of colour patterns and performance are more associated with being naturally selected to be adaptable to a particular region or niche rather than due to any conscious effort by relevant authorities. Growth rates of these groups of animals are better than the Kacang (70–80 g/day) with mature body weights ranging from 30 to 40 kg.

Various exotic purebreds have been introduced into Malaysia for purposes of crossbreeding and upgrading. These include the Anglo–Nubian, Saanen, British Alpine, Toggenburg and Jumnapari which were introduced as early as 1950 (Keeping 1951). Exotic purebreds are usually reared at government farms and institutes. Performance and adaptation of the breeds have been variable. Improved animals have been extensively distributed all over the country for breeding purposes. It is difficult to measure the impact of this dissemination of exotic animals as no proper follow-up and monitoring has been done at the various distribution points. Other important breeds that have been imported and widely distributed include the Indonesian Etawah and feral goats of Australia.

## The Goat Enterprise

As mentioned, goat rearing in Malaysia is primarily a small farmer enterprise. They are kept as a source of supplementary income and reared in a subsistence manner. In a survey conducted in 1979, it was found that goat meat production for home consumption is of minor importance to traditional goat farmers (Peters et al. 1979). Goats were kept principally for meeting short-term cash requirements. Goats are kept by all ethnic groups in the country. In West Malaysia, goats are kept by the low-income economic units which comprise smallholders, landless estate workers and landless non-estate workers. Several surveys have been conducted to determine the relationship between ownership and herd size and the interrelationships between systems and management and feed availability within these low-income economic units (Peters et al. 1979; Abdul Rahman 1980a).

In general, the number of animals kept is less than five although there are medium-size flocks. Average farm size is usually less than 1 ha. Often goats are integrated with other small-scale farming activities such as paddy, rubber, oil palm, coconut and orchards. Characteristically this means that goats are reared on a low-input system, do not demand extensive labor inputs of both time and intensity, and are kept in traditional style. Thus farmers are oblivious and insensitive to improved husbandry techniques and other technological advancement, with no incentives to increase herd size or improve scale of operations.

The pattern of goat keeping varies according to location, and thus the system of management adopted is more a function of the social acceptance of the community to goats, available land, human resources and financial status of owners as well as feed availability. This means that the system of management adopted is not a result of any economic consideration but rather, in most cases, a consequence of the environment. Several reports have been written on the various systems of management (Abdul Rahman 1980a; Rajendran and Mohna 1983). In general, the most predominant and popular system is the extensive system of management, as this requires minimum labour input and animals are usually allowed to graze on any surrounding land that is available. The intensive system of management, although uncommon, is related to the degree of industrial and economic development that has occurred within the region. In such a situation the intensive system of management is the norm, because idle land available for grazing is in short supply. Tethering is popular among those farmers keeping one or two goats, although it is more tedious and labour-intensive.

Improved grasses are seldom grown for goat keeping. This in part is due to the competitiveness of land utilisation, as income from crops is normally higher and thus it is uneconomical to plant grass for feeding goats. It has been estimated that the natural feed resources available to goat farmers do not seriously restrict goat production (Peters et al. 1979). The type of feed resources utilised by goats is the mixed natural vegetation on roadside verges, public grounds, undergrowth of plantations, crop by-products and leaves of various bushes.

Housing among goat farmers is also a function of herd size and system of management. This is because the initial investment for constructing a shed comes close to the monthly income of rural households (Peters et al. 1979). However, cost of sheds can also be minimal as evidenced in practices where goats are kept under owners' houses or in cases where owner and goats only meet at time of sale.

Designs for housing of goats have been adequately described (Abdul Rahman 1980b; Devendra 1983). In general, two main designs are predominant, viz. the ground-level type and the stilted type. No special reason can be given for this difference in housing design, except for the fact that this is more related to the farmers' architectural fancy and their level of income. However, ground-level designs are more predominant in the northern states of Malaysia with the stilted design found more in other parts of the country. Housing of goats by farmers normally does not take into consideration such factors as separation units for kids, sexes, pregnant does, health reasons, etc. Thus, in most cases, houses assume the size of large pens with no distinct separation and with crude feeding troughs.

Goats owned by these small farmers are usually of mixed origin with traces of past introduced exotic inheritances expressed in varying degrees both in their physical appearance and their performance. These usually compact, small-sized animals show high reproductive rates, short kidding intervals and high incidences of multiple births. This in part is due to natural selection which will usually favour smaller-sized animals, with the ability to reproduce at a faster rate to ensure species survival in the face of continuous adjustments to changing availability of feed resources.

## Production Problems

The Malaysian agricultural sector is predominantly tree-crop oriented for cash and export purposes. Traditional livestock farming on a large scale is an uneconomic activity compared to other agricultural activities. Therefore, because of the comparatively poor financial returns from livestock farming in the Malaysian environment, which is characterised by high cost of initial inputs and long pay-back periods, livestock development programs have always been implemented as an integral part of other agricultural activities. Ruminant industry development has largely centred around cattle with little or no emphasis given to goats or sheep, and more than 80% of the budget for livestock development is allocated to cattle. Thus, the development of the goat industry has been left much to chance and has minimal collective thrust from the relevant agencies.

With this in mind, the problems of the goat industry can be divided into the following categories:

## Production Units

Almost 95% of goats reared in the country are in the hands of the small farmers. However, the majority of farmers lack the managerial skill to operate a livestock enterprise efficiently. They are ignorant of the efficient methods of goat keeping, in particular goat breeding, feeding, management, and disease problems, and in general, economics of goat production as a whole.

Plots of land in most cases are small and uneconomic for profitable goat farming. Such a situation is more related to the social aspects of land inheritance prevalent especially among Malay farmers. Ancestral inheritance practiced over generations has led to individual farmers possessing fragmented pieces of land which in most cases are not large enough to support any agricultural activity economically. Tracts of land located by Government as grazing reserves are in most cases useless for their intended purposes. They are often badly sited and remote from the animals that they are intended to serve. Thus, they seldom carry any pasture of value and they are practically never maintained. Their value seems to be more as holding areas for stock during the rice-growing seasons when grazing in paddy fields is not possible.

The animals kept by the farmers, besides being small in number, present other problems. Due to traditional methods of rearing, a large proportion are of poor quality and unproductive. This is partly due to the unavailability of good quality stock for distribution by the relevant extension and development agencies. Further, such practices as slaughtering the largest males in the flock for festivities or sale, in the long run, lead to a degeneration in quality of the stock that is kept. Effects of inbreeding should not be precluded as causal reasons for the prevalent unproductiveness. Farmers seldom change their bucks for mating purposes. Even if they do, such as in the event of deaths of bucks, in most cases bucks bought from nearby locations are related, since farming communities within a particular location allow their animals to graze and intermix freely, leading to higher genetic relationships between flocks.

As a result of the above, efforts to increase flock size are usually thwarted by high kid mortality rates. This is a consequence of several interrelated factors such as poor milking and mothering abilities of the does, mismanagement, poor housing facilities and increased occurrences of health and disease problems. A survey done in 1979 reported the close ratio of female to young stock found in several goat farms in Peninsular Malaysia (Peters et al. 1979).

Labour presents a problem in most agricultural activities. The situation is not dissimilar in goat farming communities. Considering the state of the industry at the moment it is hardly surprising to see useful labour moving over to the urban sectors looking for better quality jobs and financial returns. Traditional goat farming among the rural sector therefore, in most cases, tends to be in the hands of older people who do not have the motivation to change. Old age and other interrelated factors often force farmers to close off their 'businesses', since none are left capable enough to continue.

Given the above considerations, it can be readily seen that efforts to increase levels of goat production will be faced with several constraints. This is because 1) utilisation of improved breeds to increase productivity of local stock cannot be effectively carried out if systems of breeding in an organised manner cannot be conducted; 2) due to the small size of farm plots, systematic animal production can rarely be practiced since profit-loss incentives hold no merit. Thus, practices like planting of improved pasture, improved systems of management and health measures are rarely adopted; 3) subsequently, since the enterprise will always remain a small, subsistence activity, it will mean that unless the farmer takes some very drastic step to change his lifestyle, which he seldom even thinks about or has the financial ability to do, his approach to goat farming will continue to remain small and stagnant.

## Supportive Mechanisms

Aspects to be included under this heading include the mechanism to provide stock, credit, infrastructure, technology and production inputs. Much needs to be done before actual patterning of the various aspects of goat production can be worked out in detail. Perhaps the single item that deserves most elaboration is the dissemination of technology to target farmers. General pertinent factors have been reviewed and identified. These include lack of interagency cooperation and linkages, lack of communication between research workers and extension workers, lack of effective extension services and a general lack of trained personnel to provide effective services to the farmers (Mohd Eusof 1983). While it may be construed that technology may not be available for the various aspects of the industry, effective linkage and sound feedback mechanisms will help in identifying and resolving some of the major problems affecting production.

### Marketing Infrastructure

This is perhaps the most neglected aspect of the industry. The marketing structure for goat production is primarily for the sale of slaughter stock, in which sales are usually transacted on the hoof. The marketing of breeding or store stock is of minor importance, and no organised goat market infrastructure exists in Malaysia. Sales are made on an irregular basis, by the individual farmers, directly to the village butcher for slaughter and sale of meat from premises that are frequently unhygienic. The only advantage of the system is that the producer invariably receives cash, the full value of his stock at the time of sale, but obviously since the number of buyers is limited, monopoly exists and the farmer seldom gets competitive prices for his stock.

## Production Research

In general terms, research on goats, and for all livestock species for that matter, must be organised to fulfill the following broad guidelines: 1) to develop and introduce technology which will reduce the constraints preventing high goat productivity; 2) to assemble and disseminate information on matters concerning goat production to appropriate extension and development agencies. This must be viewed and aimed towards resolving two clear-cut strategies: to increase goat production to meet increasing demands and to raise the standard of living of goat farmers.

Goat research in Malaysia can be divided into the following categories:

### Breed Improvement

The principal breeding goal for goat improvement is for increased meat production. Emphasis should, therefore, be attached to important meat production traits, such as early growth rate, prolificacy, maternal ability, meatiness and to a certain degree carcass quality.

Breeding research must have properly defined objectives, breeding plans and definitive breeds, and the whole program must be coordinated and synchronised to provide a continuous update for extension and development agencies.

Breeding studies should not only be geared towards provision of data on productivity performances of various breed improvement programs, but more importantly be able to provide animals so that implementation agencies can be called upon to disseminate the recommended 'breeds' or strains for subsequent development work, such as the introduction of improved breeds and the subsequent performance of animals at the village level.

There is a need to characterise the predominant breeds of goats available in the country. Agreement from all participating breeders of the various agencies on this matter is important. This is because although the Kacang goat is the breed indigenous to Malaysia, its numerical importance is gradually diminishing. Observations have shown that the Kacang as earlier defined can seldom be found in areas where goat development and improvement agencies have penetrated. Mating and distribution of goats from various disorganised improvement programs in the past have contributed to this situation, to the extent that the indigenous Kacang goats are now normally found in the very outskirts of towns and villages, out of the reach of development agencies. The implication of such a situation is twofold: while it is necessary to work on purebreds for true crossbreeding work, if efforts are not made to save this breed from further 'contamination,' research results may prove difficult to implement. Secondly, considering the large pool of localised crossbred animals existing within the country, efforts should be made to clearly identify the various predominant strains so that a program for development can also be initiated on these somewhat localised and stabilised populations.

Goat breeding research conducted in Malaysia up to now has been summarised in Tables 1–3. From these tables and review of other pertinent research, several short-term conclusions can be arrived at:

1. designated growth traits such as birth, weaning and yearling weights of the local Kacang goats can be improved by the introduction of exotic breeds of either the Anglo–Nubian, Saanen, Jamnapari or Etawah origins. While this may be so, the magnitude of variation reported does not identify any breed as the 'best' improver breed although there are tendencies to indicate that the Anglo–Nubian may be the most suitable. However, it should be mentioned here that more information should be gathered before any recommendations can be made. One of the areas which previously has not been reported in detail is the extent of hybrid vigour in the $F_1$ generation and its a subsequent performance in the $F_2$ and following generations. The average performance of stabilised flocks of a particular cross is an important evaluation

**Table 1.** Summary of body weights for various breeds of goats.

| Breed or breed-cross | Weight (kg) Birth | 3 mo | 6 mo | 9 mo | 12 mo | Source |
|---|---|---|---|---|---|---|
| Anglo–Nubian | 2.66 | 8.18 | 11.77 | 12.7 | 15.93 | |
| British Alpine | 2.68 | 5.97 | 11.69 | 14.57 | 16.47 | |
| Saanen | 2.62 | 10.09 | 12.94 | 18.36 | 20.73 | |
| Feral | 2.39 | 8.02 | 10.49 | 13.57 | 16.31 | Mohd |
| Saanen × KK | 2.03 | 9.83 | 13.76 | 16.94 | 19.03 | Khusahry 1983. |
| Anglo–Nubian × KK | 2.09 | 6.52 | 10.36 | 13.01 | 16.49 | |
| Kacang (K) | 1.56 | 5.89 | 7.64 | 9.08 | 10.59 | |
| Jamnapari × K | 2.80 | 13.80 | 24.10 | — | 40.00 | |
| Anglo–Nubian × K | 2.5 | 13.20 | 20.00 | — | 35.60 | |
| Kacang | 1.3 | — | — | — | — | Devendra 1983 |
| Etawah × K | 2.8 | — | — | — | — | |

**Table 2.** Average daily milk yields from various breeds of goats (Mohd Khusahry 1983).

| Breed | Av. daily yield (kg) Mo 1 | Mo 2 | Mo 3 | Mo 4 | Mo 5 | Mo 6 | Estimated 180-day yield |
|---|---|---|---|---|---|---|---|
| Exotic purebreds* | 0.77 | 0.57 | 0.46 | 0.44 | 0.33 | 0.17 | 92.30 |
| Feral | 0.69 | 0.25 | 0.15 | 0.10 | 0.09 | 0.08 | 40.35 |
| Kacang | 0.26 | 0.21 | 0.18 | 0.14 | 0.14 | 0.12 | 31.50 |
| Local crosses | 0.19 | 0.18 | 0.13 | 0.22 | 0.08 | 0.07 | 25.80 |

* Saanen, Anglo–Nubian and British Alpine.

**Table 3.** Milk yield and lactation lengths of Kacang and Kacang Crossbred goats (Devendra 1983).

| Parameter | Kacang | ½ Anglo-Nubian × Kacang crossbreds | ¾ Anglo-Nubian × Kacang crossbreds |
|---|---|---|---|
| Yield (kg) | 89.5 | 295.5 | 236.8 |
| Lactation length (days) | 126 | 235 | 207 |
| Yield/day (kg) | 0.7 | 1.3 | 1.1 |

criterion to determine its suitability. It should be mentioned that no reports are in existence about the performance of these various grades of animals at the village level. Most data are from government stations or farms. The small numbers of animals kept is reflected in the general lack of reports on genetic parameters or important economic traits. However, repeatability of milk yield and birth weights of goats has been reported (Anuwar bin Mahmud and Devendra 1966, 1970).

2. There does not seem to be a great depressing effect on the reproductive performance of the resulting crossbreds with the introduction of these large purebreds. Although litter size is smaller than that of the Kacang goats, the magnitude of this difference is not large enough to matter.

3. Milk production is the least investigated trait in goats. Very limited reports are available on the Kacang, the exotics, or their crossbreds. In general, Kacang goats have low milk production and their lactations lack persistency, as about 65% of the flock dry off by the fifth month of lactation (Mohd Khusahry 1978). Average monthly yields obtained range from 0.28 kg in the first month to 0.12 kg in the sixth month. The performance of the purebred exotics so far has not shown their true potential, compared with overseas reports. Interrelationship between adaptation and milk production may be a reason for the poor production.

It has been reported that studies utilising the Kacang goats as base female stock in crossbreeding with exotic sires at the $F_1$ level will need milk supplementation in order to ensure that maximum expression of genetic potential of the crossbred is to be seen (Mohd Khusahry et al. 1981). With milk supplementation, phenotypic correlation between dam's milk and pre-weaning gain is negligible (–0.02).

4. Goats of pure exotic origins, imported into this country from temperate regions, should be intensively managed to buffer them from expected environmental heat stress. A study conducted to observe changes in three parameters namely, body temperature, pulse rate and respiration rate to high environmental temperatures showed drastic three-fold increases in respiration rates after exposure to about 6 hours of no shade (Table 4). Further, depressed performance of purebred farm-born animals was observed when compared to performance of imported animals (Table 5).

### Feed

Feed availability in organised goat production may be one of the most important single limiting factors affecting total productivity. Due to land limitations it may not be possible to plant grasses of the improved type to enhance goat production. However, this problem can be alleviated by utilising available agricultural by-products from various processes of the agricultural industry estimated to be about 5 million metric tonnes annually. Analyses of chemical and nutrient contents of available by-products have been adequately summarised (Devendra 1979). Work has also been initiated to determine feeding levels of some of the more important by-products (Devendra 1983). Subsequent to this, continuing research has been conducted to determine the practical application of some of these by-products at the village levels. Among these, the by-products from the palm oil industry have received much attention. Indications are that these by-products such as palm kernel cake, palm oil sludge and palm pressed fibre can be of good feeding value whether fed singly (Abdul Rahman and Mohd Khusahry 1984) or in combination (Mohd Jaafar 1984; Kamal Hizat et al. 1984) or as a component of a concentrate diet (Abdul Rahman and Mohd Khusahry, 1983) in rations for goats. Other by-products that have been tested successfully include coconut cake, rice straw, cocoa pods, cassava chips, rice bran and fish meal (Abdul Rahman and Mohd Khusahry 1983; Mohd Jaafar 1983; Abdul Rahman 1984; Kamal Hizat et al. 1984).

Besides agricultural by-products, tree leaf feeding can be an important source of feed for small farmers. *Leucaena leucocephala* has been proven to be an excellent source of feed for cattle. Work on feeding of *Leucaena* to goats has been conducted to determine its nutritive value to goats (Devendra 1983) and the practicality of its usage at the village level (Izaham and Hassan 1983).

**Table 4.** Means for body temperatures, pulse rates and respiration rates — by breed (Mohd Khusahry 1979).

| | | *Shade* | | *No Shade* | |
|---|---|---|---|---|---|
| | | *Time of recording* | | *Time of recording* | |
| *Breed* | *Parameter observed* | *Morning* | *Afternoon* | *Morning* | *Afternoon* |
| Anglo–Nubian | Body temp.°C | 38.0 | 39.7 | 38.2 | 40.1 |
| | Pulse rate/min | 73.7 | 97.3 | 75.4 | 90.8 |
| | Resp. rate/min | 21.6 | 40.2 | 24.2 | 95.7 |
| British Alpine | Body temp.°C | 38.2 | 39.6 | 38.5 | 40.1 |
| | Pulse rate/min | 69.2 | 95.8 | 67.1 | 87.8 |
| | Resp. rate/min | 42.1 | 46.9 | 32.2 | 110.1 |
| Saanen | Body temp.°C | 38.2 | 39.7 | 38.3 | 40.0 |
| | Pulse rate/min | 65.7 | 89.1 | 67.6 | 86.2 |
| | Resp. rate/min | 27.3 | 50.4 | 36.9 | 119.7 |

**Table 5.** Comparative body weights of imported and farm bred exotic breeds (kg).

| | *Imported* | | *Farm bred* | |
|---|---|---|---|---|
| | *15 mo.* | *18 mo.* | *15 mo.* | *18 mo.* |
| Anglo–Nubian | 26.79 | 29.6 | 18.7 | 23.0 |
| British Alpine | 28.04 | 30.31 | 21.6 | 24.63 |
| Saanen | 32.35 | 35.90 | 23.93 | 26.22 |
| Feral | 34.18 | 36.22 | 18.05 | 19.4 |

Source: Mohd Khusahry 1983b.

On the subject of fodder and improved pasture feed for goats, little or no work has been done to increase its usage at the village level. However, adequate characterisation and evaluation of the most promising species has been done (Wong et al. 1982). More recently, work has been done to evaluate several species at various specific areas for dairy cattle production (Izaham and Hassan 1983).

In general, although increased improved feed resources given to goats may help to enhance productivity, this should be viewed in line with the available local feed resources at a particular village location. This means efforts should be made to identify various prevalent feed resources available in a particular region suitable for goat feeding and to combine these particular feeds in the most efficient manner such as to stimulate their increased utilisation. In this manner, results obtained from trials can have direct practical application for farmers' consumption.

### Management

Systems of management practised by farmers for goat rearing are many and varied. These have ranged from the nomadic to the intensive type. The practicality of a system for a particular location as practised by farmers varies with factors that have been mentioned earlier, although little emphasis is given to economic considerations. In general, for organised goat farming, the most appropriate system for a location must take into consideration time and labour availability, existing feed resources, the type of animals used and the overall economics of such a system. Experiences with studies on local animals of poor growth rate have shown that it is uneconomical to intensively rear these animals even with concentrate supplementation (Mohd Khusahry 1983a). In a separate study at village farm locations goats intensively reared gave better performance than those semi-intensively reared. However, this is further influenced both by the quantity and quality of local feeds available at each location. Single feed supplementation with either palm kernel cake, coconut cake or cattle pellets provided no significant improvement to gains (Abdul Rahman and Mohd Khusahry 1984). From the results of a survey conducted from 151 various goat farms, almost 50% of farmers rear their animals semi-intensively. From their observations, they also noted that highest herd productivity was found in the intensive system, where herd size average was about 6–15 animals and mortality due to diseases the lowest (Peters et al. 1979). Therefore, from the above limited studies it should be clear that under farm conditions no one system is the most suitable for all locations.

### Reproduction

Reproduction appears to be the least of all the problems in goat production. This may be because of the high reproductive rate reported in literature or because no organised breeding was ever initiated at village level. Reported results are normally from experimental farms and environmental factors such as nutrition, disease etc. may not be deciding factors in influencing reproduction. Research presently conducted at government farms tries to determine among other things the status of fertility, causes of reproductive failures both from the male and the female aspects and to adopt techniques of artificial insemination suitable for use under Malaysian conditions. In brief, two studies have been done to evaluate semen characteristics of various goat breeds (Koh 1975; Kamal Hizat 1984). Studies on use of different diluents for goat semen showed that it can be stored by using a 2.9% sodium citrate solution (Koh and Ong 1976) or trilidyl at 5°C (Kamal Hizat 1984).

### Health

In the context of goat production in Malaysia three major causes of death have been identified: kid mortality, mismanagement and disease. On the subject of kid mortality, pre-weaning mortalities appear to have the highest incidence. Predominant cause for pre-weaning deaths appears to be coccidiosis (Mohna 1976). On the other hand low kid weights at birth can reduce their survivability (Mohna and Geneshdeva 1976). Other underlying causes of mortality include general debility, pneumonia, septicaemia, helminthosis, enterotoxaemia and melioidosis (Rajendran and Mohna 1983). Deaths due to massive staphylococcal infections of the foot and resultant septicaemia due to tapeworm infestations (*Moniezia* spp.) under field conditions have also been reported (Rajendran and Mohna 1983).

## Strategy for Development and Research

### Prescribed Objectives

Research outlook, in the long run, should be in line with increasing productivity from goats as well as providing increased additional income for the rural sector. It should also be consistent with the national agricultural policy in which several steps to improve the small farm subsector are outlined. Among them are the development of more land schemes and speeding up of *in situ* development. As part of the *in situ* development program, land consolidation and organised farming will be promoted. As Malaysia is traditionally crop–oriented, it is envisaged that future strategy for goat development should be formulated to coexist simultaneously within the cropping system.

### Target Farming Clientele

Two subsectors are recognised:

1. *Small farm subsector* From a socioeconomic point of view, failure to develop or improve this subsector will hinder poverty eradication as a considerable proportion of the population who earn their

livelihood in this subsector are below the poverty line. Moreover, goat keeping by this subsector even in small numbers will help to increase overall population of goats to meet sufficiency level targets, considering a large number of farmers fall in this category.

2. *Land schemes and estates subsector* Research and development programs for increasing productivity should be directed at this subsector (especially for the land schemes) since land, labour and to a certain extent financial resources are not limiting factors subservient to goat development.

## Methodology for Improvement

1. *Small farm subsector* Several alternatives are available for goat development. The first alternative is to run goats as an integral part of the overall farming system. Since land is a constraint within this subsector, maximising productive potential from a given piece of land appears to hold merit for the small farmers since they almost always are multicrop oriented. Such diversity will ensure that they will not be as vulnerable in the event of fluctuations in prices should they depend on one single commodity. Several reports have been written on the role of goats in various crop-based farming systems. Its potential in single cropped rainfed rice areas (Wong et al. 1979), in coconut–based systems (Sharif et al. 1979), in orchard-based systems (Ooi et al. 1979) have been speculated. While this may be so, research is needed to determine the overall economic significance and suitability of goats under such a system.

Another alternative is cooperative farming. Organised farming through existing cooperatives can go a long way towards solving some of the problems, especially concerning land, faced by goat farmers. With the organisation of production units into an aggregation of farmers under a cooperative, the absorption of modern goat farming methods and to a certain degree organised processing and marketing of farm products can be practised. Organisation in such a manner, if the system is right, will help in improving methods of goat keeping and the overall livelihood of the farmer.

Communal grazing grounds can be put to good use. Several examples have been found in Malaysia where this system was seen to work. However, the most important point is the location of the grazing area. With proper guidance from relevant authorities, farmers can be better arranged and organised in their outlook to goat keeping. Sheds built by individual participating farmers can be located around the fringes of the reserved land.

Utilisation of bris and tin tailing soils could expand the area under pasture. At present there are about 155 000 ha of bris soils and 122 000 ha of tin tailing soils (Kho et al. 1979). Generally, agricultural activities on these soils are low. Therefore, competition for land for alternative purposes is not great. Research has shown that six promising grasses can be grown on bris with dry matter yields ranging from 5.3 to 17.1 t/ha (Wong et al. 1983, in press). Research should be conducted to determine the feasibility of utilisation of these soils for goat farming.

2. *The land schemes and estate subsector* Integration under tree crops has great potential to increase goat production within the country. With large plantings of cocoa, coconuts, oil palm and rubber available there is a need to look into the possibility of integrating goats under these plantation crops. Out of these four perennial crops oil palm and rubber hold the greatest promise for enhancing overall goat productivity. Early studies have shown that goats can be integrated under oil palm and rubber successfully (Abdul Wahid 1981; Tan et al. 1981) but more detailed studies need to be done to determine their overall and total feasibility. It is estimated that 25 to 35% of the country's requirements for goat meat and mutton projected for 1990 can be met if intensive integration is conducted under these two major crops (Mahyuddin and Hutagalung 1978). Further, the overall livestock policy stresses that future strategy for increasing productivity of goats and sheep is via integration, especially under these two crops.

Several studies have been done to estimate feed availability under these crops. Under oil palm between 18–24 months of age, estimated dry matter availability ranged from 6 to 10 ha (Chen and Othman 1983). Dry matter availability, however, was inversely related to the age of the palm. Studies have also been conducted to determine suitability of various ruminants under these crops. Most are of the opinion that ruminants, in general, can be reared without supplementation. Performance improved when supplementation with agricultural by-products was introduced (Jalaludin 1978; Wan Mohamed 1978; Abdullah and Basery 1982). However, evidence is still lacking on detailed studies on feed types, nutrition, reproduction and overall management of ruminants in this manner.

Studies on the feasibility aspects, although not definitive as yet, may shed some light on the possible operations that can be realised for increasing goat productivity. These suggested operations seem more practical under rubber and especially oil palm holdings. The latter is more appropriate because by-products from its processing industry such as palm kernel cake, palm pressed fibre and palm oil sludge are reliable sources of feed whether fed singly or in combination.

**Table 6.** Conceptual outlook for goat development.

| *Nature of farm* | *Input type* | *Breeding structure* | *Production system* |
|---|---|---|---|
| Government | High | Elite herd | Monocrop |
| Land scheme and estate sub-sector | Medium | Intermediate herd | Integration under tree crops with specialised operations |
| Small farm sub-sector | Low | Commercial herd | Farming system<br>Communal grazing ground<br>Farming cooperatives<br>Bris and tintailing soils |

The rationale in establishing fattening operations under both oil palm and rubber stems from the fact that both palm oil mill effluent and effluent from rubber factories can be used as sources of fertiliser (Tan and Pillai 1975; Kanapathy et al. 1981). Already both are used in varying degrees for fertilisation of original crops. Thus, should the need arise, improved pasture can be grown to feed goats kept for this specific function.

It cannot be overemphasised that while these facets of improving goat productivity under tree crops show great potential, nevertheless, intensive research efforts are necessary before speculation becomes reality.

Besides evolving alternative ways for goat keeping, the next single problem that needs to be resolved is breed improvement. Subsequent to that, the genetic improvement strategy for goats could be further enhanced should a systematic approach of improvement through a three-tier system be adopted. While location of the nucleus or elite herd should be placed on a government-controlled farm for easy collection, evaluation and dissemination of optimum genotypes, it is suggested that intermediate farms be chosen at strategic locations all over the country within the confines of the land schemes and estate subsector. In this way supply of improved animals to various interested goat farmers, notably from the small farm subsector, can be easily catered for. Close scrutiny of animal outflow from the elite herd to the lower structured herds and inflow from the other direction will ensure that enough good quality animals are available for selection and subsequent breeding. The conceptual strategy for goat development as discussed is summarised in Table 6.

## Monitoring and Coordination

To ensure the successful implementation of a program of the magnitude mentioned, careful and stringent coordination and monitoring is of paramount importance. Careful consideration should be given to record keeping, and computerisation facilities should be made available. Close cooperation and coordination between various agencies is essential for successfully implementing such a project.

## Marketing

The final link in the chain is to ensure that products so produced will be accorded healthy competitive prices. This is essential to ensure continuous incentive and motivation and to keep the industry dynamic and organised.

## Conclusion

Agricultural development within Malaysia must run according to the government's prescribed objectives. The agricultural sector at present and in the decade to come will continually be dependent on Malaysia's natural resources and tree crop earnings as this has been well established and firmly occupies a predominant position in international and world export markets.

While this may be so, in the continued effort to reduce dependence on imports for meat requirements, efforts must be made to intensify livestock production within the country. In this context, possibilities for increased goat production for meeting target productivity levels must assume new significance. Bearing in mind the competitiveness of land utilisation, the problem must be approached from the concept of evolving stratified levels of production units, those that are commercially viable as opposed to the smallholder type of production.

Research is needed to formulate a system that embraces both levels of production, the technological inputs that are required, the management technique, etc., to ensure successful running of such a scheme. And such success can only be achieved through a coordinated effort of research and implementation.

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# Goat Production in the Philippines

**O.O. Parawan and H.B. Ovalo***

GOATS in Philippine agriculture have generated considerable interest as a potentially profitable component of one-commodity and multi-commodity farming systems. The government, through the Bureau of Animal Husbandry, has investigated small ruminant development as a source of meat and milk, a livelihood activity, and a possible export potential and dollar earner. The goat, a small ruminant with a high reproductive rate and many uses, finds its place best in the present farming systems of the smallholder (1–3 ha) economy in the Philippines.

The goat development program of the country serves to complement the beef and carabeef program of the government by reducing further the reduction of the cattle and carabao breeder bases, which are dually important in the production of draft animal power and as a source of meat and milk.

With the increased interest and enthusiasm in goats among the different farming levels of the country, the commodity may yet be the suitable livestock program for the majority of Filipinos, primarily the smallholder, the landless, and the seasonal/marginal farmers.

## Status of Goat Production

The Bureau of Animal Husbandry (BAI)/Bureau of Agricultural Economics (BAECON) livestock survey 1981, shows that the Philippines has a total goat population of 1.696 million or 0.339 million animal units (5 goats = 1 A.U.), which is about 6.7% of the 5.043 million animal units of ruminants (1 cattle = 1 A.U.; 1 carabao = 1 A.U.). An estimated 99% of the goat population is in the hands of smallholders with an average flock size of 3–5 head. In a livestock production survey in the province of Zamboanga del Sur, which has 4% of the total goat population of the country, the results show that 14% of the province's farmers (lowland and upland) own goats. These statistics indicate a potential to expand the goat program.

Goat population in the different regions ranges from 2% to 18.4% of the total number. The percentage of population for the three main islands is as follows: Luzon 34.2%, Visayas 33.4%, and Mindanao 32.4%. These show a distribution suitable for a nationwide development program for goats.

## Breeds

Except for some upgrades and purebreds, the majority of the goat population in the country is of the Philippine native breed. The local goats were probably introduced from mainland Asia. Chinese traders and Arab traders could have introduced some exotic breeds 600 years ago. Devendra and Burns (1970) draw attention to the similarity between the China goat and the 'Kambing Kacang' or native goats of Malaya, Indonesia, and the Philippines. Similarly Spanish and American colonisers could have brought in a number of different exotic breeds in the 19th century. From 1906 to 1983, the country made a series of importations from Malta, Spain, Mexico, India, USA, Australia, and New Zealand. Predominant in these breeds were Nubian, Saanen, Toggenberg, Alpine, Jamnapari and Black Indian.

The effect of earlier importations in the upgrading of the local stock cannot be clearly evaluated.

There are considerable variations within the native goat population that indicate a possible upgrading at various levels by the introduced exotic breeds.

The average mature body weight of the Philippine native goat ranges from 15–30 kg (Valdez 1983; PCARR 1977; PADAP 1978). Colour markings vary from white, black, red, brown, or a combination of these colours.

Farmers raise the animal mainly for meat and rarely for milk. Milk production has been recorded with an average of 0.30 litres/day for a 120-day period (Gerona and Posas 1982). Weight gain performance of the native goat on pure grazing indigenous grasses averaged 10.33 g/day while on improved grasses/pasture the average is 6–9 g/day (Posas and Gerona 1981; Gerona and Posas 1982). These indicate that goats show a better weight gain on indigenous pasture than on improved pasture, which could be attributable to the variety of pasture species in the indigenous pasture. Grazing with supplementation of molasses plus urea and concentrate at different treatments showed an increase in weight gain ranging from 24.95 g to 53

* Philippine ASEAN Goat and Sheep Center, Bureau of Animal Industry, Philippines.

g/day (Gerona and Posas 1982). Native goats on improved pasture supplemented with 50% corn bran and 50% growing ration with 18% crude protein (CP) showed an average daily weight gain of 49.3 g/day (Bautista and Vaughan 1981). The findings compared to performances of upgrades and crossbreds indicate a need to genetically improve the native stock in terms of meat and milk yield. A comparison of meat and milk production of the native goat with crossbred and purebred goats is shown in Tables 1 and 2, respectively. Comparative growth and reproductive rates of the native with some breeds at Bagalupa Stock Farm, Zamboanga del Sur, Philippines, are shown in Tables 3 and 4.

**Table 1.** Growth response of native goats under different feeding systems.

| *Feed* | *Average daily gain (g)* | *Source* |
|---|---|---|
| 70% improved grasses + 30% concentrate (19% CP) based on 5% BW DM intake | 53 | Tan 1981 |
| Grazing indigenous grasses | 10.33 | Gerona and Posas 1982 |
| Grazing (indigenous grasses) + pure molasses (ad lib) | 24.95 | Gerona and Posas 1982 |
| Grazing (indigenous grasses) + 20:1 molasses: urea (ad lib) | 37.98 | Gerona and Posas 1982 |
| Grazing (indigenous grasses) + 10:1 molasses: urea (ad lib) | 40.81 | Gerona and Posas 1982 |
| Grazing (improved grasses) at stocking rates of 20, 40 and 60 head/ha | 9.0 | Posas and Gerona 1981 |
| Cut-and-carry (improved grasses) at stocking rates of 20, 40 and 60 head/ha | 6.0 | Posas and Gerona 1981 |

**Table 2.** Milk yield (kg) of does (2% milking for 120 days), VISCA, 1982.

| *Breed* | *No. of Animals* | *Months* | | | |
|---|---|---|---|---|---|
| | | *1* | *2* | *3* | *4* |
| Grades: | | | | | |
| High yielder | 2 | 47 | 35 | 35 | 28 |
| Breed average | 6 | 30 | 23 | 22 | 16 |
| Saanen | 2 | 35 | 37 | 39 | 29 |
| Toggenburg | 3 | 38 | 38 | 35 | 32 |
| Alpine | 1 | 37 | 31 | 29 | 16 |
| Herd average | 12 | 35 | 32 | 31 | 23 |
| Native | 1 | 9 | 10 | 9 | 7 |

## Economic Significance

The goat is considered a vital livelihood component among the smallholder and the landless/marginal farmers in the Philippines. Economic and social benefits are also attached to the animal. A survey in Zamboanga del Sur, Philippines, suggested that there are a number of benefits that motivate small-scale farmers to own and rear goats. Foremost is its purpose to provide food and financial assistance in the form of a saleable asset. Unpaid family labour in raising the animals and the practice of sharing the offspring serves to strengthen the total farm enterprise. Goat ownership is also vested with social status.

It has been shown that profitability of goats in upland agriculture was similar to that obtained from cropping enterprises with the usual farm practices (Hitchcock 1983). A budgetary analysis is demonstrated in the following comparison of returns and labour inputs for three cropping systems and a goat enterprise in Zamboanga del Sur, Philippines:

| | Net receipts Pesos/ha | Working days |
|---|---|---|
| Native corn-corn | 254 | 23 |
| Upland rice-mungbean | 492 | 44 |
| Upland rice-soybean | 815 | 43 |
| Goat enterprise | 644 | 40 |

The above figures are net receipts, i.e. gross receipts minus cash costs including labour cost.

These figures are being further evaluated under the Goat Key Farmer Cooperator concept of PADAP-ZDSDP with the objective of reducing the initial capital outlay and the training of farmers and farm technicians. More important in terms of economic significance at the farmer level is the integration of the goat as a component in the different farming systems primarily in smallholders' crop-based, freshwater-aquaculture-based, tree farming, and complementary livestock farming systems. The integration of goats into the different farm systems would maximise the utilisation of farm products and by-products, which would otherwise go to waste.

The significance of the goat can be further evolved with the landless/marginal farmers who could utilise roadside and marginal/idle lands effectively.

## Management System

The traditional tethering practice is still predominant in the different parts of the country. Some raisers just leave the goat to graze freely on indigenous pasture

**Table 3.** Growth rates of some breeds of goats at Bagalupa Stock Farm. (Bautista and Vaughan, 1981).

| *Breed Age* | *No.* | *Period when measured* | *Initial wt (± S.D.) kg* | *Final wt (± S.D.) kg* | *Growth rate (g/day) (± S.D.)* |
|---|---|---|---|---|---|
| 1. Anglo-Nubian kids | 4 | June-August 1981 | 7.5 ± 0.4 | 11.3 ± 0.9 | 63.3 ± 12.8 |
| 2. Anglo-Nubian goatlings | 7 | June-August 1981 | 13.0 ± 4.2 | 17.6 ± 0.5 | 79.3 ± 19.8 |
| 3. Anglo-Nubian × native kids | 2 | June-August 1981 | 3.8 ± 0.4 | 5.5 ± 1.4 | 58.3 ± 35.4 |
| 4. Anglo-Nubian × native goatlings | 8 | June-August 1981 | 9.6 ± 3.4 | 12.6 ± 2.8 | 84.8 ± 17.1 |
| 5. Anglo-Nubian × native young does | 9 | May-August 1981 | 22.9 ± 3.5 | 27.3 ± 4.2 | 48.8 ± 17.1 |
| 6. 1/4 Anglo-Nubian × 1/4 Saanen × 1/2 native goatlings | 3 | July-August 1981 | 11.8 ± 2.8 | 13.2 ± 2.9 | 44.4 ± 9.6 |
| 7. Native young does | 42 | May-August 1981 | 18.1 ± 3.7 | 22.4 ± 5.1 | 49.3 ± 30.3 |

**Table 4.** Interkidding interval of some breeds of goats at Bagalupa Stock Farm (Bautista and Vaughan, 1981).

| *Breed* | *No.* | *Interkidding interval in days (± S.D.)* | *No. of kids/ kidding* |
|---|---|---|---|
| Anglo-Nubian | 6 | 231 ± 28 | 1.33 |
| Saanen | 3 | 275 ± 31 | 1.0 |
| Native | 18 | 292 ± 69 | 1.19 |

along roadsides and idle grasslands. Others have make-shift houses or sheds of local materials.

However, with the increasing number of goat enterprises among commercial and semi-commercial raisers, the widespread intensive system has been adopted and it makes use of the full confinement and semi-confinement methods. This is practiced primarily by raisers of purebreds and crossbreds.

### Marketing

Marketing of goats is done by traders and middlemen but a number of transactions find their way into the livestock auction markets of which there are now almost 100 in different parts of the country. Consumption centres are still the urban areas. The price of goats for slaughter depends on size, appearance, and condition of the animal. Farm gate prices (BAECON 1981) ranged from 3.51 pesos (US$0.25) to P7.45 (US$0.53) with an average of P5.31 (US$0.38)/kg liveweight. In Metro-Manila, the price is P6.63 (US$0.47)/kg liveweight. The prevailing market price is P16.00 (US$1.14)/kg carcass.

Aside from the seasonal demand for goats, i.e. fiestas, Islamic religious rites, parties, etc., goat meat (chevon) is gaining general acceptance as a regular menu in restaurants and specialised eateries that serve delicacies of goat meat and entrails.

Recorded goat slaughter in 1982 was 89 653 head. It is assumed that a greater number is slaughtered in the different households.

Breeder goat prices, crossbreds from selected native breeds to purebreds range from P150.00 (US$10.71) to as high as P4000.00 (US$285.71).

Milk production at present is confined to commercial, semi-commercial, and government farms with a few of the smallholders engaged in dairying. Milk is either consumed as fresh milk or is processed into milk products by commercial establishments. The average market price of fresh pasteurised goat's milk is P8.75 (US$0.63) per litre (Valdez 1983).

## Limitations to Goat Production

### Sociological Constraints

Cultural constraints and traditional beliefs, i.e. the goat contributes to land desertification, destroys plants, compacts the soil, etc., need enlightenment. The sociological and cultural implications of goat development should also be examined so that there shall be no dislocation of either cultural, traditional or sociological development.

### Nutrition and Feeding

There is limited information on the nutritional requirements of native, upgrade, and purebred goats in the country. Similarly, there is a lack of information on the feeding materials, feeding behaviour, and grazing habits of goats.

### Genetics and Breeding

The Upgrading/Genetic Improvement Program using exotic breeds should be carefully evaluated for reproductive efficiency and the degree of upgrading into the local genetic bloodline. Importation of purebreds is limited by quarantine restrictions due to exotic diseases.

### Marketing

Goat production thrust must be coupled with a marketing program. Lack of market infrastructures, market information, market facilities and product processing establishments serves to stall efforts on production.

### Management and Husbandry

There is inadequate data on the most profitable economies of scale from the smallholder to the highly commercial operation. Similarly, different management levels of production from grazing to pure confinement need further evaluation.

### Research

Research studies are limited, particularly in the applied field. The lack of a unified and active national goat research program is considered to be a restraining factor.

### Health

Health problems have become a major impediment to goat production. Mortality rates in confined and semi-confined rearing reached a high level of 40% (PADAP 1981). Mortality rate is similarly high in smallholder goat production. Identified predominant diseases are internal/external parasitism, pneumonia, blood parasitism, and haemorrhagic septicaemia.

### Production Economics and Smallholder Credit

Technologies generated on goat production must be translated into the economics of the small-scale farmer considering his farming system and financial capabilities. Unless this is researched, it serves to slow down the adoption of generated technology by the smallholder. Credit facilities are also lacking for the commodity.

### Training and Adoption Rate of Successful Packages

There are inadequate technology packages that could be cycled to the training and extension programs.

Lack of trained technicians and extension delivery systems also adversely affect the industry.

### Present Research

Research into different aspects of the goat industry is being currently undertaken by the government and the private sector.

Research in the government sector is inclined towards smallholder producers. Current research activities are in the fields of reproduction and breeding, nutrition, management, artificial insemination, product and by-product utilisation, animal health, general husbandry in the different regions of the country, milk/meat production, the extension and training system, and other related aspects of goat development.

The commercial sector is more concerned with milk/meat production, breeds and breeding, animal health, and processing in intensive and extensive management.

There is a strong need to link research with extension work and smallholder enterprises.

## Research Directions

Future research will work on the integration of the goat commodity as a component of the different smallholder farming systems.

Research on the dairying aspects of the goat in the rural setting must be expanded.

The potential of the goat in complementary livestock rearing systems whether it be in pasture or confinement, i.e. cattle-goat-sheep, goat-poultry, etc. must be explored.

Integration of goats into tree crops and plantation crops, i.e. coconut, orchard, etc. must likewise be considered.

Lastly, research activities must also include goat products and by-product utilisation and processing, i.e. meat preservation, cottage dairying, tanning, manure composting, etc.

## Goat Programs

### Commodity Loan or Dispersal

This is a regular program and it involves selection and screening of interested village farmers having feed resources, housing, and the labor needed for goat production. One to three female goats are loaned to the farmer after completion of training. The farmer is obligated to give two head of offspring to the government after which the original animal becomes his property. Pockets of 10–30 head of does usually go to a village (barangay).

Supporting the dispersal program is the Barangay Buck Loan Scheme (Upgrading Scheme) whereby a grade/purebred buck is loaned for 3–12 months. The barangay is obliged to pay 10% of the book value as rental and surety bond. In the PADAP scheme, the buck loan is for a period of 3 months, with a condition of renewal. A minimal fee is charged for maintaining the buck, and for the caretaker.

### Village Goat Program

The Kambingang Barangay, a supervised credit program designed to promote goat production on a small farmer level, was started in December 1979. Records of 1982 show a total credit amount of 15 million pesos with a high repayment rate.

The program is a package scheme through the rural banking system in the countryside with support services for animal health, pasture development, training, and other technical needs.

**Kilusan Kabuhayan at Kaunlaran (KKK)**

The potential of goats in human settlement development projects has led to the establishment of a National Goat Farm. This will serve the needs of human settlement areas and KKK project proponents in the provinces.

## The Philippine ASEAN Goat and Sheep Center (PAGSC)

The Center was first proposed by the Philippine Bureau of Animal Industry in 1979, and the Center project commenced in May 1982. It is situated north of Pagadian City on the island of Mindinao in the Southern Philippines. The Center's activities include programs of production, research, training, extension, and marketing.

The project was considered at the Fourth Meeting of ASEAN-COFAF Coordinating Group on Livestock held in April, 1982.

The meeting considered the Philippines' proposal to establish an ASEAN Goat and Sheep Center and requested the Philippines to expand the proposal into an ASEAN Goat and Sheep Program with the ASEAN Goat and Sheep Center as a component of the program. The meeting also agreed that member countries submit their requirements to the Philippines to enable the Philippines to prepare a coordinated paper for presentation at the next meeting.

Singapore and Thailand responded and their requirements were incorporated in a proposal titled 'ASEAN Goat and Sheep Development Program', which was prepared by the Philippine Bureau of Animal Industry in January, 1983. This proposal included PAGSC as a component of the total program.

**PAGSC Objectives**

*A. Long-Range Objectives are:* 1. to advance the technology used in goat and sheep production; 2. to establish a training center for goat and sheep production; 3. to establish a stud for upgrading local stock; 4. to conduct educational programs on goat and sheep production technology and marketing.

*B. Short-Term Objectives are:* 1. to establish a viable goat industry and possibly sheep among ASEAN countries; and 2. to increase the supply of chevon, mutton and milk, thus improving the nutrition of the people in the ASEAN countries.

In general, the objectives of the Center incorporate five functions, viz. research; training; extension; production; marketing and financing.

**Current Projects**

*Goat and Sheep Production.* The activities on goat and sheep production are directed to crossbreeding trials with consideration to meat and milk production, reproduction capacities, adaptation to local pasture and feeding conditions, disease resistance, and other factors necessary to develop a goat and sheep industry.

The production program also aims to establish a pool of breeding goats and sheep for both upgrading and conservation of indigenous germplasm.

**Training**

Training of marginal or subsistence farmers, key farmer cooperators, livestock technicians, commercial ranch-type operators, animal researchers, training and extension personnel from the Philippines and other ASEAN countries are all proposed at the Center. Training and observation tours are likewise included in the training program.

A total of nine training sessions, involving technicians and farmers have been jointly conducted at the Center.

**Research**

Research activity is divided into seven sub-projects, viz. nutrition/pasture; management and husbandry; disease; crossbreeding; conservation of genetic resources; economic analyses, marketing and credit research; monitoring and adoption rate of successful packages.

At present, the center is conducting the following nine trials:

*Project 1:* Pasture and browse museum, aimed to test the suitability of various forage species for production in the humid tropics; to evaluate the growth, seed availability, and degree of disease and insect resistance of forage species; to collect and preserve or provide cuttings or seed for further research or extension activities.

*Project 2:* Signal Grass/Centro goat grazing trial, in which productivity and response of Signal Grass/Centro grazing is being tested.

*Project 3:* Pasture yield trial (Signal Grass/Centro and Hamil Grass/Kudzu/Centro at the Bagalupa Stock Farm), in which pasture yield is being measured at 5-weekly intervals throughout the year. This pasture cutting trial is designed to establish the number of goats that should be grazed for management purposes.

*Project 4:* Pasture yield comparison of leaf stem and flowerhead of: (1) Local Napier; (2) Sweeney

Napier; (3) Splendida; (4) Hamil grass. The project aims to compare three high-yielding tall tussock grasses with oven-dry yield of the standard Hamil grass, following the introduction of an improved Napier grass and *Setaria splendida* from North Queensland in 1980. In the pasture museum both grasses appear to produce more leaf than Hamil grass or local Napier grass, which rapidly runs to flower.

*Project 5:* Goat and sheep internal parasite control, a trial to compare response and parasite infection in monthly and strategic drenching regimes.

*Project 6:* Cut-and-carry feeding trial, designed to measure annual productivity by weight response to various cut-and-carry feeding regimes.

*Project 7:* Andesite steep hillside pasture establishment. Observations of pasture establishment problems on unfertilised steep andesite, ridge and valley land forms.

*Project 8:* Establishment of Ipil-Ipil in poorer metamorphically derived and heavily leached old alluvial soils. Attempts to establish Ipil-Ipil at the Bagalupa Stock Farm using either transplanted seedlings, bare root or direct seeding have generally been unsuccessful. This project aims to determine rhizobial and nutrient requirement for establishment of Ipil-Ipil at the stock farm.

*Project 9:* Time of kidding and lambing trial, designed to determine optional kidding and lambing and/or double kidding or lambing times for a humid tropical region.

There are also some research activities on by-product utilisation. The partial results on the utilisation of goat manure for fish (Tilapia) show that it is comparable to inorganic fertiliser. Likewise yield trials on rice using goat manure and minimum inorganic fertiliser showed rice yield to be comparable with that obtained from applying pure inorganic fertiliser.

Further trials are being undertaken on the utilisation of goat manure for rice by deep placement and pure manuring as fertiliser. Similarly, goat manure application trials on different levels of Tilapia ponds are being undertaken.

## Extension

The extension system of the Center shall be through the Key Barangay Livestock Resource Cooperative (KBLRC). The KBLRC shall be the working module of the Center to evolve a system of technology packages to reach most of the small-scale farmers in the least time at the least cost.

## Marketing

Proposed marketing/finance studies are still being evaluated. Special subprojects are:

1. Integrated farming systems
This activity aims to integrate goat/sheep raising in the present farming system, evaluating, (1) the livestock-crop system; (2) the livestock-aquaculture system; (3) the livestock-crop-aquaculture system.
2. Sloping agricultural land technology.
3. Food gardens.
4. Veterinary herbal gardens.
5. Barangay program modules.

## Future Direction of PAGSC

1. Expand activities on testing goat and sheep purebreds and crosses in terms of meat and milk yield.
2. Intensify collection of indigenous goat breeds on the basis of colour, kidding rate, size, interkidding interval, meat/milk yield.
3. Procurement of additional sheep stocks and conducting trials on their viability at barangay level.
4. Packaging goat and sheep technology applicable to lowland and upland farming systems.
5. Link activities of the Center with other institutions in the country and among similar establishments in ASEAN member countries and international organisations/establishments.

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# Goat Research and Development in Thailand

**Siriwat Sarabol***

THAILAND is a predominantly agricultural country. Its total land area is 514 000 $km^2$ with about 40% under cultivation. The climate is tropical and monsoonal with three distinct seasons: a rainy season from May to mid-October, a cool dry season from mid-October to mid-February, and a warm season from mid-February to April. The average annual rainfall ranges from 1000 to 3000 mm. The population of Thailand is approximately 50 million.

The country is composed of four geographical parts: the mountainous north, the rolling northeast, the flat plain of the central and the isthmus of the south. It is divided according to administration into 73 provinces. Of the total population, 70% live in the rural areas where there are about 4.5 million farm households. The rural population is the backbone of the agrarian economy of the country. In 1980, agriculture contributed about 26% of gross domestic product (GDP), 58% of exports, and provided employment for 70% of country's labour force. The livestock subsector accounted for about 3% of total GDP, or 12% of agricultural GDP, and represented only about 1% of Thailand's total exports or 10% or agricultural exports.

## Goat Population

Livestock production is an integral part of most of Thailand's smallholder-oriented agricultural sector. Buffalo, cattle, swine, goat, sheep, and poultry are kept by small-scale farmers. Goats have traditionally been raised by the Thai Muslims especially in the southern part and by the hill tribe people in the northern part of Thailand for several decades. Goat production is not commonly practiced in the typical smallholder farming system. The number of goats and number of holdings are presented in Table 1.

**Table 1.** Number of goats and number of holdings, 1978.

| *Region* | *Number of goats (head)* | *Number of holdings (households)* | *Average per holding (head)* |
|---|---|---|---|
| North | 4927 | 972 | 5.1 |
| Northeast | 1504 | 475 | 3.2 |
| Central | 4053 | 209 | 19.4 |
| South | 73 909 | 23 364 | 3.2 |

## Characteristics of the Thai Indigenous Goat

Thailand's indigenous goat is a small-sized goat. Birth weight of kids is about 2 kg and bucks and does weigh 30–35 kg and 20–25 kg, respectively. Height measurements are 55–60 cm for bucks and 50–55 cm for does. They possess a straight bridge from eyes to nose on the head with small and erect ears. The colour pattern varies greatly, ranging from black to brown and white and sometimes there are several colours and shades or spots on the same animal. There appears to be no seasonal breeding for Thai native goats since kidding can occur at any time during the year. The average daily milk yield is about 300–700 g in the lactation period of 160–200 days. The rate of growth from birth to 2 months ranges from 70 to 20 g/day.

## Village Management

Goat keeping has predominantly been practiced in the lower south of Thailand although goat raising is being dispersed throughout other parts of the country. There is an indication that goat rearing has traditionally existed in communities in which Islam is a dominant religion. About 95% of the goat population in the southern part of the country is being kept by the Thai Muslims with most of the holdings carrying 2–5 goats. They allow the goats to run freely and to shelter underneath the house, in rice grain storage bins and other non-utilised housing. The goats have to fend for themselves for feed, water and other activities such as mating, kidding, rearing kids, etc. Numerous goat keepers employ tethering systems by occasionally moving the goats to an area where a feed supply can be found. Herding is practiced by individuals who own more than 10 goats, for whom housing is built. The owner will drive out the goats in the morning to natural grasses in coconut plantations, oil palm plantations and other available feed sources and herd them back to the goat house in late afternoon. Some raisers save their time by training the herd buck to lead home all their goats.

* Department of Livestock Development, Bangkok, Thailand.

Information concerning diseases and parasites of goat in Thailand is very limited. Goats are susceptible to foot and mouth disease. Vaccinations against anthrax, haemorrhagic septicaemia and foot and mouth disease have been carried out by government agencies in order to eradicate these contagious diseases. Melioidosis was reported in a herd of Anglo-Nubian goats in southern Thailand. Screwworm (Callipheridae) was found to be a problem in villages of hill tribes in the highlands of north Thailand, with few other diseases being evident.

### Credits and Marketing

There is no information available on goat production credits. Village goat raising is supported by the government to some extent in the form of a buck loan program for the improvement of production. Goat husbandry in subsistence farming could provide additional protein and an important source of supplemental income. Sales occasionally occur when prospective buyers come to visit villages and ask to purchase goats. Marketing research on goats has not been conducted in Thailand although there are large numbers of Muslims who prefer goat meat. There is also some demand for goat meat from hotels and Muslim restaurants in Bangkok in order to supply Muslim tourists from the Middle East countries. Moreover, some Chinese restaurants serve a special recipe of goat meat for upper class people.

An unofficial survey on marketing was recently conducted in southern Thailand. A monthly demand for 1000 goats, both bucks and does, at a price of US$25–30 was reported. The goats were transported to the Bangkok market and some were illegally exported.

### Research and Development

Goats have been raised in Thailand as backyard animals for years. It is possible that because of the small population and the view that it is an uneconomic animal compared to other kinds of animals, there has been little interest in goat research. Milch goats were introduced into Thailand in 1950 in order to study milk production of purebred goats and their crossbreds. Few studies have reported information on the growth, physiology, carcass and milk yield of goats from various sources.

Thai farmers are crop-oriented subsistence farmers with low levels of income and because of a lack of nutritional education, malnutrition, especially protein deficiency, continues to be a health problem. In 1977 the Department of Livestock Development and the Prince of Songkla University launched a program of buck loans in order to improve village goat production in southern Thailand. This effort is aimed at the smallholders to improve the supply of family needs for meat and milk. The Department of Livestock Development commenced collecting basic information about 3 years ago by establishing a small herd of indigenous goats at the Pattani Livestock Breeding Center in the south. The Department is going to introduce some Saanen goats from Australia in order to obtain information on the potential for improving goat meat and milk production.

Since information on goats is limited, more research needs to be done in the future for the development of goat production, especially in the south. The following fields of investigation are suggested for immediate attention and support:

1. Observations and studies on the pattern of village goat production in order to identify biological, cultural, and economic problems.
2. Studies on goat prices, consumption, and marketing.
3. Investigation and identification of forages and pasture suitable for village management practices.
4. Nutritional studies on locally available feed resources.
5. Investigations on reproductive efficiency including the relevance of A.I. and fertility studies as a means of improvement.
6. Study on the prevention and control of diseases and parasites of goats.
7. Experimentation with imported milch goats and their crossbred progeny to determine their genetic adaptability to local environments in the production of meat and milk.

# Goat Development in Southern Thailand

**Sujin Jinahyon***

GOATS are of great importance in southern Thailand particularly in the Muslim areas of the border regions. For this reason an investigation into their potential as both a source of meat and milk was initiated by the Faculty of Natural Resources (FNR) in 1977. This preliminary and largely qualitative investigation has provided some information on the types of goats present, viz. a local Kambing Kajang type, and various cross breds with Anglo-Nubian, Toggenburg, and Saanen infusions. As has been reported in Indonesia, Fiji, and Malaysia, the introduction of larger breeds of goats has increased the size (and meat production) of local goats, and it was concluded from this data that crossbreeding would substantially increase goat productivity in this region.

At this point it was decided to consult a wider spectrum of opinion as to how to proceed and a workshop on goats was held at the Prince of Songkla University (PSU) in June 1983 with participants from all over Thailand and from Australia (Goat Development Program 1983).

Various aspects of goat production were considered at this workshop including the nutrition, reproductive rate, genotype suitability, disease status, management at the village level, products (milk, meat, leather, organs) and the marketing and cultural restraints to increased production. As a result it was realised that there was a lack of quantitative data on most of these topics, which it is necessary to acquire before any management packages can be developed.

In order to achieve this, the following three point program was developed:

1. Baseline data accumulation at the village level in order to appreciate the position of goats in the different farming systems of southern Thailand and more particularly to assess productivity and the factors that control it.

2. A study of local goats under improved management conditions, i.e. good nutrition, disease control, and reproductive management. As such a study would be impossible under village conditions it was decided that this part of the program would be conducted with a representative flock of local goats on the PSU campus farm. This will enable a detailed study to be made of some of the biological limitations to production such as disease, nutrition, and reproductive activity. At the same time strategies will be developed for circumventing these obstacles.

3. Commence a crossbreeding scheme, since there is a demonstrated need in the villages for larger and more productive goats. This will be initiated on the campus farm using semen from two large exotic breeds with a potential for both meat and milk production. This will enable a quantitative evaluation to be made of any increase in the productivity of the crossbred progeny. Furthermore, after the baseline data have been completed, it will then be possible to introduce in an orderly manner 'improved' crossbred male goats (50% exotic genes) to selected villages and monitor the productivity of their progeny with those of local goats, under village conditions.

The information gathered in this integrated study will provide information on (a) the present levels of productivity of goats in various farming systems in southern Thailand, (b) the restraints to increased productivity, (c) the biological restraints to productivity under improved management conditions and (d) perhaps for the first time, an objective evaluation of the effectiveness of crossbreeding with 'exotic' goat breeds for increasing goat production at the village level. From this data, management packages relevant to the different goat populations (local vs. improved) in the different farming systems will be developed to assist villages to improve both the nutritional and financial status of goat production.

## Implementation and Conduct of Program

A team of Thai scientists from different disciplinary areas (PSU) has been committed to this program together with technical and research advisers from the Thai-Australian PSU project resident in Hatyai. The physical facilities and feeds necessary to hold the experimental flock on campus are available from FNR and Thai-Australian PSU project funds. Local does will be purchased and introduced to the campus farm in October, 1984 and joined in March-April 1985. The

* Faculty of Natural Resources, Prince of Songkla University, Thailand.

details of the breeding program have been decided, and some research proposals for disease, nutrition, and reproduction studies are still being developed.

Since the program outlined above and in Appendix A is in various ways beyond the present capacity of FNR staff, there remains an urgent need for additional assistance, particularly at the technical and scientific level to complement the current program. The specific needs for aid are listed below, not necessarily in order of priority:

**Baseline Data Collection**

This program will be initiated in the near future, and has as its aims collection of biological data relating to animal production in the villages with particular reference to goats. This survey will be designed so that the results can be interpreted in relation to a survey presently undertaken to define broadly the existing farming systems in terms of socioeconomic restraints to production improvement. Assistance is required in the development of questionnaires and with a definition of the types of quantitative data needed to translate perceived limits to production into quantitative comparable data between farming systems. After the data collection stage, assistance will be needed to develop data storage and retrieval systems on the computers available at FNR (Sirius) and to interpret this data for publication. An animal production expert will be required from June 1983 for a period of 3 years to undertake this aspect, interpret data and develop relevant management packages for extension.

**Nutrition and Management**

Little is known about the feeds offered to goats in southern Thailand, and an attempt will be made during the baseline survey to collect this information. There is an urgent need to evaluate the feeds offered to goats in housed systems, and to determine the extent to which feed quantity and quality are limiting production. The possibility of developing improved pastures and browse species for goats is also of interest to the program. Songkla is an area rich in agricultural by-products and their nutritional value for goats needs determination, if their economic value as a supplement is to be assessed.

Grazing management systems, such as under coconuts and oil palm, or in predominantly cropping areas needs further study and expert assistance is required to design and develop such systems in southern Thailand.

It is foreseen that there is immediately a need for expert assistance in the design of feeding and management studies to evaluate the range of potential feeds useful to goats in this area, and to define the nutritional requirements of goats in different physiological stages, in this environment. From these studies, recommendations to improve nutritional management should arise, and be applicable to the farming systems in which goats are kept.

**Reproductive Management and Breeding**

With the introduction of breeding does to the campus farm, there is an urgent need for advice on techniques and methods used to assess reproductive activity in both males and females so that the normal patterns can be defined for this environment. The breeding program requires the use of frozen semen and artificial techniques to avoid the infertility problems usually associated with the introduction of 'exotic' bucks into this environment.

FNR will fund a staff member skilled in reproductive techniques in cattle to train in Australia with Dr. Barrie Restall (N.S.W. Department of Agriculture, Wollongbar) to learn at first hand, and to develop further, techniques of artificial insemination with goats, semen storage techniques, methods of synchronising oestrus and stimulating ovulation in goats. These techniques will then be further developed and applied at FNR for use in the 1984 joining program. However, there is an urgent need for some basic equipment to support these techniques and the attendance of trained personnel at the first mating exercise. Apart from the technical training, it is believed that much will be learnt about the reproductive rate (potential and realised) of goats in southern Thailand and this information is essential if restraints to increased productivity are to be defined.

**Animal Health**

It is anticipated that some diseases may be limiting the productivity of goats in southern Thailand, but there is presently little information on types, incidence, or severity of diseases in goats. There is an urgent need for assistance to define the epidemiology of various diseases in goats in this area, develop relevant treatment for cure or prevention of the most important diseases. Expert assistance will be needed by FNR staff to develop the investigative techniques needed for identification of disease at the village level.

**Staff Education**

A major problem in developing this program is the lack of relevant literature on goat production in southern Thailand. Also, there is an urgent need for staff to attend international conferences, and visit other research institutes in Asia and Australia to discuss production problems and research.

In addition to the help required at the consultant's level from people working on similar problems in

Australia, there is undoubtedly an equal need for contact over longer periods by scientists at the immediate postdoctoral level who would be involved along with their Thai counterparts in the day-to-day implementation of this program. This aspect is just as important as the necessity of Thai-counterpart staff going to Australia to acquire particular techniques or to work on related problems.

From the above program it can be clearly seen that a long-term commitment to goat research has been made by the team at FNR, and that some resources are available for the implementation of the major parts of this program. However, there is also an urgent need for expert advice and financial assistance with various aspects of planning, implementation, and interpretation of this program. For this reason, it is proposed that specific assistance at the scientific and technical level be sought from ACIAR to provide information on the broader management aspects of goat production and aspects of reproductive biology, breeding and nutrition, which are as yet poorly understood by not only Thai scientists but also other scientists studying goat production in other tropical countries. It is also suggested that the dual aims of cultivating research into goat production in Thailand and of improving the income of the poor Thai farmer will be served through such a program.

## Summary: Goat Development Program in the Southern Region of Thailand

Research Team: Staff of the Faculty of Natural Resources, Prince of Songkla University, and staff and advisers from the Thai-Australian Prince of Songkla University Project (ADAB funded).

### Objectives

To make available to Thai villagers, information and technology that will improve the productivity of goats for meat, milk, and leather in the village system and thereby improve the living standards of poor Thai farmers.

### Program

• Identification of present productivity and management restraints operating at the village level (1984–86).

• Introduction of local goats to the improved management system at University campus farm and evaluation of biological restraints to production in this environment (1984–91).

• Use campus flock to breed crossbred goats from introduced exotic goats using artificial insemination with frozen semen. Evaluation of performance of first cross (50%) and second cross (75%) on campus with local goats raised under the same system (1984–91).

• Introduction of first cross and second cross goats to selected villages and evaluation of these introductions with local contemporaries raised under 'traditional' and 'improved' village management systems (1987–93).

• Development and extension of relevant management packages for improved goat production in the villages (1987–93).

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Goat Development Program in the Southern Region of Thailand 1983. Proceedings of Seminar held at the Prince of Songkla University, Hatyai, Thailand. Sponsored by the Faculty of Natural Resources and the Thai-Australian Prince of Songkla University Project.

# Goat Production in Indonesia: Current Status and Potential for Research

**M. Rangkuti, M. Sabrani and Beriajaya***

IN Indonesian farming systems, goats are an important component especially among small farmers (De Boer et al. 1982). The animals are kept for multiple purposes, as a source of quick income to meet household cash needs, manure, hide production and also as a means to give employment to the farmer's family. The role of goats can be seen also from their contribution to the total meat consumption. Approximately 10% of total meat supply is from sheep and goats. Among the ASEAN countries, out of 7.9 million goats, 77.1% is found in Indonesia, and 79.7% of this population is in Java (Anon. 1979). Two major breeds are found in Indonesia, the Kacang and Ettawah. Crosses between the two breeds represent the largest group in the goat population. Today more foreign breeds have been introduced such as the Saanen.

**Table 1.** Human, sheep and goat population-density distribution.

| *Regions/island* | *Area ($km^2$)* | *Human population/ $km^2$* | *Goat population/ $km^2$* |
|---|---|---|---|
| Java | 129654 | 716 | 47.1 |
| Bali | 5561 | 494 | 4.2 |
| Sumatra | 473606 | 59 | 1.6 |
| Kalimantan | 539460 | 13 | 0.1 |
| Sulawesi | 189196 | 60 | 1.6 |
| West Nusa Tenggara | 20177 | 141 | 4.9 |
| East Nusa Tenggara | 47876 | 62 | 4.7 |
| Maluku | 74505 | 19 | 1.1 |
| Irian Jaya | 421981 | 3 | na |

Source: Anon. (1982).

Table 1 shows the goat population distribution across provinces relative to the human population.

In terms of human population and goat population density, a strong correlation can be noted. This is because goat production structure is highly charactérised by traditional small-scale farming activity, low level of investment and input use (Thomas et al. 1982). These phenomena are further explained in Tables 2 and 3. The average production per year per household based on macro data was only US$29.1, with the capital asset value US$74.7. From these data the ratio of capital/production per household was 2.6 or approximately 3% return on capital per year. In terms of rupiah (Rp) currency based on a household survey, income per household per year from goat enterprise was Rp 38 326 (US$39.51) while income per doe was Rp 18 835 (US$19.41) and income per hour of labour was Rp 50 (US$0.05). Compared with crop production, goat enterprises have very low labour productivity. This was Rp 298 for rice and Rp 254 for corn per hour of work (Anon. 1984). The low productivity of goats could be due to the labour intensive production system, low herd size, low kidding rate and low offtake rate (Table 4). The contribution of goats to the farmer's cash need was only 2% (Anon. 1984).

**Table 2.** Economic status of sheep and goats in 1982.

| | | |
|---|---|---|
| Production: | (1) Total production ( × 1000 tonne) | 59.0 |
| | (2) Total value (million US$) | 121.7 |
| | (3) No. of household (HH) | 4 180 000 |
| | (4) Average/HH (US$) | 29.1 |
| Ratio of capital to sheep and goats: | | |
| | (5) Value of capital asset per HH (US$) | 74.7 |
| | (6) Ratio of capital/product per HH/(5/4) | 2.6 |

Source: Sabrani et al. (1983).

These productivity data may vary across the region due to large differences in management practices. The degree of grazing and zero grazing combinations under a certain agro-ecological environment could produce wide differences in productivity. The important point is that the present management systems offer an employment opportunity with a low opportunity cost value.

It is difficult to assess the productivity of goats in Indonesia under these varying management systems,

* Research Institute for Animal Production, Bogor, Indonesia.

**Table 3.** Economic return per year to goat farmers in two Javanese villages based on a household survey.

| *Location* | *Herd size (head)* | *Animal unit (AU) per farm* | *Off-take (AU)* | *Off-take (%)* | *Income/ HH (Rp)* | *Income/ doe (Rp)* | *Income/ hour of work (Rp)* |
|---|---|---|---|---|---|---|---|
| Cirebon | 3.00 | 0.1195 | 0.0682 | 57 | 36547 | 21498 | 44 |
| Bogor | 5.67 | 0.1641 | 0.0805 | 49 | 40104 | 16171 | 56 |

Source: Sabrani et al. (1982).

**Table 4.** Productivity of Indonesian goats.

| *Description* | *On station* | | *Specific* | |
|---|---|---|---|---|
| | *Kacang goat* | *Ettawah* | *farmer's cross* | *Village cross* |
| Litter size (head) | 1.76 | 1.42 | 2.00 | 1.92 |
| Kid survival (%) | 78 | 78 | 66 | 79 |
| Kidding interval (day) | 210 | 290 | 270 | 400 |
| Birth weight (kg) | 1.6 | 2.9 | 2.1 | 1.8 |
| Weight at weaning (kg) | 8.7 | 13.1 | 11.1 | 8.1 |
| Mature weight (kg) | 18 | 24 | 25 | 22 |

Source: Knipscheer and Kusnadi (1983).

breeds or strains, cropping systems, socioeconomic conditions, and little research has been conducted. Outside Indonesia, few references can be obtained for comparison (e.g. Devendra and McLeroy 1982; Pharo 1982). Efforts have been initiated to compare the goat productivity on village farms, on the research station, and on specialised farms (Table 4). The length of the kidding interval was longest and body weight was lowest in the village as compared to those of on-station and specialised farms. Poor nutrition and uncontrolled breeding management at the village level have reduced growth, as well as productivity. There is the need for goat development today to provide goat meat; this is likely to substitute for beef, which is now declining. Development programs in provinces are mostly directed at improving goat production technology, credit and production sharing systems, and marketing, with the main objectives being to increase land input, improve income and reduce risk and seasonal variation. The programs are oriented to develop a goat production model under small-farm conditions in rural areas. For this reason the development of research policy for such small-scale farming units requires a deep understanding of the complexity of interactions among livestock, farmers, and the environment.

## Constraints to Productivity

Although there seem to be good prospects for developing goat production that provide a means of raising the income of small farmers, some limitations were identified (Sabrani et al. 1982; Anon. 1984). The limitations, which are physical, biological and socioeconomic in nature, create figures of high mortality, low growth rate, low reproductive performance, low off-take rate, poor marketing systems, and low capital availability.

## Diseases

Appendix 1 gives a list of some diseases of goats, which have been reported in Indonesia.

Although a number of diseases of goats in Indonesia are now well recognised, there is little information on the relative importance of these diseases on goat productivity in the country. In broad terms, the diseases of significance in reducing productivity can be divided into three main groups: first, those that cause acute disease and frequently death, e.g. acute helminthiasis and anthrax; second, those that cause a chronic, debilitating disease, e.g. chronic endoparasite infections; and third, those classified as reproductive diseases causing infertility, prenatal or neonatal deaths, etc. In addition there are diseases of high morbidity but low mortality, e.g. conjunctivitis, which may have some effect on productivity. There are also diseases that can be transmitted either directly or indirectly to humans (zoonotic diseases), which are of some public health importance, e.g. hydatidosis and rabies.

Those that have veterinary and economic impact are endoparasites, ectoparasites, pneumonia, orf (contagious ecthyma), pink eye, goat pox, and mortality at or around parturition.

Endoparasites can occur in up to 80% of a sample (Beriajaya 1983). The diseases consist of gastrointestinal worms and coccidia and are mainly due to grazing practices under wet tropical conditions.

Based on a 1979 survey, 28.2% of goats suffered from pneumonia (Iskandar et al. 1983). The agent, however, has not been identified but it is suspected to be a combination of bacteria and virus.

Statistics for small ruminant mortality in Central Java show that 50.6% of total mortality (13.4%) occurred at birth, 43.3% during the preweaning period and 6.1% after weaning. The high rate of mortality at birth in most field surveys is very often overlooked; this seems to be a critical aspect of production improvement.

## Nutrition

Poor nutrition in the village goat can be seen as low growth rate and low body weight at birth, weaning, and at maturity. It seems that rice monoculture in large areas creates difficulties in providing a balanced feed source for goats who prefer a mixture of leaves and grasses. In addition to this limitation, there is the uncertain source of feed as shown by the high percentage of goat keepers who obtain feed from land that is not their own, and the seasonal variation in feed supply due to climatic conditions. These impose nutritional problems for stable goat development. The major physical factors affecting feed supply potential are precipitation (duration and intensity), elevation, slope, and soil type.

Appendix II presents data on the feed composition of goat diets in three villages. By cut and carry management, field grasses dominated feed composition in all locations in terms of percentage and frequency of feeding. The percentage of grass was relatively higher during the dry season, while herbs became lower. The same thing happened also with crop by-products. The fluctuations in feed composition from wet to dry seasons are a typical problem in nutrition in which nutritional levels decline in the dry season due to increased fibre and reduced protein. This limitation occurs in composition and in the quantity of feed, which also declines.

## Reproductive potential

In a village environment, the reproduction rate of the goat is still about 1.14 kid per adult female per year (Kartadihardja 1979). However, on specialised farms a reproduction rate of 2 young animals per female is realised (Soedjana et al. 1983). Potential reproduction rates achieved at research stations and at well-managed village units (Setiadi and Sitorus 1983) reach 3 kids per doe per year. This difference may be due to the lack of selected males for breeding purposes and the uncontrolled breeding system. This is demonstrated by the length of the kidding network and the uneven distribution of male ownership within a certain area.

## Market

As far as meat is concerned there are few marketing limitations. The demand for meat has shown an increasing trend due to the increase in income per capita and the increase in human population. However, the beef supply potential is declining as shown by the decline in cattle and buffalo populations. The most critical limitation in goat marketing is the marketing system itself. The system fails to transmit market information to the farmers and to stimulate production. The multi stages of the system create inefficiency at the farmer's level (Sabrani et al. 1982, 1983).

In terms of goat milk, the demand is limited to a particular ethnic group. Thus the problem is limited consumption and dairy goat production is unlikely to expand rapidly.

## Capital limitation

Capital constraint in goat development is reflected by the relatively small flock per farm and low input. The goat enterprise utilises the non-cash input intensively, especially family labour. The goats utilise marginal land, crop residues, and grasses. The low economic return coupled with the capital constraint seem to be one of the major limitations in technology transfer because the improvement that can be made produces a very marginal impact.

To reduce these production limitations, a sharing production program (GADUHAN) offers an excellent opportunity to small farmers. In this program female animals are distributed and part of their offspring is used as pay-back. The program is used where credit and repay conditions are not feasible.

## Current Research

The present goat research program is included in the Small Ruminant, Animal Disease and Farming System Research Program. Problem-oriented research is organised around five general areas that were identified as potential constraints to increasing small ruminant productivity. Within each problem area, several specific projects are being undertaken.

The Small Ruminant Program investigates four main areas of research (feed, genetic, economics, and sociology) with the U.S. Small Ruminant Collaborative Research Support Program. The Animal Disease Program is supported by Australian Government assistance.

The Breeding Research Program is designed to assess: (1) the effects of environment on reproduction; (2) management of mating to reduce kidding interval; (3) the genetic basis of high prolificacy; (4) grading of Ettawah and Kacang goats; (5) comparison of progeny.

The Nutrition Research Program involves: (1) feed evaluation; (2) supplementation studies; (3) determination of protein quality of crop by-products, grasses, and legumes.

The Socio-economic Research Program investigates: (1) socioeconomic analyses of marketing systems; (2) women's role in small ruminant production; (3) labour utilisation analyses; (4) comparative budgeting analyses; (5) animal sharing analyses; (6) on-farm technology testing; (7) agroeconomic profile analyses.

The Disease Research Program comprises: (1) studies on endoparasite epidemiology; (2) studies on scabies; (3) comparative study of orf (contagious ecthyma) and goat pox; (4) an abattoir survey; (5) studies on pink eye; (6) studies on small ruminant resistance to cyanide toxicity in cassava.

## Research Prospects

There is a need to continue the present research programs to provide solutions to the many and varied farm problems. In addition to this, the use of research results in specific locations such as transmigration areas, should be given high priority.

Investigation of land use, cropping pattern and goat production-interaction must be intensified in the future. The investigations are directed to the development of appropriate technologies, which may be able to strengthen the linkage among land, crop, and goats under small-farm environment. This strategy of research has to be developed since capital and small farms dominate the goat production problems.

Management variables that produce a positive impact on production and reproduction performance should be intensified. Examples are selective feeding, supplementation, feed storage, feed treatment, breeding practices, and housing.

Last but not least, the development of methodology for goat production analyses must receive reasonable attention. Lack of good research methodology can create bias in analyses.

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**Appendix I. Some diseases of goats in Indonesia**

| *Diseases* | *Agent* | *Occurrence* |
|---|---|---|
| 1. Anthrax | Bacterial | Sporadic |
| 2. Reproductive disease | Bacterial | Sporadic |
| 3. Enterotoxaemia | Bacterial | Sometimes |
| 4. Collibacillosis | Bacterial | Sometimes |
| 5. Salmonellosis | Bacterial | Occasionally |
| 6. Pneumonia | Bacterial, Viral | Common |
| 7. Foot rot | Bacterial | Rare |
| 8. Haemorrhagic septicaemia | Bacterial | Sporadic |
| 9. Pink eye | Rickettsiae, bacterial | Sporadic |
| 10. Foot and mouth disease | Viral | Sporadic |
| 11. Pox | Viral | Sporadic |
| 12. Orf | Viral | Sporadic |
| 13. Papillomatosis | Viral | Rare |
| 14. Rabies | Viral | Rare |
| 15. Helminthiasis | Parasitic | Common |
| 16. Coccidiosis | Parasitic | Common |
| 17. Ectoparasite infection | Parasitic | Fairly common |
| 18. Blood parasite infection | Parasitic | Rare |

**Appendix II. Contribution of major crop by-products, shrubs and leaves to sheep and goat diets[a]**

| | | *Garut* | | *Ciburuy* | | *Cirebon* | |
|---|---|---|---|---|---|---|---|
| *Common name* | *Botanical name* | *Wet*[b] | *Dry*[b] | *Wet* | *Dry* | *Wet* | *Dry* |
| Crop by-products: | | | | | | | |
| Bean straw & hulls | *Glycine soja* | 14.0 | 5.9 | — | — | 1.6 | — |
| Cassava leaves | *Manihot esculenta* | 6.8 | 10.8 | 72.7 | 45.9 | — | — |
| Maize stover | *Zea mays* | 16.9 | — | 2.9 | 2.7 | 5.2 | — |
| Peanut straw | *Arachis hypogaea* | 0.6 | — | — | — | 4.4 | 14.1 |
| Potato stover | *Solanum tuberosum* | 0.2 | — | — | — | 12.8 | — |
| Rice straw | *Oryza sativa* | 23.0 | 22.2 | — | 2.7 | — | 12.8 |
| Sweet potato vines | *Ipomoea batatas* | 4.5 | 9.0 | — | — | 12.8 | — |
| Water melon stover | *Citrullis lanatus* | 2.2 | — | 9.0 | — | 13.2 | 9.0 |
| Shrub and tree leaves: | | | | | | | |
| Avocado leaves | *Persea americana* | 0.6 | 0.9 | — | 1.4 | — | — |
| Banana leaves | *Musa paradisiaca* | 20.8 | 23.5 | 9.1 | — | 2.8 | 2.6 |
| Capoc leaves | *Ceiba pentandra* | — | — | — | — | 6.0 | 1.3 |
| Erythrina | *Erythrina* sp. | — | — | 2.9 | — | 10.0 | 1.3 |
| Hibiscus | *Hibiscus tiliaceous* | 4.6 | — | 2.8 | — | 6.5 | 32.1 |
| Hibiscus | *Hibiscus rosa-sinensis* | 2.5 | 3.2 | — | — | 1.9 | — |
| Jack fruit leaves | *Artocarpus heterophyllus* | 1.2 | 3.2 | — | 8.1 | 2.4 | — |
| Leucaena | *Leucaena leucocephala* | 0.9 | 1.4 | 1.8 | 2.7 | 1.6 | — |
| Mango leaves | *Mangifera indica* | — | 5.0 | — | — | — | — |
| Papaya leaves | *Carica papaya* | 0.3 | 5.9 | — | — | — | — |
| Sesbania | *Sesbania grandiflora* | — | 2.7 | — | — | 7.6 | 20.9 |
| Thorn apple leaves | *Datura fastuosa* | 0.2 | 0.9 | — | — | 1.2 | — |

a. Data are expressed as a percentage of total crop by-products, shrubs and tree leaves, on an as-fed basis.
b. Wet = wet season; Dry = dry season.

Source: van Eys et al. (1983).

# Potential and Problems of Goat Production in Indonesia

**I.C. Fletcher***

THE broad distribution of ruminant animals in relation to human population and land area is presented in Table 1 to emphasise two general points. First, the goat is numerically an important domestic animal, and on this basis alone the potential and problems of goat production merit consideration. Second, the ratios of small ruminant and human populations to land area differ widely between Java and the rest of Indonesia. This suggests a large potential for increasing goat production through an expansion of numbers, though with enormous problems associated with human population shifts and the development of new land areas. These problems are being addressed through national transmigration schemes, and are not considered here. Emphasis is given rather to the potential and problems of goat production in relation to improving the productivity of existing populations, with the understanding that modest increases in numbers might also be achieved through improved utilisation of existing resources.

**Table 1.** Distribution of ruminants in Indonesia in relation to human population and land area (adapted from Juwarini and Petheram 1983). All units are × 10.

| | *West Java* | *Rest of Java* | *Rest of Indonesia* |
|---|---|---|---|
| Goats | 1.0 | 4.0 | 3.1 |
| Sheep | 1.8 | 1.8 | 0.5 |
| Cattle | 0.2 | 3.7 | 2.7 |
| Buffalo | 0.5 | 0.5 | 1.5 |
| People | 28 | 58 | 64 |
| Land area (ha) | 4.4 | 8.6 | 177.5 |

There is relatively little published or accessible information about the productivity of goats in Indonesia. Small ruminant literature seems somewhat biased towards sheep, possibly because national administration has long been centred in West Java, which also happens to be the only province in which sheep outnumber goats (Table 1). In general, sheep and goat husbandries are not obviously different. It is common within a single village to find some farmers with sheep and others with goats, and reasons for keeping one species or the other appear to be a matter of personal preference rather than any perceived difference in management requirements, productivity or profitability. Indeed, the potential productivity of both species is probably about the same (Obst et al 1980; Chaniago and Obst, unpublished data). Differences in forage utilisation might be expected, but limited evidence (Table 2) suggests that the types of forage offered to sheep and goats vary more between villages than between animal species. Reference is made in this paper to sheep or to small ruminants in general where specific information about goats was not available, but this does not imply that superficial similarities between sheep and goats extend to all aspects of management and production.

**Table 2.** The percentage composition of forage offered to housed sheep and goats in two Javanese villages (van Eys et al. 1983).

| | *Ciburuy* | | *Cirebon* | |
|---|---|---|---|---|
| | *Sheep* | *Goats* | *Sheep* | *Goats* |
| Grasses and herbs | 96 | 93 | 83 | 76 |
| Shrubs and tree leaves | 1 | 2 | 10 | 10 |
| Crop by-products | 3 | 5 | 7 | 14 |

## Potential Benefits from Improved Production

### Economic Well-being of the Rural Population

Over 80% of the total population of approximately 150 million people live outside of the major cities and are largely dependent on agricultural production (BPS 1981). Average farm size is small (commonly less than 0.5 ha in West Java), and many rural families are landless (Thomas and Rangkuti 1983; Basuno and Petheram 1984). Specialised small ruminant farms (Knipscheer et al. 1983) are relatively rare, and most

* Small Ruminant Program Adviser, Balai Penelitian Ternak, Bogor, Indonesia.

of the goat population is maintained by smallholders and landless farmers as a sideline enterprise to generate additional household income. Thus any improvement in goat productivity, besides increasing national production of the various commodities discussed below, will also have the important general consequence of improving the economic well-being of the large rural population.

### Meat

Meat production from all domestic livestock (cattle, buffalo, sheep, goats, and poultry) currently provides an average per capita meat protein consumption of less than 2g/day (BPS 1981). By the year 2000, with predicted population growth, meat production must increase by about 60% to maintain even this level of intake, and by about 170% to achieve a proposed daily target of 2 g meat protein consumption/person. Because of their low capital cost, proficiency, and ease and cheapness of maintenance, goats have particular potential to contribute to this increasing requirement for meat production.

### Leather and Manure

These by-products of goat production are included because they have real economic value, though they are a function of total animal numbers rather than of productivity per animal. Leather is utilised both locally and as an export commodity, and manure has particular importance in Indonesian agricultural systems. It may contribute as much as 25% of the gross income from small ruminant production (Basuno and Petheram 1984), and in some areas is considered to be the most important product from goat farming.

### Milk

There is a high demand for cow milk and dairy products in urban areas that cannot be met by local production, and more than 80% of the present milk consumption is supplied by imported milk powder. The potential for goat milk production is almost totally unrealised. Local goat breeds are capable of producing up to 2 litres of milk per day (Chaniago and Obst unpublished data), but there are few goat dairies, and some of these do not milk on a regular basis, but maintain unweaned kids with the does and remove them for hand milking only when there is a local demand for the milk.

Milk is generally not an important component of the diet of rural people. In a survey of the consumption of animal products by traditional village farmers (Suradisastra and Nolan 1983a), only 6% of respondents claimed to consume milk 'often', 21% 'seldom', and 73% 'very seldom' or 'never'. This was apparently a consequence of the high cost or unavailability of purchased cow milk, and ignorance of or resistance to the potential utilisation of small ruminant milk.

It is difficult to understand why an existing potential for goat milk production should remain unrealised in a country with expensive milk imports and a low per capita animal protein consumption. Two approaches seem possible. First, milk could be accepted from goat farmers and mixed with cow milk in those areas that already have an established cow milk collection system. This would have little initial impact on total milk production, but would test the response of goat farmers to the opportunity of earning extra cash income from milk production and, if successful, could be extended to goat milk collection from hotter low altitude areas near the urban markets, which are better suited to goat than to dairy cow production. Second, and more difficult because it offers no income incentive, a research and education program could be established to promote the consumption of home-produced goat milk as a source of high quality protein, particularly for children, in goat-raising areas that are too remote from markets for cash sales.

### Fibre

Indigenous goat breeds have no potential for commercial fibre production (Robinson 1977). However, common management systems involving continuous housing, and relatively low labour and production costs, could readily be adapted to the production of high quality fibre such as mohair or cashmere to provide increased and diversified income for goat farmers and additional national export income. The manufacture of cloth and garments, possibly of a 'cottage industry' type, might be included to make use of inexpensive labour and provide additional rural employment. (Hand weaving of traditional patterned cloths from imported cotton is already practiced in many parts of the country). Potential difficulties with the importation and acclimatisation of suitable animals, and in the development of production, manufacturing and marketing skills, make this a possibility for future rather than immediate consideration.

## Scope for Improved Production

Average productivity of village goats is about one offspring weaned per breeding female per year (Kartadihardja 1979), and a growth rate of 20–40 g/day (Petheram unpublished data). The potential of these animals is about two offspring weaned per breeding female per year (Obst et al. 1980) and a growth rate of more than 100 g/day (Chaniago and Obst, unpublished data). There is thus a potential to approximately double meat production from the existing goat population. The potential for milk production is difficult to define, but the average daily per capita consumption of 0.27 g milk protein (BPS 1981), largely from cow milk, could be provided from 4 million does with an average daily milk production of about 300 ml. As already stated, there is no potential for fibre production in indigenous goat breeds.

## Potential Sources of Improved Production

### Genetics

The introduction of exotic genotypes, although sometimes superficially seen to provide a quick and easy means of improving productivity, should not be considered at least until the present wide gap between actual and potential production of existing genotypes is reduced. An example of the doubtful benefit of exotic genotypes (Table 3) shows a comparison of the productivity of indigenous Kacang goats and Ettawah goats, now considered as an indigenous breed but originating predominantly from the earlier importation of Jamnapari-type goats from India. In this comparison the larger and faster-growing Ettawah goats actually produced less meat than the Kacang goats, particularly when results were expressed per unit of doe metabolic body weight to give consideration to differences in feed requirement associated with different body size. Studies with sheep similarly have shown that indigenous animals produce more meat per unit of feed intake than larger and faster growing exotic crossbreds (PARD, unpublished data).

On the other hand, because the goat population is virtually an unselected one with considerable within-bred variation in growth rate and body weight, genetic selection for increased production among indigenous genotypes under existing or improving management systems could be a useful component of any wide-ranging program for improving goat production. Any selection program should of course ensure that existing high potential levels of fertility and fecundity are maintained, and would need to include a system for distributing genetically superior animals into the general population.

**Table 3.** The productivity of two Indonesian goat breeds (adapted from Knipscheer and Kusnadi 1983).

| | *Kacang* | *Ettawah* |
|---|---|---|
| Doe wt (kg) | 18 | 24 |
| Litter size | 17.6 | 1.42 |
| Kid survival (%) | 78 | 78 |
| Kidding interval (days) | 210 | 290 |
| No. kids annually weaned | 2.39 | 1.39 |
| Weaning wt (kg) | 8.7 | 13.1 |
| Wt kid annually weaned/doe (kg) | 20.8 | 18.2 |
| Wt kid weaned/kg doe wt 0.75/year (kg) | 2.38 | 1.68 |

### Nutrition

There are a few situations where small areas of pasture grasses or legumes are grown to stabilise land terraces in erosion-prone watershed zones, or where they are stipulated as a condition of government credit schemes supplying small ruminants to smallholders. For the most part, however, feed for goats comes from a wide range of plant species associated with crop residues, tree leaves, and grasses and herbs ('weeds') growing on unproductive lands. The nutritive value of these plant species varies widely (Lowry et al. 1983), and their availability varies both between regions and between seasons within regions. Further, feeding systems vary along a continuum from grazing all year round to continuous housing and hand feeding (Thahar and Petheram 1983). Under these conditions it is obviously impossible to make any general statement about nutritional constraints on goat production, though observation and experimental responses to improved nutrition indicate that energy, protein and/or mineral insufficiencies limit production in at least some animals for some of the time.

Means of improving nutrition include storing forage for use in the dry season, chemical or biological treatment to improve low quality roughages, the provision of mineral supplements and/or high quality feed supplements, and improved utilisation of existing feedstuffs. The last-mentioned approach is particularly attractive in view of the constraints on improving production imposed by farmer attitudes, discussed below. Housed animals are generally fed ad lib, but on any available mixture of plant species that the animals are known to eat without apparent regard to species differences in nutritive value. Further, all animals are usually run together and offered the same mixed herbage except that breeding males, if present, may be penned separately and given preferential feeding. There appears to be scope for improved productivity from existing feedstuffs by selective harvesting of higher quality herbage, when possible, and by the selective use of higher quality herbage from within the harvested material for those animals that have the greatest nutrient demand for production at that time (e.g. young growing animals fed preferentially to non-lactating does, or does in late pregnancy or early lactation fed preferentially to non-working males).

### Reproduction

There is no apparent seasonality in reproduction, nor any pattern of planned mating in relation to seasonal variation in feed availability or market prices. The average goat herd of 3–5 animals often does not include a breeding male, and the general situation is probably similar to that described for sheep in which 10 of 22 village flocks did not maintain any rams of breeding age, and the others maintained rams on average for only 6 months of the year (Bell et al. 1983). Males, whether maintained or borrowed, are commonly used for hand mating rather than being run with females for a prolonged mating period, and mating is not always arranged at the appropriate time. For example, Bell et al. (1983) observed ewes being held for mating without necessarily being in oestrus, and supported this observation with records that 9% of 55 village ewes mated in this way were already pregnant, and only 26% of the non-pregnant ewes conceived to that mating.

There is preliminary evidence that goat reproduction can be increased by improved nutrition during late pregnancy and early lactation (Chaniago and Fletcher unpublished data), and there is scope for improving nutrition either in the ways already discussed or by controlling mating so that maximum nutritional requirements for reproduction coincide with periods of maximum herbage availability. Another and perhaps more immediate means of increasing reproduction could be the development and application of management systems that ensure adequate male/female contact at the appropriate times.

### Health

Ill-health is an important problem of village goats (Basuno and Petheram 1984), and improved disease and parasite control is undoubtedly an important potential avenue for increasing the productivity of village animals. Discussion of the varying incidence of the wide range of bacterial, viral, parasitic, and metabolic diseases is beyond the scope of this paper.

## Production Constraints

### Research and Development

A case for increased research and development can be made for most types of agricultural production in most countries, and goat production in Indonesia is no exception. Potential productivity is reasonably well defined, but much remains to be known about how and to what extent this potential can reasonably be achieved through the various avenues already mentioned. It is not intended to suggest specific priorities for research between and within the general areas of genetics, nutrition, reproduction and health, but rather to discuss the particular importance of considering farmer access to and acceptance of research results in determining any such priorities.

### Farmer Access to Research and Development

The educational level of smallholders and landless farmers, i.e. the majority of goat rearers, is generally low. For example, Basuno and Petheram (1984) found that 68% of ruminant rearers in a village near Bogor had never attended school, and only 1% had progressed beyond primary schooling. This situation will change as the farmers' children, now receiving education, become involved in agricultural production. Nevertheless, it is clear that scientific publication of the results of research and development will not be directly accessible to the goat farmer.

The established agricultural extension service has difficulty in covering the very large and widely dispersed rural population. Extension workers were the main source of information for only 5% of small ruminant farmers in two Javanese villages surveyed by Suradisastra and Nolan (1983b). Both of these villages were near agricultural extension centres, and the situation can only be worse in outlying areas. Limited personal experience, and observations such as those of Bell et al. (1983) already mentioned, suggest that even existing knowledge is not well extended, so it cannot be assumed that the farmer will have even indirect access to the result of research and development from central or regional research centres.

It is virtually impossible to duplicate the widely diverse conditions of smallholder goat production within research centres, and many research results therefore must be tested in village situations before they can be recommended for adoption. Because such results will be not only directly applicable but also immediately accessible to the farmer, high priority should be given to research and development programs carried out within the village.

### Farmer Acceptance of Research and Development

It is clear from Table 4 that small ruminants are kept principally as a means of capital accumulation and storage for use at times of emergency cash need (for such things as medical costs, school fees, and family celebration or ceremonies), and only secondarily as a source of regular income. Farmers undoubtedly want additional income from small ruminants, but see the answer in increased numbers (Basuno and Petheram, 1984), which has very real constraints imposed by limited capital, labour, and in some cases forage availability, rather than increased productivity from existing animals.

A great many factors work against the ready acceptance of any results of research and development that may lead to increased productivity. The fact that small ruminant production is only a supplementary and not a major source of income, and even then regular income is only of secondary importance, is not conducive to extra inputs of limited capital or labour. Animal products are sold as they become available or as money is needed, so there are no regular marketing periods that would allow a comparison of economic return before and after any change in technology. Further, real increases in productivity are not easily detected in the short term from very small herds with high inherent variation. There is a reluctance to make any cash inputs because of low income and a tradition of maintaining animals on 'free' communal forage, compounded by the time delay between expenditure and receipt and difficulties of judging cost effectiveness. Finally, there is a general disinclination to change, exemplified by a survey of small ruminant farmer attitudes (Suradisastra and Nolan 1983b) in which 85% of respondents agreed that 'success in farming is more dependent on God than on the efforts of man.'

Thus priority should be given to research and development, which has the potential to increase productivity through simple technology changes with little or preferably no cash cost. Radically new, complicated or expensive inputs, no matter how cost effective, are unlikely to improve productivity in the short term because of problems with farmer acceptance.

## Summary

Goats in Indonesia have an immediate potential for increased meat production, a longer-term potential for increased milk production, and a possible future potential for fibre production. Increased meat production could come from improved nutrition, reproduction and health in existing genotypes. Increased milk production is a step further away in that utilisation must first be developed before any great emphasis is placed on productivity, and fibre production is even further away since it would require the introduction of exotic genotypes and development of new management techniques.

A major problem of increasing production through research and development is limited farmer access to and acceptance of new information. Priority should be given to research and development programs that extend directly into the villages, and that have the potential to increase productivity through simple technology changes with little or preferably no cash cost.

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# Research for Goat Development in Asia: A Management Consultancy Viewpoint

J. Lindsay Falvey*

THE majority of goats in Asia are found on the Indian subcontinent (India, Bangladesh, and Pakistan) where 90 million goats produce more milk than the 120 million goats present in Africa (Devendra 1975). In terms of meat production, approximately 75% of the 1.9 million tonnes of goat meat produced per year comes from tropical countries with some 32% from India (Devendra and Owens 1983). Such figures are based on goat populations and do not highlight the limitations of present production systems. Research in India concerning goats is conducted according to productive function (e.g. milking goat research at the National Dairy Research Institute, Karnal).

A national goat research program in India with major stations at Assam, Andhra Pradesh, and Hyderabad provides an integrated approach with emphasis on crossbreeding to increase milk production and to a lesser extent meat production. The depression in production of $F_2$ stock is a continuing area of research. Nutrition research tends to be related to concentrate feeding for milk production, which appears to be essential in many states. Interpretation of results from experiments conducted on government farms presents a minor development problem but is now acknowledged.

## Research and Development

### The Role of Goats in Development

Agricultural research in Asia has an increasing responsibility to be seen as supporting development policies and programs. Development relies strongly on political will; national policy as the expression of government activity is affected by research in two major ways, viz. (a) providing solutions to development problems, or (b), presenting new information to government for the allocation of funds to a new area. The former point is of greater importance to developing countries in Asia, particularly when it relates to an existing industry. The latter point is an important philosophical link in the role of research in more developed countries. With respect to goat research, this paper is biased toward the provision of solutions to development problems.

Experience with goats and goat research in Australia is limited by the relative insignificance of the goat industries in Australia. However, expertise in technical fields related to goat development does exist as this meeting testifies. The presence of interest and relevant expertise yet limited experience provides an opportunity to meet the stated goals of ACIAR in a way that may not always be possible in industries where Australian expertise is closely associated with Australian social and economic constraints. To be used to advantage, the expertise available in Australia should be viewed as a resource to be coordinated in an overall program. Similarly, in many of the Asian countries that may join in a goat research program, goat research is not allocated a high priority and expertise in the goat fields is generally less available than in other fields.

In development, the criteria for expansion or introduction of an animal species to an economic environment are (a) degree of competition for human feed resources; (b) investment cost and rate of return; (c) potential for export of product from production area; and (d) social acceptability.

Goats fulfil such criteria in many possible situations in Asia although certain technical limitations appear to restrict development at the present time. Many of those limitations in the wet tropics may be related to the origin of goats in the dry tropics. Thus solutions to technical problems is an important point in preparing for the development of the industry. However, other problem areas may also restrict development such as the social and economic areas, and preparation of a development strategy relies on acknowledging each of these areas as being critical. In the discussion of problem-orientated research (ACIAR 1983), the areas of social and economic research must be combined with technical research in a coordinated program with predetermined goals. When considered in a development context, the question of the technical productivity of goats becomes only one aspect and I therefore wish to talk more about the other aspects because the technical points will be covered in other papers.

* MPW Rural Development Pty Ltd. Perth, W.A., Australia.

## Development Context

As development is usually considered on a national basis, it is at this national goal level that decisions concerning priority research areas can be made. Formulation of general goals will therefore be accomplished by (a) a consensus of perceived problems across a region, and (b) integration of common national goals. These two mechanisms are separated in the means by which they are determined. The first mechanism involves discussion among researchers such as is being achieved at this workshop. The second involves national planners; this is more difficult to accomplish on a regional basis and is possibly best undertaken entirely at national level initially to determine specific goals and then allowing persons involved in a coordinated research program to seek to integrate these goals.

Therefore, the development context that we can consider must be general. Accordingly, we can look at some general principles of importance to goat development research. Experience in goat development programs suggests that, more so than with other common domestic species, expansion of goat production is more likely to succeed in areas where goats are already raised. This is of little import to some countries or provinces where goats are universally known; however, in Thailand, for example, this would concentrate development and research attention on the southern provinces rather than the northern highlands.

The time lag inherent in all extension undertakings added to the time inputs required for research, preclude consideration of attempts to introduce goats to new areas of Asia unless some strong and substantial political commitment is guaranteed. Determining solutions to existing problems potentially leads to faster implementation of results. The alternative of researching a new area where goats have not previously been raised requires attention to many potential and perceived constraints prior to entering a problem-oriented research phase. Regional research programs do not exist in Asia; the approach adopted by ILCA (1979) is based on finding solutions to problems in areas where goats are raised and provide some 20–30% of the meat consumed in the area.

Understanding the social environment where development is planned is critical to the success of the development and the research phase must include analysis of social problems in addition to any technical problems identified. Two overriding considerations supporting a significant social research input for goats in Asia are:

1. Goats are commonly raised on a smallholder basis in Asia and thus development of the industry necessarily involves large numbers of people.

2. Goats require specific management inputs (McKensie 1974) and expansion of the industry necessitates additional labour inputs.

Devendra (1978) notes that the potential for goat development is great in Asia in general and is dependent on proper management inputs. Acknowledging the importance of management inputs, top-down planning for goat development or simple extension of technical advances will not ensure successful development. The close association of people with goats highlights the need for initial social research inputs into goat research programs.

## Research Areas for Goat Development in Asia

The areas of research to be considered with respect to most development are social, economic and technical, together with the additional input of political will. The possible secondary impact of research on political will is mentioned only to illustrate the operation of this mechanism in the long term; this is not considered to be of major import in the phase of problem-oriented research.

### Social Research

Social research provides a means of answering questions concerning the reasons for lack of adoption of new technology. It also provides an understanding of the direction in which research should aim. By highlighting such matters as social taboos, these aspects can be considered in research programs. The most common means of incorporating social research into research programs is by use of surveys. Such surveys do not have to be conducted by social scientists alone and probably are better conducted in conjunction with economic and technical researchers to promote an understanding of the context in which research is to be conducted.

Social surveys must be related to the options available in order to present useful results. Development orientation in such surveys is assured by preliminary investigation of national policy goals and alignment of these general goals with technical alternatives.

With respect to goats, management inputs constitute a specific social and technical question. Under Asian smallholder systems, goats are usually raised with minimal inputs; an increase in reproduction and the implied increase in goat population would probably not be suited by simple expansion of the management system. A higher labour and/or capital input is most likely to be required. It is usual for livestock raisers in general to increase livestock management inputs as human population pressure increases (Lageman 1977).

However, such correlations are based on situations of necessity; thus research concerning improved management techniques under field conditions would be best concentrated on areas of higher human population density.

The investment cost for entering goat production is significantly lower than that for entering cattle or buffalo production and the rate of capital return is faster. This was found to be the main reason that farmers entered goat production in the Philippines (BAI, no date). In social terms, the proportion of the population that can afford to enter goat production also requires definition in a development area in order to phase development and determine the needs for grants, subsidies, or loans.

Technical and social research should be ongoing and related closely to each other. However, a development orientation may preclude the use of villagers' goats in technical research. Examples include crossbreeding programs where exotic breeds have been introduced to farmers in Asia and the performance of progeny subsequently recorded by researchers. Crossbreeding with exotic males is usually easy to introduce because it promises visual improvement. The associated risks accruing from inadequate nutrition, management and disease control can jeopardise the extension relationship between development agency and farmer while the research may still appear to obtain satisfactory results. Thus, while the relationship between social and technical research must be close, a development orientation necessitates consideration of the final objective.

Surveys of goat industries have been conducted in many areas of Asia (e.g. Falvey 1977) and serve as basic information sources for technical research. However, ongoing social research inputs are required as solutions to technical problems are found in order to determine the acceptability of the innovations.

## Economic Research

Economic research can be divided into market research and cost/benefit analysis. Initial market research is essential to development inputs to ensure that increased production is saleable. In many Asian development situations involving goats the additional products are assumed to be consumed by producers. Development is usually more successful if products are also sold as this provides some transfer of commodities to producers. For example, in the Philippines, Sweeney (1981) has suggested that goat meat consumption may be rising from 0.2 kg per capita per annum (compared with 3.9 kg for poultry, 6.2 kg for pork and 2.2 kg for beef) as a result of rising meat prices and the higher efficiency of goat meat production. Cost/benefit analyses at the producer level provide an indication of the farmers position; national economic benefit may also be a consideration of some Asian Governments and political decisions based on other development criteria, often social development, can transcend farm level financial analysis.

Some other economic research tasks for Asia include (a) comparisons of small and large breeds, (b) comparisons of goat production with other ruminants, and (c) economic description of the farm system and the role of the goat.

Upon completion of individual technical research projects, development packages using these results and social research should be prepared. Presentation of results in such terms provides planners and development agencies with the information required to determine the nature of the development promotion.

## Technical research

The disciplines of technical research of relevance to goat production have been discussed in other papers. The major technical subject area recurring in discussions of goat development is disease control; this is highlighted in both Asia (Pharo 1981) and Africa (ILCA 1979). The origin of the goat in the dry tropics apparently leads to some susceptibility to diseases of the humid tropics, which constitute large areas of Asia. Goats in the drier areas of India appear less susceptible if nutrition is adequate. Health is often overlooked as a research area and assumed to be a development problem that can be met from existing knowledge. However, the economics of disease control in goats in Asia have not been determined and appear to be a widely spread requirement for a practical research program. Nutrition in support of development relates primarily to improvement of ration quality under local conditions; other more basic nutritional research in support of these objectives may also be justified to assist in applied research design. Breeding research has been reported from pilot experiments cum development efforts in various places such as Thailand (Suthiwanich 1982) and the Philippines (Anista and Anchau 1982); such approaches have drawbacks in both research and development terms. Breeding research, while appearing further advanced than other technical areas in Asia, still requires controlled breed comparisons for most development situations. The relationships between nutrition, management and breed type, and the relative economics of different breeds under varying circumstances, necessitate the integration of breeding research programs with other programs.

Vaughan (1981) has identified research areas for the ASEAN region as:

1. Nutrition — growth rates with and without supplementation;
   — comparisons of native and $F_1$ animals;
   — feed/reproduction interactions for local and $F_1$ goats.
2. Management — tethering effects on growth and reproduction;
   — low cost housing;
   — nutrition/time of mating;
   — age at first kidding.
3. Disease — effect of housing, drenching and vaccination on disease incidence;
   — survey of diseases in local goats.
4. Breeding — selection within native populations;
   — $F_2$ depression production;
   — milking breeds utility.

Specific technical research needs must be determined for each identified area of potential development, due to the increasing sophistication of development planning in most Asian countries. This requires discussion between planners, technical researchers, social researchers, economic researchers, research coordinators, and the research sponsor. In each specific project area such meetings should determine programs that can be linked to an overall program, coordinated by the research sponsor. Within this context it can be seen that technical research serves the interests of development, and that development planning relies on consultation with technical researchers.

## Research Coordination

Coordination of research is implied throughout this paper as an essential input to effectively utilise limited resources for goat research in Asia. Within the primary constraint of keeping research practical and acknowledging the diverse social and physical environments in Asia, the concept of discrete development packages being produced from a centralised research program seems limited.

Research networks are a common means of encouraging researcher communication and hence stimulating interactive research, however networks cannot be an end in themselves. The responsibility of researchers to contribute to national development remains the primary orientation of research, which a communication network must acknowledge. Thus research conducted by service agencies within the countries concerned is likely to receive local support and acceptance assuming that it is well executed. Coordination of the research conducted by such agencies on one hand and research institutions on the other is therefore necessary.

Coordination of an Asian goat research program includes the following tasks:

1. Collation of research topics for social, technical and economic areas.
2. Determining or seeking information on the congruity of existing research objectives and national development plans.
3. Selecting programs supporting development plans likely to be allocated priority by government.
4. Promoting communication through meetings and publications.

The primary inputs to an Asian goat research program would be provided by ACIAR funding and general coordination. Australian resources to be provided under ACIAR would include expertise from Government institutions and departments, and private sector development specialists. The roles of institutions could be clearly defined to specific research areas while that of development-oriented companies could be defined as social and economic research (analyses) in conjunction with the technical research conducted by institutions. This would include integration of program design with national development plan objectives as a service to research coordination; it would not include the preparation of development projects from the research results.

Researchers in participating countries would contribute actively in their respective research programs and in the coordination and network activities assisted by ACIAR. Facilities for practical animal production research in most Asian countries are adequate for this program although commitment by cooperating governments will require their upgrading some facilities.

## Conclusion

Research should support development objectives and this should be a requirement of research coordination. Research coordination can be effected in various ways and is an essential ingredient of an Asian goat research program. The specialist nature of Australian expertise in this field suggests that general research and development expertise should also be engaged in the program.

Goat research for Asia requires an initial concentration on identification of development opportunities. This accommodates the social constraints to development and implies the need for an early commitment to social and economic research. Research would be concentrated in areas of greatest potential for development, which will usually be areas where goats are already being raised. Based on the experience of raisers and existing research, technical research can being at an early stage. In order to accelerate the program, an initial survey incorporating social, economic, and technical constraints to development will be necessary in most instances.

To coordinate the results of surveys, they should be conducted in a similar manner to each other in different areas and countries. Coordination of surveys would be effected through a common input in all surveys. This coordination input could then form the basis of a network for technical research and follow-up and economic research.

With a recognised high potential for goat development in South and Southeast Asia, efficient use of limited research funds and experience necessitates a close association between research and development.

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# Goat Production and Research in Fiji

S.W. Walkden-Brown*

THE exact date of the introduction of goats to Fiji is not known, but they were reported to have been raised by missionaries and European settlers as early as 1860. Subsequently from 1877 to 1916 some goats appear to have been introduced from the Indian subcontinent along with Indian settlers. There has been a steady increase in goat population since the first agricultural census of 1933, when there were 20 433 recorded. Census records for 1942, 1950, 1969 and 1978 show 27 183, 23 787, 66 151 and 121 567 respectively.

The first serious look at goats as farm animals in Fiji appears to have been taken in the early 1950s when the Economic Review Committee recommended the importation of bucks for the upgrading of local animals. A goat breeding centre was established at Sigatoka Research Station and locally purchased does were crossed with imported Angora, Saanen, and Toggenburg bucks, the objective being to produce a suitable meat goat for Fiji conditions.

Despite an encouraging start, subsequent observations suggested that Saanens and Toggenburgs were unsuitable for upgrading as they failed to thrive well under local conditions. The Angoras were too small to significantly improve the meat-producing potential of Fiji goats. These results led to the introduction of the Anglo-Nubian breed in small numbers in the late 1960s for crossbreeding trials. This breed has proved successful, and the current upgrading program is now based largely upon it.

In October 1972, the Fiji Government approached UNDP/FAO for assistance in the development of a goat industry, to improve local production of goat meat, and to curb imports of this commodity. A feasibility study concluded that commercial goat farming could be practically and economically viable under correct management. A program of inputs necessary to commence a national goat development scheme was prepared, and the project Fiji 75/004 was initiated. Since September 1975 the project has been implemented jointly by the Government of Fiji and UNDP/FAO.

Production over the years can only be estimated from population data, as the proportion of total production that can be accurately quantified is very small. This is due to the fact that the vast majority of goats are sold directly to the consumer and are slaughtered at home for home consumption. There has been a decline in registered slaughterings over the past decade from 769 animals in 1973 to 358 in 1982. Total production of goat meat is calculated by taking the average carcass weight passing through the abattoirs, and multiplying by 33% of the total population estimate, based on census findings.

The distribution of the goat population has always been largely determined by the density of the Indian population in an area and the suitability of the area for goats. Thus the Western Division contains the bulk of the national herd. Exceptions to the above rules are the keeping of goats on large copra plantations in the Northern and Eastern Divisions by Europeans, Fijians, and Part Europeans and the maintenance of large herds of goats on islands by Fijians in the Eastern Division and the Yasawas.

The stated intentions for goat production in the DP8 period can be summarised as follows:

- To produce more goat meat to meet local demand and substitute for imported goat meat and mutton. A total of 125 farms are to be established on 1250 ha of land during the DP8 period. Goat meat production is targeted to be boosted from 360 to 500 tonnes per annum over the period.
- To create employment and income in rural areas by the establishment of smallholder farms.
- To integrate goat farming with crop farming.

## Goat Productivity in Fiji

The 155 000 goats in Fiji are distributed through Divisions as follows: Western 67%, Northern 21%, Central 6% and Eastern 6%. The province of Ba has the maximum concentration, holding 42% of the national herd. Other population statistics are as follows:

- By sex and age: nearly 50% are females over 10 months old, nearly 15% are males over 10 months old, and 35% are males and females under 10 months of age.

* Ministry of Primary Industry, Suva, Fiji.

• By type of land tenure: leased 59%, (19.5% crown, 39.5% native), freehold 16%, unleased 25% (all native land).

• By race of owner: 64% owned by Indians, 29% by Fijians, 7% by other races.

• By type of holding: 46% on cane farms, 8% on commercial livestock farms (probably higher in 1983), 3% on copra plantations, and 43% on other types of holdings.

• By farm size: 31% of goats were held on holdings under 1 ha, 45% on farms 1–10 ha, and 24% on farms greater than 10 ha.

**Production Systems**

The vast majority of goats in Fiji are kept as a subsidiary enterprise, and because of competing demands for time, and other reasons, most farmers use very low or zero management systems for their goats. There is no uniform single system of management practiced in the country. Most goat farming falls into one of the following size categories.

• Small scale goat raising by Indian farmers as a sideline to sugarcane or other cash crops. Nearly 91% of goats are reared by subsistence and small scale farmers. These goats are raised largely for personal requirements with occasional sales, and are usually tethered by roadsides, or on uncropped hillsides and flats by day, and given shelter and protection of some sort at night.

• Goat raising by Fijian cattle farmers in the Western Division, particularly in the Beef Schemes such as Yalavou, Ului saivou and Tilivalevu. These farmers tend to graze goats extensively on native and semi-improved pastures under goat fencing, with provision for shelter, but with few other management inputs or supervision.

• Goat raising by Fijian land owners on offshore islands particularly in the Yasawas. These herds range without restriction or supervision apart from occasional night yarding and slashing of *Leucaena leucocephala* (Vaivai) for the goats to eat.

• Large scale goat raising by copra plantation owners in Vanua Levu, Taveuni, and Laucala with a view to maintaining clean plantations to facilitate nut collection.

• Goat raising, mainly by Indian farmers, as a sideline to dairy farming in the Central Division.

• There now exist some 450 supervised commercial goat farms where management inputs in the areas of breeding, health, nutrition, and stock control are being stressed and in most cases adopted. These farms are scattered throughout Fiji, with a concentration in the Western Division. The farms include the first five types described above, as well as new farms that are run solely as goat farms. Their unifying characteristic is the importance placed on the goat enterprise, which is run along commercial lines, usually with management inputs not found in the other goat raising systems outlined above.

**Goat productivity from pastures**

Stocking rates range from 1.2 breeding does and follower/acre, (3 does/ha), on mission grass country at Yalavou; 2.0 does/acre, (4.7 does/ha), on Nadi Blue/*Desmodium heterophylum* country at Sigatoka Research Station; 3.1 does/acre, (7.4/ha), on *Paspalum*/Batiki Blue grass/Para grass/*Pueraria phaseoloides* country at Wainigata Research Station in Macuata; up to 8 does/acre, (20/ha), on some Central Division Farms using the semi-intensive system, through to 20 does/acre (47/ha) on some fully intensive farms in the Western Division.

There has been insufficient work done on determining the best pastures for goats in various parts of the country. The continued reliance of the industry upon Nadi and Batiki Blue grass will result in a continuation of suboptimal productivity per unit of land. In Bua and Macuata, stocking rates are being doubled with the use of Koronivia grass, instead of Mission or Nadi Blue grass. The possibility of raising goats on *Setaria*, Guinea, and Koronivia grasses, as well as imported strains of Vaivai (*Leucaena*) and other tropical legumes should be more fully investigated. It is recommended the Pastures section of the Research Division be directed to include research into goat pastures in their program. There is currently an under-utilised pasture section SFA at SRS.

**Meat Production**

The goat population is estimated at 155 000 in 1983. This is based on a conservative 5% annual growth rate since the 1978 Agricultural Census. Using the accepted formula, production of goat meat in 1983 is projected at some 550 tonnes of goat carcass. Table 1 outlines production and imports over the last years.

Under 1% of the total estimated production is slaughtered in registered slaughterhouses. This is a reflection of the awareness of farmers of the superior profit margin in direct sales to consumers, the number of small farms that grow goats only for home consumption, and the preference of many consumers for home slaughtering. The latter in turn reflects the cultural and religious customs of the consumers. For example, some Hindus and Muslims find objection to eating goat meat from animals that have been slaughtered in a slaughtering facility that also processes cattle or pigs, regardless of the fact that the killing lines are entirely separate. Currently there appears to be an increase in the number of animals passing through slaughterhouses, probably due to increased national

**Table 1.** Goat meat production and net imports

| | Local | | | | | Imports | Total Consumed | | |
|---|---|---|---|---|---|---|---|---|---|
| | Abattoirs | | | Other | | | | | |
| | *Killed (No.)* | *Wt. (t)* | *Av. Wt. (kg)* | *Est. Wt. (t)* | *Total Wt. (t)* | *Imports Net (t)* | *Local + Imports (t)* | *Local (%)* | *Per capita cons. (kg)* |
| 1978 | 235 | 2.6 | 11.3 | 303 | 305.6 | 285 | 590.6 | 51 | 1.0 |
| 1979 | 130 | 1.5 | 11.4 | 330 | 331.5 | 242 | 573.5 | 58 | .9 |
| 1980 | 72 | 1.0 | 13.8 | 450 | 451.0 | 230 | 681.0 | 66 | 1.0 |
| 1981 | 158 | 1.7 | 10.7 | 500 | 501.7 | 236 | 737.7 | 68 | 1.1 |
| 1982 | 358 | 3.9 | 10.8 | 525 | 528.9 | 247 | 775.9 | 68 | 1.2 |

**Table 2.** Retail price and per capita consumption of some meats in Fiji.

| *Meat type* | *Retail price/kg (Nov. 1983. Whole carcass basis)* | *Per capita carcass consumption (kg) (1982)* |
|---|---|---|
| Beef | $1.98 | 12.0 |
| Mutton | $2.35 (Lamb fore-quarter) | 6.0 |
| Pork | $2.50 | 1.1 |
| Chicken | $2.95 | 5.1 |
| Goat-Imported | $3.00 | |
| Local culled does | $4.50 | 1.2 |
| Buck at $2.00/kg l.wt basis | $6.20 | |

production, which in some cases has not been able to be marketed through conventional channels.

## Demand

Goat meat is the premier red meat in the eyes of much of the Indian population. It is not subject to restrictions on religious grounds as are beef and pork. Table 2 outlines the current retail prices and per capita consumption of the major meats consumed in Fiji.

The demand for goat meat is naturally dependent on price. On this basis, demand for goat meat can be divided into four categories that are not altogether interchangeable.

• Demand for live goats for home slaughter. Currently prices range from F$1.80 to $2.60/kg liveweight. This is the major market areas and demand remains strong. The demand from this market can be held responsible for the annual growth rate of over 5% in the goat population over the past two decades.

The demand for this commodity is seasonal in nature, there being major peaks in demand during the year. In order of importance, these peaks are at Christmas/New Year (late December), Eid ul Zhua (currently in early September, but 7 days earlier every year) and Easter (early April). Between seasonal peaks, demand is maintained by weddings and other private festivities. There is evidence that we are currently approaching saturation of this market in some areas as seen by the recent shift from passive selling by farmers to aggressive attempts to sell by some. Unless there is a significant fall in price it is anticipated that production will outstrip demand for live goats at these prices, over the next year or two. Naturally this will force a price reduction and demand can be expected to increase.

• Demand for fresh goat meat at $6.00/kg and over, (i.e. the actual cost of meat bought on the above basis). This appears to be a limited market area, as can be seen by the failure of many butcheries to retail this product, and the very low official slaughter figures.

A 25 kg goat sold to a butcher at $2.00/kg liveweight would retail for about $6.20/kg in a butcher shop. An analysis of the various costings provides the following picture:

| | | |
|---|---|---|
| Purchase price at $2.00/kg liveweight | = | $50.00 |
| Killing fee at abattoir | = | 1.70 |
| Meat inspection fee | = | 0.30 |
| 30% mark up for retail | = | 15.00 |

A 43% dressing out percentage would result in a carcass weighing 10.75 kg. Spreading the costs over this weight of carcass would necessitate a retail price of $6.23/kg.

• Demand for fresh or frozen goat meat at approximately $3.00/kg. Using imported frozen goat meat to satisfy this, the current demand is some 250 tonnes per annum. Local, fresh goat meat, being a superior product could expect to create greater demand at this price, or a similar demand at a higher price, say $4.00–$4.50.

• Demand for mutton at approximately $2.50/kg. This is a huge market area; Fiji imports some 3800 tonnes of mutton per annum to meet the demand. Goat meat offered on a same price basis could be expected to take a good share of this market.

In short there is a very large reservoir of demand for goat meat, but the demand for the current high priced commodity offered by farmers may be met by projected production over the next year or two.

**Milk**

Despite the known milk producing potential of Fiji goats, there is no commercial production of goat's milk. Average yields of 1.6 kg/day, and 1.75 kg/day over 90-day lactation periods have been recorded at Sigatoka and Wainigata Research Stations from does on grass pastures with supplementation. There is potential for increasing the number of rural and peri-urban families who keep goats for home milk production, but commercial production is unlikely to expand in the immediate future.

**Fibre**

While Angora blood is much in evidence in some of our goats, animals are not of a high enough grade to produce useful fleeces. On the other hand a variable proportion of goats exhibit the tendency to grow cashmere, or pashmina, over the autumn/winter period with a late winter/early spring shedding. As yet this rather valuable commodity is completely unexploited. In Australia a cashmere industry is being established from a feral goat base. Certainly we appear to have a broad genetic base in the national herd, from which cashmere producing goats could be selected.

**Marketing Organisation**

There is a dearth of reliable or factual information on this subject. At present there is no single organised market able to cater for sale of goats on a large scale; sales involve private, on-farm transactions, between the farmer and consumer. While this system offers the highest rate of return for the farmer, it does not cater for large-scale sale of stock, nor does it apply in some areas of current goat development in remote or predominantly Fijian areas.

Organised marketing occurs in the following ways:

• Sale to Indian middlemen based around the major urban centres. There has been a contraction in the number of goats disposed of by this method recently, due to the collapse of a large Lautoka-based operation, and difficulty experienced by some middlemen in disposing of stock at a profitable price. In the Western Division M.A.F. staff are actively engaged in the marketing of stock for farmers, acting as links between farmers and middlemen, and providing transport at cost.

• Sale through Commercial Undertakings, a branch of M.A.F. This method was developed in April 1983, primarily to cater for the sale of the large volume of goats being produced by the Yalavou Rural Development Project, but it also processes goats from the Eastern Division and now other areas in the Western Division.

• Goats in small numbers are sold live at markets in all major towns, particularly in Labasa. There have also been annual organised sales of goats from the Yasawas on Lautoka Wharf. Recently there have been problems obtaining prices expected by farmers at these sales.

• Sale to registered butchers through registered slaughterhouses.

• Sale through unregistered slaughtering establishments for illegal sale of meat. This illegal trade cannot be accurately quantified but it is thought to be of a significant volume.

• Sale of imported frozen goat meat through butchers, supermarkets and other retail outlets.

The prime marketable product is a live entire male goat in the weight range 20–30 kg for which anything from $40 to $70 is paid. Beyond this weight consumers are unwilling to maintain the high price per unit weight, that is offered in this weight range. The sale of female goats for slaughter can be restricted by religious and traditional beliefs that appear to vary markedly between individual consumers and whole areas or districts. The major prejudice is the Hindu aversion to killing the mother animal, or any animal that may be bearing young at the time of slaughter. At present there are few problems encountered with the sale of surplus female stock due to the present high demand for breeding stock, the industry being in a state of expansion.

However, problems have been encountered with the disposal of aged culled does, which can only be marketed for $25–$30 each. The marketing of castrated stock is also an area subject to differing opinions, and it is not clear to what extent there is prejudice against these animals.

The absence of large-scale organised marketing reflects the relative lack of sophistication, and the small-scale nature of the goat industry to date. With the technical inputs recently given to goat production, the scale of production on some farms and projects is now beyond that which can be adequately handled by the traditional marketing systems. The increase in goat production expected over the next decade will surely result in widespread changes in goat marketing, either in the methods involved or in the current pricing structure.

**Farm Economics**

This area warrants further investigation so that the factors involved in enhanced profitability, and those which act as constraints to profitability are more clearly defined and appreciated. As with most enterprises, goat production can be very profitable in some locations, under certain sets of circumstances. However it is now apparent that significant numbers of farms have been established without due regard to the potential profitability of the operation.

It is beyond the scope of this paper to give a detailed economic analysis of goat production under the many systems of management and wide range of locations that it occurs. However, this analysis has been undertaken elsewhere (Walkden-Brown et al. 1983), and suggests that high profit margins per doe ($30) are possible where family labour and improved management techniques are used.

A study conducted at the Yalavou Project revealed that the variability of actual farm production, compared to the budgeted target, was far greater for goats as compared to cattle in the project. It should be noted that the increased variability extended on both sides of the budgeted targets. This reflects the greater sensitivity of goat production parameters to management inputs, than those for beef production. Table 3 demonstrates how this sensitivity can be directly extrapolated to the economics of goat farming.

**Table 3.** A model of four farms, demonstrating actual net profit per doe with variations in production and marketing parameters (labour not costed).

| *Farm No.* | *Kidding %* | *Kid mortality %* | *Price/kg l.wt. (Grower/cull)* | *Net profit per doe* |
|---|---|---|---|---|
| 1 | 80 | 20 | $1.80/$1.00 | $ 3.66 |
| 2 | 120 | 10 | $1.80/$1.00 | $23.66 |
| 3 | 120 | 10 | $2.20/$1.40 | $34.74 |
| 4 | 150 | 5 | $1.80/$1.00 | $37.66 |

The failure of many farms to perform adequately and economically is not always the fault of the farmer or of his stock. In many cases too much has been expected of both. It is a great deal to expect of any commodity, that the cost of developing virgin land into farmland, using money loaned at semi-commercial rates, can be borne by that commodity, while at the same time providing the farmer with an income on which to live. In essence such farmers are pioneers, and pioneer land developers overseas in the past have generally been highly motivated persons, usually with the twin incentives of large tracts of land, free or at very low cost, and of access to very cheap labour. Later land developments in such countries have been carried out by already successful farming enterprises, or as major projects with major government subsidisation.

It is possible that if future large-scale development of virgin land into grazing land is to be successful, government subsidisation of such development may have to increase. A simple method would be for the government to pay a subsidy for proper fencing on a per kilometre basis, with a further subsidy for pasture development on that land on a per hectare basis. These subsidies would be effective and not open to abuse, as are so many other subsidies. They also directly reward genuine development that has called for farmer inputs. In effect it is a more selective subsidisation that would benefit those who deserved it most.

### Social Aspects

Over 24% of the agricultural holdings in Fiji maintained goats in 1978, and the number of such holdings had more than doubled over the preceding decade. There are currently some 15 000 goat holdings in Fiji. Over and above this large manpower reserve, there is a reservoir of potential goat farmers amongst existing farmers of other types (e.g. copra, sugar cane) and amongst land owners or lease holders who are currently not engaged in farming.

The training of most farmers occurs through the normal extension network and is supplemented by field days, manuals and other publications, radio broadcasts, the newspapers, and for some, specific training at Sigatoka Research Station. Extension officers tend to be overloaded with farms, servicing between 20 and 120 farms each.

The performance of a large majority of farmers is suboptimal for the following reasons:

- Persistence of traditional low input, low productivity production systems, with the relegation of goats to low priority by mixed farmers.
- Failure of many new farmers to fully grasp and implement the relatively complex management requirements of goat farming.
- Farmer absenteeism and poor work attitudes.
- Real production problems, most notably internal parasitism, foot rot, dog attacks, poor nutrition and high kid mortality.
- The development of farms that in reality are not economically viable, due to problems of scale, and/or location. There is a great deal of variability in performance amongst goat farmers, due to the high sensitivity of performance parameters to management inputs.

The distribution of goat farms in Fiji is widespread with a concentration in the Western Division. In general the commonly stated needs and interests of these farmers are:

- Strengthening of extension services, particularly in Northern and Eastern Divisions. This usually takes the form of requests for increased supervision. This would entail increased staff numbers and/or increased staff mobility.
- Easier access to animal health products.

• Access to accurate technical data on production and economic aspects of goat farming.

• Financial help or concessions in a variety of forms, most notably in the form of subsidised breeding stock, and further subsidisation of fencing.

• Assistance with transportation of materials and animals and assistance with purchasing and marketing of stock.

## Political Aspects

FAO/UNDP, through the goat project, has injected $527 300 in the form of staffing and technical aid into goat development over the last 10 years. This support ceased when the project was handed over to the Fiji Government in early 1983. The projected government financial inputs over the DP8 period are $630 000. The impetus given to goat development under the FAO/UNDP project has been largely responsible for major development to date.

Over the past few years there has been a great deal of financial assistance given to goat farmers in the form of loans from the Fiji Development Bank (FDB), and direct grants through various agencies. The total number of FDB assisted goat farms is 237 with loans totalling $1.54 million. Other forms of financial assistance have included government subsidies on fencing materials, fertilisers and chaff cutters, and the declaration of a total income tax exemption for goat farmers for the DP8 period.

The present goat industry is based on a large number of widely scattered farms with no recognised representative body and no organised marketing system. A degree of cohesion is provided in the form of supervision and technical assistance to farms from the Animal Health and Production extension team, however, the industry itself has little infrastructure. The government infrastructure involves the following full-time staff working with goats:

• Administration: 1 S.A.O. (UNDP/FAO) — till end of 1983, 1 V.O.

• Research: 5 S.F.A.s 1 F.A., 4 Unestablished Staff, and 3 Casuals

• Extension: 1 T.O. III (Lautoka) and 6 S.F.A.s (Nausori, Sigatoka, Tavua, Lautoka, Bua, Levuka). In addition there are many livestock officers working part-time on goats.

## Goat Improvement

Reproductive performance ranges from kidding percentage of 200% per annum, for does fed concentrates virtually ad libitum, to 175% in an elite breeding herd at Sigatoka Research Station, and the herd at Wainigata on legume-dominated pastures with low parasite burdens, to a 110–120% average on government stations and better farms, to 50–60% on some poorly managed extensive-type properties. This parameter is very sensitive to the level of management and nutrition, particularly the latter. Does on excellent nutrition can be mated when 8 months old, depending on the season, at around 23 kg liveweight, whereas most does in Fiji usually do not mate fruitfully until around 17 months.

Mortality at government stations averages 8.5% per annum, but on many farms figures of 20–30% would be more accurate, with individual cases of mortality rising above 50% per annum in a given year due to dog attacks, internal parasitism and exposure to inclement weather. This parameter is also highly sensitive to management skill.

Traditionally, male goats reach the optimum marketable size of around 25 kg at 12–18 months, but by the provision of improved nutrition this period has been reduced to as short a period as 5 months in nutrition trials at Sigatoka Research Station. This parameter is highly dependent on the nutrition and breeding of the animals involved. Infusions of Anglo-Nubian blood improve birth weights and growth rates under virtually all situations.

### Technical Problems

Some of the technical problems facing the industry and needing solutions are as follows:

• Lack of sufficient management skills amongst farmers.

• Low stocking rates, and poor nutritional quality of most pastures used for goat farming, leading to low productivity per acre, coupled with high costs for housing and fencing.

• The animal health problems of internal parasitism, dog attacks, and foot rot. Dog attacks occur all over the country while the other two problems are accentuated in the Central Division, and wetter areas of other Divisions.

• The lack of a large-volume organised marketing system. Until this is developed there will be constraints on the scale of production that can be entered into by individual farmers, particularly using fully intensive systems. This is potentially the major constraint facing the future development of the industry.

• The problems of uncontrolled grazing, leading to erosion and pasture damage. While this problem can be attributed to poor management, (e.g. overstocking, grazing steep gradients) it must be accepted as a problem when good management cannot be guaranteed.

### Social Problems

The major problems here are attitudinal.

• Full-time goat farming is non-traditional and carries little status. This is particularly true in some Fijian communities.

• Many new farmers see goat farming as a low capital, low management, high return enterprise, which it is not. This belief has its origins in the common knowledge that goats excel when left to run wild. It is not widely understood that once goats are contained in fences, on pasture, in our climate, a host of disease and other problems are now exacerbated, and that the control of these require constant attention, (i.e. daily) and a high density of stockmanship.

• Lack of promotional incentives amongst livestock staff. Many staff remain at SFA level for very long periods leading to a loss of morale and attempts to move to another field where promotional opportunities may be better.

## Economic Problems

Some of the goat farms that have been established with FDB loans appear to have been over-capitalised. The burden of debt and interest repayments on these farms is beyond the means of the goat farmers.

While many farmers and field officers are aware of the ability of goat enterprises to produce a good gross margin (income less variable costs) there is less understanding of the capital-intensive nature of goat farming using the present systems and the effect that this capital burden has on profitability. Certainly the economic evaluation of projected farms could be improved.

There is a dearth of information on production and economic parameters of goat production in the field, under various systems of management. As a result research station production parameters are too often applied in farm planning without a full appreciation of the inputs used on the research stations to achieve these results.

It is expected that the increases in production presently being effected may lead to an oversupply of the live goat market by 1984–85, forcing a reduction in price.

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# Goats in the Solomon Islands

G. Simpson*

THE goat (and hair sheep) offers the advantages of meat, milk, and hide/skin products combined with high fertility and growth rates in a medium-sized package. As such both were considered desirable for the Pacific by the early European settlers and Indian transferees. To present-day Pacific people, the goat also offers an animal that can exist on low cost, easily available feed, an animal that is small enough to be consumed regularly without refrigeration, and small enough not to cause fear due to its size. In addition, goats may be more profitable to produce than the larger ruminants and may have low capital costs, which makes them ideal for village production and consumption.

However, goats are not without their problems. They originated in a browsing habitat in drier climates and are highly suited to such environments, especially in terms of their parasites. They are not traditional animals to most people in the Pacific, in contrast with Asian situations. The goat is potentially a highly destructive animal to the environment, especially in the dry tropics. Few cases of severe ecological disturbance have been recorded in wet tropics. However, for the individual farmer they can be a source of hardship if not managed correctly.

Nevertheless most Pacific countries have selected the goat as an animal for consideration. It has often been chosen in preference to the hair sheep and often for unstated or subjective reasons. In certain countries, e.g. Papua New Guinea, the hair sheep is considered by some people as being superior. In fact the Priangan and Black Bellied Barbados sheep may have certain advantages over goats. This question has been investigated quite thoroughly for Fiji.

A correspondence survey of Pacific neighbours to the Solomon Islands revealed that nearly all such countries are interested in investigating further the potential of the goat and are involved in breeding and research programs. Various degrees of success are being achieved and, with the exception of Fiji, most efforts are on a small scale and are often repetitive in their investigations.

* Principal Veterinary Officer, Veterinary Livestock Department, Honiara, Guadalcanal, Solomon Islands.

The major needs for successful goat development in the humid tropics relates to developing appropriate management programs and techniques. If village consumption is not the aim, markets and a marketing system are also required.

The Solomon Islands is commencing a fairly large goat development program in conjunction with a pre-existing breeding and research program. The development program is directed at smallholders, for village production, and the consumption of goat meat, while also making available dairy type goats. Containment of smallholder goats is to be mainly by tethering and herding rather than by specific goat pastures.

## Present State of Knowledge

### History

The date of the first goat introductions is not known but the breeds introduced were Saanen, Alpine, and Toggenberg. Most would have arrived in the post World War II period. However, during the 1950s and 1960s they were present on various government stations, missions, and individual holdings.

In the 1970s the numbers and quality of goats fell for various reasons including neglect, wild dogs, theft etc. In 1972 the present government flock was established but received a low priority treatment until the early 1980s. The 1982–84 breeding and research program was put onto a more formal basis, in conjunction with government diversification away from cattle to a policy involving other small farm animals. A very small amount of Anglo-Nubian blood was introduced in 1980.

### The Government Flock, Tenavatu

#### CLIMATE

It is wet or humid tropical and oceanic. Meteorological data from an adjacent station reveal that the rainfall pattern is continuously wet with the highest average rainfall in the January-March period (maximum average 313 mm) and less than 150 mm/month from April-December. All months have a high variability. Relative humidities at 0800 hours average 90.9% and the mean monthly temperatures are 30.0°C (maximum) and 22.7°C (minimum).

**Table 1.** Herd reproduction and survival data.

| Year | Average herd size | Average number of nannies | Fecundity (kids/ nanny/ year) | Approx. kid survival rate at birth (%) | Approx. adult mortality rate (%) | Approx. flock offtake rate (%) | Comments |
|---|---|---|---|---|---|---|---|
| 1972 | 4 | 2 | 3.0 | 33 | 0 | 50 | High reproduction from older nannies. Sporadic iodine deficiency symptoms apparent in kids. |
| 1973 | 6 | 2 | 3.5 | 71 | n.r. | n.r. | As above |
| 1974 | 10 | 5 | 1.6 | n.r. | 10 | 40 | Wild dog-caused deaths apparent from here on. |
| 1975 | 15 | 4.5 | 1.3 | n.r. | 13 | 27 | |
| 1976 | 12 | 4 | 1.0 | n.r. | 17 | 58 | |
| 1977 | 12 | 5 | 3.4 | 76 | 67 | 42 | Reproductive carry-over from previous year. Sporadic iodine deficiency symptoms. Severe wild dog deaths. |
| 1978 | 16 | 8 | 1.3 | 70 | 13 | 25 | |
| 1979 | 26 | 13 | 1.5 | 85 | 15 | 4 | Sporadic iodine deficiency in kids. |
| 1980 | 24 | 18 | 0.9 | 18 | 8 | 38 | Severe iodine deficiency symptoms. Retrovirus introduced. |
| 1981 | 47 | 21 | 2.2 | 98 | 15 | 26 | Iodine deficiency overcome. |
| 1982 | 75 | 37 | 2.1 | 83 | 17 | 44 | Flock build-up for later distribution. |
| 1983 | 90 | 45 | 2.1 | 80 | 13 | 44 | Start of distribution on a larger scale. |

### Nutrition

It is mainly from daytime grazing. The pasture is grown on highly fertile black soil plains with sulphur being the main deficiency. The main pasture species are para grass (*Brachiara mutica*) and centro (*Centrosema pubescens*), but the pasture is of varied quality and quantity.

### Management

Until 1983, the flock was managed in separate goat paddocks, with year-round mating. Kids were weaned at 3 months or at 10 kg body weight and often were sold subsequently, except for flock replacements.

In 1983 the flock was divided into two flocks of breeding does, and seasonal mating was introduced.

### Flock Performance

The information in Table 1 is incomplete and probably understates the true story. Statistical analysis has therefore not been possible and only certain trends may be valid. The under-recording was mainly of dead kids and is assumed to be fairly constant over the years.

Table 1 reflects four periods in the breeding and 'research' work:

1. An initial period of small sample numbers biased by the presence of highly fertile older does.
2. A period of low priority in goat work with poor records, high losses of adults due to wild dogs and possibly the emergence of a kid death-at-birth syndrome.
3. A severe episode of kid death-at-birth syndrome. Periods 1 and 2 were accompanied by a very slow flock growth.
4. Improved management and performance. Does were retained to build up the flock until distribution of breeding animals recommenced late in this period.

## Major Problems

### Quality of Research

Objectives and programs have now been set and staff positions improved.

### Wild Dog Attack

Improved fencing and 1080 poison have reduced this problem, but these measures are not generally applicable in the village situation. The presence of horns, night housing, and daytime attention, especially if the animals are tethered, is essential.

### Internal Parasites

Worms are a major problem in intensive, pasture fed goats. The major parasites identified so far have been *Haemonchus, Trichostrongylus, Ostertagia, Oesophogostomum* and *Moniezia* species.

Cross infection with cattle parasites from cattle on the same property is suspected but has not been proven.

Mortalities have been reduced to low levels by monthly drenchings with broad spectrum anthelmintics (Nilverm and Panacur, both registered) but the effect on growth rates has not been assessed.

The worm problem is almost certainly due to the fact that the climate favours worm egg and larvae survival and rapid worm reproduction, while at the same time the goats are being forced to act as grazing animals. Research herds can often use expensive anthelmintics but this option may not be available to, or be adopted by, village people. Instead a biological approach, probably involving forage browsing, is required.

### Dehorning

Dehorning to reduce the numbers of goats being caught in cyclone mesh fences and for ease of handling was tried in the early 1980s but was discontinued because (a) it was a painful procedure, (b) distorted horns usually regrow and (c) horns for protection against wild dogs was seen to be advantageous.

### Iodine Deficiency

Sporadic cases of a kid death-at-birth syndrome occurred throughout the 1970s. However, a major episode appeared in 1980 and iodine deficiency was diagnosed. Limited histopathological studies and iodine supplementation confirmed the diagnosis of iodine deficiency.

Iodine supplementation initially consisted of sodium iodide orally to 10 pregnant does and 10 controls. Subsequently the kid deaths were quickly resolved by iodised salt being fed ad lib but the enlarged thyroids took 3–4 months to return to normal size.

The current practice is to feed iodised salt daily at 1 kg/week to the flock. Declining kid survival rates since 1980 may indicate that this is insufficient and that unlimited access to iodised salt blocks (with sulphur) is recommended.

### Caprine Retrovirus (CAEV)

This disease is also termed caprine arthritis encephalitis. In 1980 three Anglo-Nubian purebred kids (2 male, 1 female) were introduced from Australia. All three subsequently showed clinical symptoms of CAEV infection, despite quarantine procedures (based on the prevailing state of knowledge of CAEV) before entry. Clinically, CAEV was not present before 1980. All three importations are now dead. Clinically CAEV does not appear to have established as a disease. Quarantine regulations have been modified. At this stage only New Zealand has defined its CAEV status and seems to be organised to supply goat exports free of CAEV.

### Selective Grazing

Limited observations on the goat grazing pattern at normal grazing pressures have revealed:-

- A decrease in grass leaf percentage due to selective grazing especially of para grass (*Brachiara mutica*).
- An increase in legume percentage (*Centrosema pubescens*).
- A change in the weed balance — certain weeds are selectively grazed to various degrees (including moderate control of *Sida* sp) and others are ignored to various degrees (including such troublesome species as 'Mile-a-Minute' (*Mikania micrantha*)).

The result is that where a good para grass/ centrosema pasture is grazed by goats the quality is improved. However, if the pasture has a significant weed component, then the weed percentage initially declines as the palatable species are removed, but the unpalatable species subsequently increase. In the extreme case, the weeds may become dominant.

### Photosensitisation Syndrome

In October 1983, four young weaner goats exhibited clinical signs consistent with photosensitisation and one goat died. The symptoms did not recur after the flock was removed from the paddock involved. The paddock contained large amounts of 'Mile-a-Minute' with small amounts of para grass.

### Seasonal Breeding Pattern

Goats may be seasonal breeders, but there may be a breed effect as well. The Queensland Department of Primary Industries recommends mating in the April-May period. In India, the incidence of oestrus is highest during June-October.

In the Solomon Islands, there is a marked seasonal reproductive effect with peak conceptions in the December-January period, which is a time of increasing day length, and hence factors other than photoperiodicity are suspected.

In any case with this pattern, it is suggested that any restricted mating practice should involve only one mating per year and this should be during the December-January period. This coincides with the high rainfall period with greater pasture growth, and allows kidding in the dry season. However, at that time pasture growth for lactation may or may not be sufficient for high growth rates of kids.

### Other Problems

In general, the production and disease situations for goats are very good. The following conditions have been commonly observed in other countries, but they are either absent or show a low incidence in the Solomon Islands.

1. Abortion (present in Tuvalu and Kiribati)
2. Brucellosis
3. CAEV (present in Fiji and possible other Pacific countries)
4. Coccidiosis present in Solomon Islands (present in Fiji, Tuvalu)
5. Dermatophilus (in Fiji)
6. Dystokia
7. Enterotoxaemia (in Fiji)
8. Foot conditions (scald, foot rot, laminitis). (In Fiji)
9. Genetic defects (hermaphrodites from polled animals)
10. Ketosis
11. Leptospirosis
12. Lice, mites and ticks (in Fiji)
13. Liver fluke
14. Mange (psoroptic mange in Tuvalu and Fiji)
15. Mastitis (in Kiribati)
16. Milk fever
17. Mineral deficiencies (iron (Tuvalu); cobalt/vitamin $B_{12}$ (Kiribati))
18. Pink eye
19. Poisoning (metal, plant etc; pyrrizolidine alkaloids in Kiribati)
20. Retention of afterbirth
21. Ringworm
22. Scabby mouth
23. Sore teats
24. Starvation exposure complex
25. Tetanus (in Fiji, Kiribati)
26. Tuberculosis

## Present Research

Within the context of a breed introduction program, an evaluation program, and a breed improvement program, the aims of research at present are to:

- Select for an improved, dual-purpose goat and a milking goat capable of high performance and acceptance in the Solomon Islands environment, and to distribute the progeny especially to provincial multiplication flocks.
- Establish parameters for reproduction, milking and growth (to weaning), mortality, and costs of production of the two 'breeds', in a semi-intensive situation.
- Establish cost-effective disease and worm control measures; egg counts to be performed.
- Observe the cattle/goat/pasture/worm interactions.
- Observe the impact of goats on the Solomon Islands situation, especially the village environment.

## Future Research

Answers to the present goat problems can be sought by technology transfers, regional research, and specific country research. Whatever the avenue taken, the emphasis for the Solomon Islands for the immediate future has to be on priorities and the appropriate technology suitable for village-style goat production, where animal husbandry skills are of a low standard.

In this regard, the following items are of prime importance:

- An evaluation of the economics and suitability of free grazing versus tethering (by a more successful method).
- An evaluation of goats grazing under coconuts for the benefit of both the goat and coconuts.
- An evaluation of grazing cattle and goats, especially in terms of weed control and internal parasites.
- The development of an efficient means of biological control of worms. A suggested method is to develop a system of browsing a tall grass such as Elephant Grass (*Pennisetum purpureum*), with a high protein forage tree such as *Leucaena leucocephala*. This may also involve the question of mimosine toxicity in humid tropic goats.

# Research in Goat Productivity in Tropical Africa

**L.J. Lambourne***

The goat has a long and honorable association with human settlement and development in Africa. Earliest traces of human habitations in the 5th millenium B.C. in Egypt reveal only the goat as a domesticated animal in the early Neolithic period, and goat skins were the earliest materials used for carrying water and as wrappings for the dead. Not only the goat, but indeed some evidence of dwarf goats, has been found in artefacts from as far back as the old or middle kingdom of Egypt (Epstein 1971).

There is good evidence for the introduction of the goat into Africa via Egypt, from its sites of earliest domestication in Anatolia and Central Asia about 6500–7000 B.C. The goat evidently fitted well into the various husbandry systems of the upper Nile, through which they made their way to Central and West Africa. The present populations of the various zones of Africa reflect the great but often unrecognised importance of the goat among present day livestock production systems.

Table 1 shows that in actual numbers, goats are only slightly fewer than cattle and far more numerous than sheep. Converted to a common unit of 250 kg liveweight, goats outnumber sheep and camels and equines, but cattle contribute 10 times their number.

Table 2 shows markedly higher concentration of sheep and goats than of cattle in the arid zone, and slightly lower concentrations of sheep and goats in the semi-arid and subhumid zones. Relative to the area of each zone, cattle are poorly represented in the arid zone but well represented in the semi-arid. All ruminants are poorly represented in the humid zone,

**Table 1.** Livestock population in tropical Africa by species, in numbers, and converted into TLU[a].

| *Species* | *1000 × Head* | *TLU conversion* | *1000 × TLU* |
|---|---|---|---|
| Camels | 11135 | 1.0 | 11135 |
| Cattle | 147510 | 0.7 | 103257 |
| Sheep | 103865 | 0.1 | 10387 |
| Goats | 125287 | 0.1 | 12529 |
| Horses | 2899 | 0.8 | 2319 |
| Mules | 1478 | 0.7 | 1035 |
| Donkeys | 7618 | 0.5 | 3809 |

a. Tropical Livestock Unit = 250 kg liveweight.
Source: Jahnke (1982) from FAO Production Yearbook, 1979.

**Table 2.** Land, livestock and human resources, by zone.

| *Zone* | *% area km²* | *% cattle Hd* | *% sheep Hd* | *% goats Hd* | *% people M.E.** | *Annual rainfall (mm)* | *Growing period (days/yr)* |
|---|---|---|---|---|---|---|---|
| Arid | 37.3 | 21.3 | 35.7 | 38.6 | 12.2 | < 600 | 0 – 90 |
| Semi-arid | 18.1 | 30.8 | 22.2 | 26.5 | 12.2 | 600 – 1200 | 90 – 180 |
| Subhumid | 21.7 | 22.2 | 13.6 | 16.2 | 22.4 | 1200 – 1800 | 180 – 270 |
| Humid | 18.5 | 6.0 | 7.9 | 9.2 | 22.1 | > 1800 | 270 – 365 |
| Highland | 4.4 | 19.7 | 20.6 | 9.5 | 9.6 | Usually > 1500 Altitude > 1500 | 180 – 270 |

* Population economically active in agriculture, as man-equivalents (M.E.) taken as 38.5% of total population, the overall mean figure.
Source: Jahnke (1982).

* International Livestock Centre for Africa (ILCA), Addis Ababa, Ethiopia.

clearly a reflection of the dangers of tsetse and trypanosomiasis in a heavily vegetated zone, and all species of livestock are relatively concentrated, goats least so, in the highlands, generally temperate or subtropical and providing quite benign conditions for livestock husbandry.

## Economic Importance of Goats in Africa

Sandford (1982) summarised the economic importance of the goat in world production, pointing out that of the world population of 400–500 $\times$ $10^6$ goats, 95% were in the developing countries, and of this amount, 30% were in Africa, 23% in India/Pakistan, 17% in China, 23% in Asia and 7% in Latin America. In global terms, goat production yields 60% value as milk, 35% as meat, and 5% as skins. Of total world livestock production, goats give 6% of meat, 4% of skins, and 2% of milk.

The figures vary considerably between countries and between production systems. Indeed often the basic statistics are open to question, since, as Wilson (1982) pointed out, there is a marked tendency for goats to be underestimated numerically, as well as economically and socially.

Demiruren (1982) presented FAO estimates of the overall contribution of goats to world food production. During the interval 1965–79 world goat numbers increased by 20% — those in Africa by over 40%, associated with an increase of 47% in goat meat production and of 14% in goat milk production.

Estimated demand in 1990 for goat meat and milk is 37% above present production, which will call for an average increase of 2.8% per annum, to maintain present levels of consumption.

Within Africa, the greatest goat populations are in the semi-arid area of 10 countries extending from the Atlantic to the Indian Ocean, taking in most of the Sahel as well as Sudan, Ethiopia and Kenya.

In these countries, which are among the poorest in the world with GNP per caput ranging from only US$110 to US$340 (excluding Nigeria whose oil wealth boosts this to US$600), 66% of Africa's goats are found on 37% of its land surface. For these 10 semi-arid countries Wilson (1982) calculated that small ruminants together produce 31% of the meat, while constituting only 16% of the liveweight biomass. These estimates probably understate the total contribution of smallstock because many more are slaughtered, without being recorded, for home consumption. The goat has the particular merit, in areas of uncertain rainfall, that it will continue better than other animals to produce through droughts and similar stress periods, and recover more rapidly afterwards.

Wilson estimated human offtake of goat milk at about 22 kg per year per doe, a total of over a million tonnes per year in the 10 semi-arid countries. Devendra (1981) estimated that goat milk contributed in the semi-arid zone of Africa about 10% of total human milk consumption.

Apart from their direct contribution to domestic food supply, small ruminants form an important item of international trade, particularly with tropical Africa in the sale of live animals from the stock raising Sahelian countries or areas to the more humid coastal countries where livestock numbers are drastically limited by the tsetse fly.

Any discussion limited to purely economic terms must greatly understate the importance of small ruminants, particularly goats, to the total social, cultural and economic welfare of pastoral countries. The multiple role of the goat as a reliable producer in bad times, as a fast breeder in recovery periods after drought, as a readily realisable liquid asset to finance other purchases, as a convenient-sized meat animal to kill for social or religious celebrations, as the first step in establishing a herd, to be converted later into the more prestigious cattle herd — these functions were well described by Dahl and Hjort (1976), Devendra (1981), Sandford (1982), and Little (1982).

## Development of Breeds for Various Ecological Zones

### Extensive production systems

In arid and semi-arid areas goats and sheep are commonly grazed together during the day, often with cattle and camels where these too are kept. The goats may be of the common Savanna or Sahelian type, with local variations, or in East Africa, of the small East African type. The former weigh about 30 kg when adult and are commonly white, black, or brown or combinations of these. In northern Nigeria a recognised variant is the Red Sokoto or Maradi goat, a slightly more compact animal of 20–25 kg, of which the skins are particularly prized.

In East Africa many locally identified breeds or strains are described (Wilson 1982a) and a general feature is the reduction in adult size of these goats from the north towards the equator, and a gradual increase in size from the equator towards the south (Epstein 1971). Several desert breeds are recognised in Sudan, Somalia, Eritrea, and Ethiopia.

The Galla or Somali goat of eastern Ethiopia, the Ogaden and Somalia is distinguished by a smooth white coat, average size of 30–40 kg, and a reputation for better milking ability than some desert breeds. The Galla is common in northern areas of Kenya. The 'Small East African Goat' is the usual type found in Uganda, Kenya, and Tanzania — this description is fairer than 'Dwarf East African Goat' since this goat is of neat proportions and is not to be confused with the true dwarf goats of Central and West Africa. The Small East Africa goat is a hardy fertile animal of about 25–30 kg, kept mainly for meat production (Sacker and Trail 1966).

These goats show the necessary attributes of good foraging ability, grazing, and browsing widely often climbing into the branches of *Acacia* and other browse trees if that brings better feed within reach. They are able to walk considerable distances when herded with cattle or camels, are economical in water use, being able to manage easily on a 2 or 3-day watering regime in the dry season. In these attributes they resemble the common goat of many other semi-arid tropical areas, and there is no reason to suppose that their genetic variation, their potential for further improvement by selection, their digestive and lactation mechanisms, are different from those studied in other countries.

#### Semi-intensive husbandry in more humid areas

Similar types of goats are found in better climatic zones, where the importance of cropping dictates that they must be tethered or confined during crop planting, or in some cases, confined permanently. In these zones better growth of grasses, legumes, and shrubs, and the availability of crop and household residues, improves the general level of nutrition and would permit the introduction of specialised exotic breeds to increase meat (Taneja 1982) or milk (Sahni and Chawla 1982) production. The desire to produce an improved or a dual purpose animal must be balanced against the common experience that crossbreds are so much less well adapted to local conditions of climate, parasites, nutrition, and disease, that they may in fact be inferior to the native goat, particularly in the hands of local pastoralists or smallholders. The conclusions of Palian and Racokzi (1976) in the FAO/UNDP Sheep and Goat Project in Kenya, and of Cartwright (1983) reporting Small Ruminant CRSP research, were that existing genetic variability within indigenous breeds was very important and should be studied and exploited, before starting complex crossbreeding programs. Wilson (1982, 1982b) came to similar conclusions from other crossbreeding projects.

#### Humid Zones

In the more humid areas the livestock population is limited by the occurrence of the tsetse fly *Glossina morsitans*, which may carry several species of the blood parasite *Trypanosoma*. Trypanosomes may infect also a wide range of wild genera, especially warthogs and several reptiles. Forested areas of high humidity are the habitat of the tsetse fly, and in such areas the keeping of the usual breeds of cattle and sheep becomes impossible, or at least uneconomic because of the high cost of chemotherapy. Zebu cattle enter this zone only for the dry months — the only permanent cattle are those of the trypanotolerant breeds N'Dama and West African shorthorn (ILCA 1979a). The savanna goat and sheep breeds too, are replaced by the dwarf trypanotolerant breeds, often grouped as West African dwarfs of the so-called Fouta Djallon type. Crosses of dwarf and savanna types are common, and possess an intermediate degree of tolerance, permitting them to live in areas of low to intermediate tsetse and trypanosomiasis challenge.

Goats of similar general features are found in many countries of Central Africa and Epstein (1971) considered that two types of hereditary dwarfing mechanism are represented in this large and heterogenous population. The first is pituitary hypoplasia, making for an individual of small stature but otherwise normally developed. The second is hereditary achondroplasia, which results in an adult animal with a normal trunk but disproportionately stunted extremities. Both types occur in Central and West Africa; Mecha and Agunwamba (1982) examined the physical measurements and reproductive histories of 'dwarf' goats in S.W. Nigeria and divided them into three classes, differing markedly in withers height, liveweight, fertility, gestation period, and generation interval. This suggests that considerable intermingling has occurred among populations that had developed in the comparative isolation of villages in dense rain forest, through the combined effects of three main factors, viz. natural selection favours smaller individuals under adverse conditions; the hardiness and unique appearance of dwarf goats may have caused some deliberate selection by their owners; and inbreeding resulting from isolation of small groups may well have led to a reduction in size as well as to the appearance or the strengthening of dwarfing influences (Epstein 1971). Dwarf West African (Cameroon) goats have been taken to Europe where under sustained good nutrition and with protection from the cold climate, they have responded with higher rates of gain and substantially greater body size (Hofs et al. 1984; Zemmelink et al. 1984) than recorded in Nigeria by Ademosun et al. (1984).

The great importance of the dwarf breeds lies in their adaptation to the forest zone and their resistance to the effects of trypanosomiasis.

### Goat Production Systems in Tropical Africa — Productivity and Limitations

#### Productivity of Goats in Extensive Grazing Systems of the Arid and Semi-Arid Zones

The nature of these often nomadic or transhumant milk-dependent pastoral systems was described by

Garcia and Gall (1981). Dahl and Hjort (1976) give a detailed discussion of many characteristic features of pastoral systems. The systems found in Northern Kenya are described fully by Rumich (1973) and Field (1982), and those of the Malian Sahel by ILCA (1982). Helland (1977, 1977a) described the modifications introduced by the Group Ranch concept and also the traditional controls on human and livestock population in the Borana people of E. Africa.

The composition of livestock herds of nomadic and transhumant pastoralists varies considerably; Rumich (1973) noted that those who migrate only locally tend to have more small ruminants than camels and cattle. Of those who migrate extensively, the poorer have more sheep and goats, the richer more camels and cattle. Families which lost their camels and cattle in the drought or epidemics of the mid 1960s tended to rebuild first their flocks of sheep and goats.' He noted too that sheep and goats had the vital role of providing cash for economic necessities as well as providing meat particularly for festive occasions, thus sparing cattle for major family gift or inheritance responsibilities (Dahl and Hjort 1976).

In normal herding and grazing, goats are usually run with sheep and cattle. They do not compete with other stock. Many research workers have reported that cattle are mainly grazers, sheep and some browse, goats prefer a wider variety of forage, favouring browse species, and camels browse predominantly. Thus Lamprey and Field (1983) gave the preferred feeding heights above ground as follows: sheep 0 — 20 cm; goats 20 — 120 cm; and camels 120 — 300 cm.

Table 3 shows the composition of the diet of the various livestock species, which reflects their very different preferences. Dicko and Sangare (1984) report the data in Table 4 for the agropastoral systems of the Malian Sahel and Niger flood plains. These reinforce the evidence of the goat's browsing propensities, reported by Lamprey and Field (1983) and Schwarz et al. (1984).

It is substantially because of this habit that the productivity of the goat is better sustained in the dry season, browse being usually of higher nutritive value than the mature standing grass available to sheep and cattle (Le Houerou 1980; Lamprey et al. 1980). Figure 1 taken from Wilson (1982b) shows the way in which the lactation curves of small ruminants maintain milk supply to pastoralists at times when there is a shortage of cow's milk. Goats are more often milked than sheep, and lactation levels of only a few hundred ml per day from a reasonable number of goats make a vital contribution to family welfare.

Though milk is the mainstay of the extensive pastoral systems, blood is sometimes taken, too, from goats, but their major role is as a source of meat for consumption, sale or exchange. The early sale or slaughter of young males may be deduced from the age

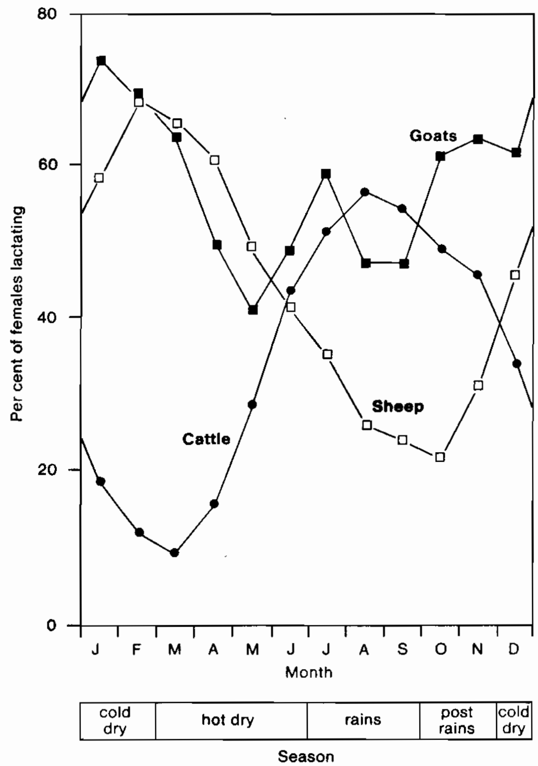


**Fig. 1.** Complementarity of lactations in mixed species production systems.

**Table 3.** Composition of livestock diets in N. Kenya rangelands.

| *Species* | *Proportion of intake* | | |
|---|---|---|---|
| | *Trees & shrubs* | *Dwarf shrubs* | *Other plants* |
| Cattle | 0.0 | 3.0 | 97.0 |
| Sheep | 9.3 | 23.7 | 67.0 |
| Goats | 29.9 | 22.5 | 47.6 |
| Camels | 29.0 | 47.5 | 22.5 |

Source: Lamprey and Field (1983).

**Table 4.** Grazing preferences of livestock in Central Mali.

| | | | | | | |
|---|---|---|---|---|---|---|
| % on millet stubble | 16 | 7 | 2 | 6 | 2 | 2.5 |
| % on rice straw and regrowth | — | — | — | 34 | 10 | 2.5 |
| % on browse shrubs | 11 | 34 | 87 | 3 | 11 | 58 |
| % on pasture | 73 | 59 | 11 | 57 | 77 | 37 |

Source: Dicko and Sangare (1984).

and sex structure of goat (and sheep) flocks. Thus Semenye (1983) reported the figures in Table 5 for the Samburu region of Northern Kenya.

**Table 5.** Age/sex structure of Samburu Flock, Kenya.

| *Definition* | *Age (Mo)* | *Males* | | *Females* | |
|---|---|---|---|---|---|
| Milk teeth | 0 – 14 | 122 | 73 | 177 | 32 |
| 2 | 15 – 21 | 14 | 8 | 49 | 9 |
| 4 | 22 – 28 | 6 | 7 | 57 | 10 |
| 6 | 29 – 35 | 7 | 3 | 69 | 13 |
| 8 | over 36 | 16 | 9 | 201 | 36 |

Source: Semenye (1983).

These are similar to the data reported by Wilson et al. (1981) from the Elangata Wuas Group Ranch in Kenya and by ILCA (1982) for Mali. The flock composition shown in Table 6 for several production systems emphasises the fact that disposal of males starts at ages of a few months, and that males older than 12–18 months are those kept for breeding and occasional castrates (Moutons de case) for fattening.

With meat production as their main value, the productivity of goats depends on numbers and weight of kids weaned. Table 7 summarises data from several pastoral production systems showing that goats have early first parturition, high twinning rates and early reconception. The prime weakness is in the high mortality of young kids, illustrated in Table 8.

This results from a combination of under-nutrition and disease and preliminary work of Mack (1982) has shown that kids are particularly susceptible to internal parasites, scours and respiratory diseases, as are adult goats. A major problem with goats in all pastoral zones is contagious caprine pleuropneumonia (CCPP) caused by a *Mycoplasma* (Cottew, 1982; Ola Ojo 1982). The extensive grazing system may help to prevent rapid spread of disease among adults, but kids may be held in a boma or pen during their early weeks and this favours transmission of any infection present. Offtake of milk for human use also may cause initial undernutrition, predisposing kids to secondary infections.

### Productivity of Goats in Semi-intensive Systems

In the more productive subhumid zones, systems of tethering during cropping phases, and of grazing with partial confinement, at night and during bad weather, are common. These call for a greater degree of control, some provision of cut forage, crop or household residues, and permit better health care and higher levels of productivity (Njwe, 1984; Devendra, 1981). Bradford (1981) reviewed earlier work on the potential value of improved dairy goats and concluded that the prospects for their use in medium to high potential areas of Western Kenya were encouraging. Stotz (1981) concluded from a smallholder management analysis that dairy goats would probably be economically feasible on farms with less than 0.5 ha available for grazing or forage production, but that on larger farms cows would be superior. He cited data for milk yields of several dairy breeds in Kenya and elsewhere, and Fitzhugh (1983) gave similar figures for crossbred does on Kenyan smallholder farms. Results of the upgrading of local goats by crossing with Swiss Alpine

**Table 6.** Some examples of management objectives related to flock structures (structure as percentage of total animals).

| | *Area/ethnic group* | *Use* | *Males* | | *Females* | |
|---|---|---|---|---|---|---|
| | | | *Total* | *Castrates* | *Total* | *Breeding* |
| Sheep | Mauritania/Moor | Meat/hair | 22.9 | 6.2 | 78.1 | 58.6 |
| | Mali/Fulani | Meat/wool | 25.5 | 11.3 | 74.5 | 55.9 |
| | Tchad/'Arab' | Meat/milk | 26.7 | 'few' | 73.3 | 53.7 |
| | Sudan/Baggara | Meat | 22.2 | 0.0 | 77.8 | 57.7 |
| | Ethiopia/Afar | Milk | 7.8 | 0.0 | 92.2 | 61.4 |
| | Kenya/Masai | Meat (fat) | 31.4 | 15.4 | 68.6 | 54.2 |
| Goats | Mauritania/Moor | Milk/meat | 20.2 | 1.2 | 79.8 | 55.1 |
| | Mali/Fulani | — | — | — | — | — |
| | Tchad/'Arab' | Milk/meat | 28.3 | 'few' | 71.7 | 48.1 |
| | Sudan/Baggara | Milk/meat | 23.6 | 0.0 | 76.4 | 51.2 |
| | Ethiopia/Afar | Milk | 3.3 | 0.0 | 96.7 | 65.5 |
| | Kenya/Masai | Meat (fat)/milk | 33.8 | 10.3 | 66.2 | 48.3 |

**Table 7.** Some measured production parameters for African goats and sheep in semi-arid areas.

| | *Mali Sedentary* | *Tchad 'Arab'* | *Sudan Baggara* | *Ethiopia Afar* | *Kenya Masai* | *Uganda (station)* |
|---|---|---|---|---|---|---|
| Sheep | | | | | | |
| Age at 1st parturition (days) | 470 | 440 | (349) | — | 540 | — |
| Parturition interval (days) | 254 | — | 275 | — | 344 | 257 |
| Average litter size | 1.05 | 1.07 | 1.14 | 1.05 | 1.02 | — |
| Number of young/year | 1.52 | 1.04 | 1.56 | 1.20 | 1.08 | — |
| Wt. at 150 days (kg) | 16.3 | 21.5 | 18.8 | 15.3 | 13.7 | 14.3 |
| Daily gain (g) to 150 days | 90.7 | 120.0 | 99.7 | 82.0 | 69.5 | 72.0 |
| Productivity Index (g young/kg female/year) | 460 | 400 | 530 | 450 | 566 | 740 |
| Goats | | | | | | |
| Age at 1st parturition (days) | 484 | 415 | (290) | — | 456 | — |
| Parturition interval (days) | 271 | — | 238 | — | 289 | 297 |
| Average litter size | 1.23 | 1.12 | 1.57 | 1.10 | 1.16 | 1.30 |
| Number of young/year | 1.65 | 1.13 | 2.41 | 1.15 | 1.47 | 1.60 |
| Wt. at 150 days (kg) | 12.9 | 9.5 | 12.8 | 8.8 | 10.6 | 11.6 |
| Daily gain (g) to 150 days | 70.7 | 49.3 | 71.1 | 45.3 | 52.1 | 64.7 |
| Productivity Index (g young/kg female/year) | 460 | 240 | 620 | 390 | 432 | 480 |

**Table 8.** Kid mortality preweaning in Masai flocks, Kenya.

| | | | | |
|---|---|---|---|---|
| Parity (%) | 1<br>23.3 | 2<br>20.0 | 3<br>13.1 | >3<br>21.2 |
| Season of birth (%) | Short dry<br>23.8 | Long rains<br>14.6 | Long dry<br>31.4 | Short rains<br>19.3 |
| Type of birth (%) | Single<br>18.8 | Twins<br>25.8 | | |
| Flock (%) | Best<br>12.4 | Worst<br>40.0 | | |

Source: De Leeuw and Peacock (1982).

bucks at Ngozi, Burundi (pers. comm.) show that milk production of the native does, 0.5–0.7 kg/day, is increased to 1.5–2 kg/day in crossbred does kept under similar semi-intensive smallholder conditions. The performance of Galla and Small East African goats and their crosses also showed satisfactory productive performance, but there were kid losses of 16–36% due mainly to pneumonia, scours, and weak or still births (Cartwright 1983).

ILCA results in subhumid N.Nigeria show that flocks average 6–7 head, with 98.6% fertility, 22.4% kid mortality to 90 days, and a net offtake of 23.4% annually. Thirty-two per cent of goat sales coincided with the need to raise cash to buy fertiliser (ILCA Ann. Rept. 1983).

### Goat Productivity in the Humid Zone

This zone, comprising humid forests and the slightly drier derived savannas, is an area of village agriculture, where small stock are kept by 40–50% of households as an important sideline rather than a major activity. Average numbers of sheep and goats vary from farm size from 3–4 on holdings of less than 5 ha, up to 10–12 on large farms of 20–100 ha (ILCA 1979). They normally graze or browse freely around the village fields and forested areas, being tethered or confined only when they would otherwise damage the all-important crops. The area is generally infested by tsetse fly, and the sheep and goats must therefore be of the trypanotolerant dwarf breed(s). These dwarf goats weigh only 20–25 kg fully grown; birth weight averages 1.2–1.4 kg, less for twins, and growth rate is commonly only 20–50 g/d, even though no milk is taken for human consumption. Neonatal and early losses are variable but probably exceed 20%, and annual mortalities cited by ILCA (1979) range from 10 to 40% over four years in three states of Nigeria.

Principal causes of this high mortality are the respiratory diseases, diarrhoeas, and parasitic disease. The zone is noted for the epidemic disease 'peste des petits ruminants', sporadic outbreaks of which cause high mortality (ILCA 1983). This 'PPR' is caused by a paramyxovirus and can be described as a pneumono-enteric stomatitis, related to human measles and canine distemper and often complicated by secondary pulmonary bacterial infections (Obi 1984). While no specific vaccine is available, the disease can be controlled to a substantial degree by treatment with tissue culture rinderpest vaccine (TCRV). Internal and external parasites are a major problem, but ILCA research (Mack 1982) showed that use of TRCV could reduce the incidence of PPR from 14% to 4% in the

**Table 9.** Main causes of morbidity in small ruminants in Nigeria as percentage of observed cases, before and after veterinary intervention.

| | Goats | | | | Sheep | |
|---|---|---|---|---|---|---|
| | *Forest* | | *Savanna* | | *Forest* | |
| *Disease* | *Before* | *After* | *Before* | *After* | *Before* | *After* |
| PPR | 13.5 | 3.6 | 17.6 | 0.0 | 0.0 | 0.0 |
| Pneumonia | 7.6 | 17.9 | 5.0 | 21.3 | 3.1 | 7.0 |
| Footrot | 0.4 | 8.9 | 0.6 | 3.3 | 7.0 | 23.2 |
| Helminths | 6.7 | 16.1 | 2.8 | 24.6 | 16.4 | 11.6 |
| Ecto-parasites | 8.6 | 1.8 | 2.3 | 0.0 | 26.4 | 0.0 |
| Mange | 37.5 | 10.7 | 60.7 | 3.3 | 13.3 | 0.0 |
| Accidents | 13.9 | 16.1 | 4.7 | 19.6 | 28.9 | 30.2 |
| Others | 11.8 | 25.0 | 6.3 | 27.9 | 4.7 | 27.9 |
| Total numbers | 237 | 56 | 357 | 61 | 128 | 43 |

Source: Mack (1982).

**Table 10.** The effect of veterinary intervention on the productivity indices of small ruminants in Nigeria. Index I is total weight of offspring at 5 months/dam/year. Index II is total weight of offspring at 5 months/unit weight of dam (kg)/year. Index III is total weight of offspring at 5 months/unit metabolic weight of dam ($kg^{0.75}$)/year.

| | | *Weight of dam (kg)* | *Index I (kg)* | *Index II (g)* | *Index III (g)* |
|---|---|---|---|---|---|
| Goats in forest | Before | 15.1 | 7.5 | 500 | 1010 |
| | After | 16.7 | 10.3 | 620 | 1280 |
| Goats in savanna | Before | 13.9 | 7.2 | 520 | 1050 |
| | After | 14.7 | 10.5 | 710 | 1430 |
| Sheep | | 21.1 | 21.1 | 690 | 1480 |

forest and from 18% to zero in the derived savanna. A monthly dipping program reduced mange incidence from 38% to 11% in forest goats and from 61% to 3% in savanna goats. Overall morbidity is shown in Table 9 and the effect of the veterinary package on total productivity in Table 10.

Little supplementary feed is normally given, but Sempeho (1982) noted some use of crop byproducts in some households.

Despite the great impact of disease and a generally poor nutritional environment, dwarf goats have an excellent reproductive performance (Osuagwah and Akpokodje 1982), kidding first at about 560 days, with a mean litter size of 1.6 giving an annual reproductive rate of 2.1 kids per doe (Mack 1982). Okali and Upton (1984) point out the potential for increased production and marketing of small ruminants in S.W. Nigeria; 40% of local sales were of animals bred in the northern states, and an analysis showed that of total exits from village flocks, 9% were sales, 19% were for household consumption, and 46% were losses through disease.

### Goat Productivity in the Highlands of Africa

Table 1 showed that goats are relatively poorly represented here; the highlands comprise 4% of Africa's surface and have 20% of the cattle and sheep, but barely 10% of the continent's goats. The highlands lie in the tropics but in fact have generally a cool subtropical climate where better nutrition, cooler conditions and relative freedom from diseases and parasites enable cattle and sheep to show to advantage. Apart from the different socioeconomic conditions, this zone would correspond rather to temperate regions of the world in which goat husbandry is comparatively well established and well supported by research.

## Locations and Topics of Current Goat Research

The number or proportion of goats in a national herd, and their economic importance, are, regrettably, not always related to the standard of husbandry, health care, or of scientific research in that country's goat industry. An attempt can be made to identify the main lines of past and ongoing research by analysing the output of published results. A recent bibliography of international literature on goats prepared for Winrock International by Henderson and Fitzhugh (1983) provides over 3900 references suitably indexed. References from sub-Saharan Africa were most numerous for Nigeria, followed by S. Africa, Kenya, Egypt, Ghana, Sudan, Somalia and Tanzania.

Activity in published research does not appear to be related to absolute goat population, nor to the proportion of goats in the national herd but to more complex features.

The breeds most reported were, obviously, those of the countries most frequently reporting and the bulk of the published research deals with topics in animal health and breeding. This reflects the fact that veterinary diagnostic facilities are better developed and supported than other government services in most African countries, because of the enormous importance of severe disease epidemics of the past, the need for vaccine production and distribution, and for adequate diagnostic facilities in all countries depending on livestock. The considerable number of publications dealing with reproduction and breeding indicate a widespread, almost ritual, preoccupation with introduction of exotic breeds to improve productivity and with fecundity as a prime measure of this.

## Current Reseach Institutions and Programs

*Kenya* An FAO/UNDP Sheep and Goat Development Project has been operating in Northern Kenya and in the higher potential areas for some years. Early interest was particularly focused on the improvement of Galla (Somali) and Small East African does under arid and semi-arid rangeland conditions and the establishment of national breeding centres for this purpose. This work has not proceeded far, and more attention is now going into development of dual purpose goats for smallholder farms in better-potential areas. Because of evidence of heavy losses from disease and parasites, a major part of the Project's work has been located at the veterinary laboratory at Kabete and on veterinary research farms of the Kenyan Ministry of Livestock Development.

The work has recently been strengthened and broadened to include socioeconomic aspects, marketing, forage production as well as the Cooperative Research Support Programme (SR-CRSP) of USAID under Title XII of the Famine Prevention and Freedom from Hunger Act of 1975. Winrock International also has established a cooperative program of research and training, based at the Kenyan Ministry's National Rangeland Research Station at Kiboko.

ILCA has a research program in the Masai pastoral system in the Kajiado area based on an initial monitoring of several Group Ranches in the Kajiado region. This has identified marketing and young stock mortality as problems in increasing productivity. Differences in productivity of up to 100% exist between flocks in the same areas, and research is now aimed at identifying the factors of management responsible for these important differences.

*Sudan* Small ruminant research is under the control of the Head of Planning and Programming Research Section, Ministry of Agriculture and Irrigation, Animal Production Research Administration, in Khartoum (P.O. Box 293). Research is carried out at two sites — Um Banein, 400 km south of Khartoum and at Ed Huda, 150 km south of Khartoum. Some research is being carried out on goats at the Faculty of Agriculture, Khartoum, and research on Sudan desert sheep (500) of three types is going on at Ed Huda. A sheep flock is maintained also at Um Badein.

A substantial new project is under way in western Sudan (Western Sudan Agricultural Research Project, WSARP) but no results are yet available. This is understood to cover the main livestock and agricultural production systems of the area.

*Somalia* Security problems along the frontier have limited research and development in pastoral zones of both Somalia and Ethiopia. Somalia is largely dependent on livestock production and has schemes of water harvesting for special fodder production areas, a special government Department for Rangelands and a rather innovative scheme for 'nonformal' education of nomadic and transhumant pastoralists. Little information is currently available on goat production outside the appraisal reports of the World Bank and other development agencies or consultants.

*Nigeria* This country has a very large goat population and a relatively well developed infrastructure of veterinary and other research centres, and an excellent university system, with animal research, including dwarf goats, at the universities of Ibadan, Ife, and Nigeria. The agricultural University of Ahmadu Bello (ABU) at Zaria in the north is closely linked to the National Animal Production Research Institute (NAPRI) nearby, which operates several animal breeding stations and has an active program of forager and animal production research. ILCA operates a research team at Ibadan in S.W. Nigeria, studying the subsistence village cropping and small ruminant systems of the humid forest and derived savanna zones. Limitations to productivity of dwarf goats have proved to be nutritional and, particularly, infectious and parasitic diseases. The latter can be substantially controlled by veterinary treatment (Mack 1982) while a system of 'alley grazing', using leguminous browse (*Leucaena* and *Gliricidia*) (Sumberg 1984) in lines so as to cause least interference to cropping, promises to improve both animal nutrition and crop productivity. Extension of ILCA's work to the southeast of Nigeria shows much greater use of housing and 'cut-and-carry' feeding systems (Mack et al. 1984).

ILCA has a second team at Kaduna in northern Nigeria, where the subhumid conditions support cereal cropping and an important transhumant Fulani pastoral system. The interaction of livestock and crops is extremely important — crop residues help to alleviate the nutritional stress of the dry season, and livestock return nutrients to the fields for the next crop. Research has shown that goats play an important but subsidiary part in this area, which is primarily a cattle-rearing milk-consuming system. Inclusion of legumes in the crop to improve the yield and quality of the residues, and sowing of *Stylosanthes* or other forage legumes as small (2–4 ha) special purpose 'fodder banks' promises to greatly improve productivity of all livestock. Here, too, goats normally suffer much less than cattle in the dry season, because they use the abundant browse plants available.

*Mali* Research is centred in the Institut National de Recherche Zootechnique, Forestiere et Hydrobiologique, with which ILCA's team cooperates, particularly at the Station du Sahel at Niono where ILCA's animal work is located. At Bamako there is a Central Veterinary Laboratory, set up as a subregional centre for vaccine production. Mali is greatly dependent on livestock rearing in the Sahel uplands, and there is a complex traditional system in which livestock herds and flocks return from the uplands at the beginning of the dry season, when the waters of the annual flooding of the Niger valley have receded, leaving a relatively abundant growth of grass. Goats and sheep are found in large numbers in this pastoral system, and in the more recent agropastoral variants in which millet residues in the Sahel villages, or rice straw in the irrigation schemes of the Niger 'delta', are used as dry season livestock feed. In these systems, too, goats provide greater resilience of production because of their browsing ability in the dry season (Tables 3 and 4), their rapid breeding ability (Table 7), and their milk production at times when few goats are in milk.

*Rwanda and Burundi* These countries face acute population pressure and are anxious to develop goat husbandry.

Karma Research Station, northeast Rwanda, in the eastern savanna region near Akavenga Game Reserve. A selected group of 250 does of the local strains were used for crossing with Anglo-Nubian, Swiss Alpine, or Saanen bucks. Mortality among imported bucks was heavy and the work is now entering a second phase in which does and bucks from a new importation will be used to produce purebreds locally, in the hope that they will be better adapted to local conditions of nutrition, disease, and parasites.

Fresh importations will be Swiss Alpine — the earlier Saanen crosses gave poor reproduction, and the Alpines were preferred to the Anglo-Nubian. The purpose is to produce a more productive $F_1$ crossbred doe and a 3/4 exotic buck for use by farmers on native does.

Native does yield 0.5–0.7 kg/day of milk; the Alpine crosses yield 1.5–1.7 kg/day under local grazing conditions without concentrate supplements. Better health care is needed.

Burundi: Some sheep and goat nutrition and production work is going on in the Agronomy Department of the University at Bujumbura.

Ngozi–Kayanza Goat Improvement Project. This project is financed by GTZ and uses Swiss Alpine (milk-meat) and South African Boer (meat) bucks to produce crossbreds for release, and to mate to farmers' does. The $F_1$ and $F_2$ progeny produce quite well, giving (Boer crosses) 1–1.5 kg/day and (Alpines) 1.5–2.0 kg/day compared with 0.5–0.7 kg/day from local does.

The increased milk is fairly well accepted locally but is still looked upon as something to be given as a tonic to children and old people rather than as a normal food item. The goat is still seen as primarily a meat animal and Boer crosses are proving to be the more popular for this reason.

### General

The number and range of topics covered in the 1982 International Conference on Goat Production and Diseases (Tucson, Arizona) indicates that many universities and research institutions in Africa are taking fresh interest in this subject. ILCA finds a very keen response from African organisations in its training and conference program and is now setting up a Small Ruminant Research and Information Network to encourage sheep and goat research and development in Africa.

## Present and Future Needs in Goat Research

There are some unanswered or partially answered questions that are relevant to practically all goat production systems:-

- Are goats superior in intake or digestive ability to other ruminants? This has recently been discussed by Louca et al. (1982), amplifying earlier work of El Hag (1976) and many others.

For each experiment that confirms this, there is another which refutes it. There is no longer any doubt that goats have different feed preferences, but it is not clear whether the small differences between them in rumen size and function are of any real significance. Work reported by Johnson (1983) suggests that there is little or no difference between sheep and goats in digestion of feeds of relatively good quality. On feeds of poorer quality (higher cell wall content) he concluded that sheep showed a higher digestion coefficient as a result of longer retention time in the rumen. Goats passed the residues more quickly, with a lower digestion coefficient but higher relative intake. A similar mechanism has been suggested for the donkey, to explain the remarkable ability of that animal, too, to thrive on poor quality fodder (King 1983).

• Are goats able to thrive on browse species because of digestive mechanisms which counter the very high tannin content of some such plants? ILCA nutrition research is now exploring this field, which could be important in relation to the use of, e.g. cassava foliage by ruminants (Reed et al. 1982).

• Why are goats particularly susceptible to pulmonary infections including CCPP? What can be done about this?

• What can be done to reduce kid mortality?

• Although goats are used primarily for meat, their milk is used, particularly for children, in many societies. How can *Brucella melitensis* (Alton 1982; Nicoletti 1982) be controlled or eliminated, specially in extensive systems where vaccination is difficult or hard, and in smallholder systems where slaughter would not be acceptable?

An improvement scheme for goat and sheep production combining husbandry, health and genetic improvements, was proposed by Wilson (1982b).

Other questions are important in specific production systems.

### Arid/Semi-arid Pastoral Systems

• Is it possible to improve production by careful selection within indigenous breeds? Present methods probably select, unintentionally, for small and slow growing kids, since males are killed from quite early ages and probably the heaviest are killed first. Survivors who are kept for breeding, will thus tend to be twins of lower birth weight, or kids of poor milking dams. Communal grazing and watering systems also tend to permit indiscriminate mating.

• In some areas (e.g. Maasai) aprons are fitted to bucks to prevent mating at certain periods. This makes it possible to produce kids for particular religious festivals. Mating appears to be stimulated by periodic freeing of bucks. Does this practice have potentially wide application in relation to feed supply or human needs for milk?

• Given that African pastoralists have a firm belief in the curative properties of certain saline waters or salty outcrops, are there widespread mineral deficiencies or imbalances that could easily and economically be corrected? Mineral blocks are accepted very widely, without scientific evidence of response to any of their components.

• Where individually-owned flocks use communally-owned rangeland, what can be done to improve the nutrition of the flocks? An ILCA workshop concluded that there were few purely technical options available (Lambourne and Butterworth 1983). Better livestock policy decisions by governments or para-statal bodies concerned with rational resource utilisation would help, and there is an urgent need for pastoral societies to come to some form of social-territorial organisation so as to be able to introduce better grazing methods, agreed stocking policies, improvement of pasture and browse resource by agreement among the members of the 'association' (Sandford et al. 1983).

• What is the role of the goat in land degradation and desertification? This has been discussed vehemently since well before Maher (1945) and Edwards (1948) made it a scientific issue. Current opinion tends to accept that the goat grazes so little that it cannot be held responsible for over-grazing; this must be blamed on overstocking with the grazing species, cattle and sheep. True, the goat is often seen grazing on degraded land, primarily because once the grass disappears the goat (and the camel) are the only animals that can still survive and produce there. Should we speak of these early changes in a vegetative association as 'degradation' if the land is producing more in its 'degraded' state than it did before?

• Given a strong case that land which can be cropped, will be cropped, and that pastoralists will slowly be forced on to the poorer parts of the land they now use, should goats be studied and promoted as more productive, versatile and socially valuable animals than cattle? To persuade pastoralists with a long tradition of cattle keeping to switch to goats would require very convincing evidence and demonstrations. It happens now only after severe stock losses through disease or drought, when there is an urgent need to rebuild with least capital outlay.

### Semi-intensive or Intensive Systems

• Are crossbred dual purpose goats more productive than indigenous goats? Does higher production outweigh their greater susceptibility to local parasites and diseases? At what cost in health care?

• Can more efficient complete crop and forage production/animal husbandry/marketing systems be developed, perhaps with the use of biological-economic models of smallholder farm enterprises (Okali and Upton 1984)?

• Given the much greater biological efficiency of milk than of meat production, can the milk goat be used as the ultimate livestock component on intensive small farms in places where population pressure is very high.

• Going even further, does the goat have a role in African suburban milk or meat production?

**Humid Forest and Cropping Areas**

The role of animals here is twofold — to produce meat as an essential protein component of human diets and to assist in maintaining or restoring soil fertility in fragile soils where the traditional 'bush-fallow' period must become shorter as population pressure increases.

• Given that such regions are likely to be tsetse-infested for a long time to come, is the trypanotolerance of dwarf goats a true genetic character or one acquired or developed through contact with the organism? Can it be transferred to other breeds or enhanced; can its mechanism be elucidated? (Whitelaw 1983).

• Does improved nutrition strengthen this tolerance?

• Are there economically acceptable ways to reduce the toll of disease and parasitism?

• What are the production penalties resulting from low-level disease, from morbidity as distinct from mortality? Trypanotolerant goats do acquire trypanosomes.

• If mortality can be controlled, would there be an advantage in a selection program to increase productivity, given that household flocks are so small that one 'certified' selected buck would be enough for a village?

## Conclusion

In sub-Saharan tropical Africa, the goat is a highly productive and versatile animal, well adapted to the exigencies of different climatic zones and intimately linked into the socioeconomic life of the pastoral/farming communities. Most pastoralists, smallholders, and villagers have goats but there are large differences in productivity among flocks in the same area.

Research on goats is patchy, even in countries where goats are important, but in a small number of countries there are active and productive research groups. Their work has sometimes been poorly related to the real needs of their production systems, reflecting research training in the developed countries where many aspects of goat production are quite different from those in Africa.

Veterinary diagnostic and research services are relatively well developed in many countries; health measures now available should permit control of some of the most serious diseases, but research is needed on the very heavy and widespread mortality of kids, and on parasitic and pulmonary infections of adults.

Genetic improvement by introduction of exotic specialised breeds has promise in certain places, but more attention should be given initially to selection within indigenous adapted populations.

There are a number of fields where more research is needed — health and nutrition are most important as disciplines but broader questions, like the development and testing of innovative farming systems, the role of goats in overgrazed arid pastoral areas, and their ability to reduce risk or restore reasonable production quickly after drought, also deserve long term experimental study.

*Acknowledgements* I owe a great deal to the work of ILCA colleagues on whose results I have drawn heavily. If the ILCA 'systems approach' seems to be overemphasised, that is because it appears to correspond best to the needs of African national institutions and livestock producers, by recognising the complexity of African problems.

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# Manipulation of Reproduction in the Goat

N.W. Moore*

In comparison with other production ruminants there is a shortage of information available on reproductive characteristics of the goat and this is particularly so of procedures which might be used to manipulate reproductive performance. The two major reasons for the shortage of available information would seem to be a general lack of interest in goats by researchers and the assumption that the reproductive characteristics of the goat are similar to those of the sheep. There are indeed similarities between sheep and goats, but there are several marked and important dissimilarities.

### Breeding Activity

The goat is generally considered to be a 'short-day' breeder with the peak incidence of breeding activity occurring in the autumn and early winter. This would seem to be so of animals located in the higher latitudes. (40° N or S). In France, where there is a large population of milch goats, breeding activity in the does is confined to September–February (autumn and winter) whilst libido and sperm production in the male are at their lowest in the summer (Corteel 1975). However, in areas closer to the equator there may be little evidence of any annual variation in breeding activity in either the male or female and it has been claimed that several breeds that appear to be largely confined to tropical areas will breed at any time of the year (Devendra and Burns 1970). In some situations, breeding activity may be aligned to an annual rhythm of events other than changes in the photic environment, e.g. the advent of the wet season and associated availability of feed while an established pattern of breeding activity can be modified by unusual climatic conditions. Large numbers of feral goats are found in the north western areas of New South Wales (lat. 31–33° S) and in most years kidding is confined to late winter-early spring following mating in February-March. However, when unseasonal rains occur in late winter-spring some animals are found with young kids in the following autumn.

* Department of Animal Husbandry, University of Sydney, Camden, N.S.W., Australia.

In breeds that show a well-defined breeding season kidding tends to occur in the non-breeding season and mating is not likely to occur until the next breeding season. Hence, these breeds will generally kid only once each year, usually at the same time in successive years. In breeds that are reputed to mate at any time of the year, two kiddings each year should be possible, but this is rarely achieved. Three kiddings in two successive years is generally the best achieved. The interval between successive kiddings in animals used primarily for milk production usually exceeds that of meat breeds. The extended period of lactation and resultant lengthy period of lactational anoestrus in milch animals, and the desire to obtain as many kids as possible from meat breeds would seem to be the major factors responsible for the difference in the intervals between successive kiddings. Further, it is likely that the incidence of multiple births in meat breeds will exceed that in breeds used primarily for milk production.

## Manipulation of Reproductive Performance

### Artificial Insemination (AI)

The benefits that can be achieved by the use of AI in goats, as in other production species, are well appreciated. Semen can be readily collected by artificial vagina or by electroejaculation and the insemination procedures are essentially similar to those used in sheep (Salamon 1976). In the ewe it is extremely difficult to penetrate the cervix beyond some 1 cm of the external OS with an insemination pipette of about 5 mm ext. diam., whereas in most does semen can be deposited deep within the cervix or even into the body of the uterus (Moore and Eppleston 1979a). In the doe conception rates in excess of 60% have been readily achieved following a single insemination with fresh semen and the limited information available would suggest that some $100 \times 10^6$ sperm in an inseminate volume of 0.05–0.10 ml are required to achieve acceptable conception rates. Dilution of high quality semen (in excess of $2 \times 10^9$ sperm/ml) at rates of 2:1 (diluent:semen) do not appear to markedly depress conception rates (Patel 1967; Moore and Eppleston 1979a; Ritar and Salamon 1983), but it may not be advisable to use diluents containing high concentrations of egg yolk (in excess of 5% — v/v). Buck seminal plasma contains the enzyme phospholipase A, which hydrolyses the lecithin in egg yolk to fatty acids and lysolecithin, which are toxic to sperm and coagulate the diluent (Roy 1957). Removal of seminal plasma by washing and centrifugation prior to dilution can diminish the problem, but the simple alternative is to use heated cows milk (90–95°C for 10 min) as a diluent (Moore and Eppleston 1979a).

One of the major benefits of AI, that of the rapid spread of improved genotypes in existing population, is to a large degree dependent upon the successful storage of goat semen. Goat semen has been successfully frozen, but most diluents used in the frozen storage of semen contain egg yolk in concentrations that will result in agglutination of most samples of buck semen. Egg yolk is used because of its cryoprotective capacity. In early work frozen storage of buck semen could only be reliably achieved if seminal plasma were removed before the addition of glycerol/citrate/egg yolk diluents (Corteel 1975). Recently, it has been shown that goat semen can be successfully stored frozen without removal of the seminal plasma using Tris/glucose/citrate/egg yolk-based diluents, but the final concentration of egg yolk should not exceed 1.5% v/v (Ritar and Salamon 1982; 1983).

### Control of Time of Mating

In does experiencing full breeding activity, control of the time of mating and hence of kidding allows kidding to be programmed to suit production, environment, labour and market conditions. Further, if AI is to be used it is highly desirable that the time of oestrus and ovulation in groups of does be synchronised so that they can be all inseminated at the one time. Intravaginal pessaries containing progestagens as developed for use in sheep have been successfully used to control the time of oestrus in milch does (Corteel 1975) and in Angora does (Moore and Eppleston 1979a; Ritar and Salamon 1983). Prostaglandins are effective luteolysins in the doe (Hearnshaw et al. 1974), but as in other species they may not be effective during the first few days after oestrus (Moore and Eppleston 1979a).

Following pessaries inserted for 16–18 days most does will be in oestrus 36–60 hours after removal of pessaries and one insemination at 48 hours or two inseminations, one at 48 and the other at 60 hours after removal of pessaries, should give conception rates in excess of 50%. The conception rate to AI in does treated with pessaries can be somewhat less than that in untreated does (Moore and Eppleston 1979a) and it may be that the effect of treatment on fertility could be overcome, as in the ewe, by increasing the numbers of sperm inseminated. If does are to be mated by natural service then only bucks producing high quality semen should be used.

### Induction of Oestrus and Ovulation

Attempts to decrease the interval between successive kiddings will almost invariably involve the induction of oestrus and ovulation during periods of sexual quiescence (seasonal, postpartum or lactational anoestrus). Intravaginal pessaries with gonadotrophin (e.g. PMSG) have been successfully used to induce oestrus and ovulation with subsequent conception rates to AI in excess of 50% in milch goats in France (Corteel 1975). PMSG (400–800 iu depending upon breed) is given 1–2 days before removal of pessaries, which are inserted for 16–18 days, and does are inseminated at 36 and 60 hours after removal of pessaries. Similar procedures have been used to induce oestrus and ovulation in Angora and feral does in Australia but conception rates to AI and to natural service have been generally low and frequently less than 40% (N.W. Moore, unpublished data). In many does the induced corpora lutea regress prematurely at around 3–5 days after the induced ovulation.

Procedures used in mature does for the induction of oestrus and ovulation during periods of sexual quiescence should be successfully for the induction of oestrus and ovulation in does approaching puberty, but there seems to be no information available on the use of pessaries in prepubertal does.

### Superovulation and Embryo Transfer

PMSG, a crude horse anterior pituitary extract (HAP), and a pituitary FSH preparation of porcine origin (FSH-P; Burns Omaha, USA) will readily induce superovulation in does (Moore 1974; Moore and Eppleston 1979b; Armstrong et al. 1983a,b) and the time of superovulation can be controlled when the gonadotrophin is given near the end of a period of treatment with progesterone or intravaginal pessaries, or just before treatment with prostaglandins. PMSG is given as a single injection whereas HAP and FSH, because of their greater rate of inactivation, need to be given on 3 or 4 consecutive days. PMSG has the further advantages of being readily available and relatively cheap, but in comparison with HAP and FSH high doses of PMSG result in a high incidence of persistent follicles, which can adversely affect fertilisation and development of embryos (Moore and Eppleston 1979b; Armstrong et al. 1983a). Rates of fertilisation in excess of 80% can be achieved by natural service, whereas mating by AI, into the cervix or directly into the uterus, has been reported to depress fertilisation (Moore and Eppleston 1979b). Recent work in this laboratory indicates that the low rates of fertilisation were due to the use of poor quality semen rather than due to the AI procedures. On occasions there could be valid reasons for the use of frozen semen in which case insemination directly into the uterus using laparoscopic procedures may well be the appropriate method of mating required to achieve high rates of fertilisation.

In the goat, as in the ewe, embryos are collected and transferred surgically (Moore 1982). There seems little chance of developing non-surgical procedures for collecting embryos, but transfer using laparoscopic procedures may well be a possibility.

The use of superovulation and transfer to increase the numbers of progeny from selected females within established breeds or strains is well recognised and transfer has been used in Angora goats in Australia for this purpose (Moore 1974; Moore and Eppleston 1979b; Armstrong et al. 1983b). However, the potential value of transfer in 'grading up' programs is not well appreciated. Table 1 provides a comparison of what could be achieved in programs of grading up to 7/8th exotic animals using standard methods of AI or procedures involving transfer. The calculations have been done making the following assumptions:

a. 90% kidding to mating by AI at two oestrous periods.
b. Transfer used on ½ and ¾ breed does with each doe providing 6 kids.
c. ½ breed and ¾ breed females first mated at 1½ years, giving a generation interval of 2 years.
d. Sex ratio of 1:1.
e. Base stock of 500 indigenous does available.

In practice it may well be possible to mate at age 1 and hence decrease the generation interval to 1.5 years. Further, does to be used for transfer could be rigorously selected for the desired characteristics.

**Table 1.** Progress in grading up to 7/8th exotic breeds.

| *Year of operation* | *Number of does of breeding age* | | | |
|---|---|---|---|---|
| | *Base stock* | *1/2 breed* | *3/4 breed* | *7/8 breed* |
| A — using AI only | | | | |
| 0 | 500 | — | — | — |
| 1 | | — | — | — |
| 2 | | 225 | — | — |
| 3 | | — | — | — |
| 4 | | | 101 | — |
| 5 | | | | — |
| 6 | | | | 46 |
| B — using Embryo Transfer | | | | |
| 0 | 500 | — | — | — |
| 1 | | — | — | — |
| 2 | | 225 | — | — |
| 3 | | | — | — |
| 4 | | | 675 | — |
| 5 | | | | — |
| 6 | | | | 2025 |

## Storage and Transport of Embryos

Procedures for the frozen storage of sheep, cattle, and goat embryos have been developed (Moore and Bilton 1977) and the technique has been successfully used for the transport of cattle and sheep embryos between countries (Bilton and Moore 1977; 1983) and there seems no reason why goats cannot be similarly transported (Bilton and Moore 1976). In addition to being rapid and cheap, the transport of animals as embryos would aid in preventing the introduction of exotic diseases, allow young to obtain some immunity against local diseases from their recipient mothers, and allow young to adjust more readily to foreign environments.

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# Genetics and Breeding of Goats

**W.A. Pattie***

In this review, emphasis will be given to a summary of the information needed to allow the design of efficient breeding systems, the extent to which the published literature provides this information and a discussion of priority areas for research into goat breeding in the tropics. Specific areas for discussion will be the manipulation of genes having a readily identifiable effect, the use of introduced stock and methods for improving existing types. The value of modern breeding technology and factors affecting the distribution of genetic improvement will also be considered.

In general, goat production in village or smallholder agricultural systems in the tropics will be taken as the main frame of reference. In these systems, meat production is the main objective but in many cases this is combined with the production of milk, fibre or leather and in some regions, specific enterprises concentrate on one of these products. Information relating to these various end products will be covered within the discussion of the various genetic principles.

It is assumed that for any genetic improvement programs under consideration, the overall breeding objectives and the important animal characteristics relating to these objectives have been established. For the long term, it is important that these objectives and relevant characteristics be specified in terms of production from the whole system per unit of input including food, land, and other resources. Unfortunately no research program can feasibly investigate all of the inter-relationships involved but it is clear that each project should be designed to provide part of the information needed so that later research of a systems analysis type can be based on reliable and meaningful data.

## Specific Genes with Identifiable Effects

A common feature of all animal improvement programs is that the presence of genes with undesirable effects in the population can reduce progress towards achieving the main breeding objectives. This occurs because selection potential must be used to manipulate the frequency of the genes involved. Ricordeau (1981) has summarised the main genes that have identifiable effects, most of which occur in low frequencies and cause few problems. In terms of affecting production potential, the most important are probably the genes controlling horns and colour. The remainder would cause no greater problems than exist in breeding populations of any other species.

### Horns and Associated Problems

The absence of horns is caused by an autosomal dominant gene that has a marked difference in expressivity between the sexes, particularly in heterozygous animals (Ricordeau and Lauvergne 1967). In general, goat producers in tropical regions do not seem to be concerned about the horned status of their goats but the poll gene can have an important influence on productivity through its association with abnormal reproductive development.

Homozygous polled females develop as pseudohermaphrodites and are infertile while about half the homozygous males are sterile (Ricordeau et al. 1972). Heterozygous animals do not appear to be affected. Of itself this phenomenon would not be a major problem as most breeds used in the tropics are horned (Mason 1981). However, the poll gene occurs in a higher frequency in some breeds (e.g. Anglo-Nubian) that have been used for crossing with local breeds and the need to control its occurrence in later generations of their offspring will reduce potential selection differentials for important production characteristics.

### Colour

The precise genetic basis for inheritance of colour has probably not been fully elucidated although Lauvergne (1982) has described five gene loci, some interacting and some with multiple alleles, that affect hair colour. Economically, colour will probably only have general importance in fibre producing goats where white is desired. Because dominant genes are involved it is relatively easy to breed a herd with a large proportion of white goats but segregation will sometimes produce coloured animals.

* Department of Animal Production, University of Queensland, St. Lucia, Qld., Australia.

Cashmere goats with coloured hair frequently grow white down but there are no published reports on its genetic control. However, as processors will almost always down-grade this cashmere to a non-white colour grading (G.A. Smith, pers. comm.), breeders will give preference to white-haired stock. In the early stages of a breeding program where fibre production is based on a foundation population containing coloured goats, selection pressure for weight and quality will be reduced until a white herd is established.

### The Use of Introduced Stock

In most of the tropical regions of Southeast Asia, there are populations of small, apparently well-adapted goats. These have probably not existed for long on an evolutionary time scale (Mason 1981) and the mechanism of their migration could well have resulted in some types predominating purely by chance. It is therefore reasonable that investigations be made of the possibility that breeds or types from other regions may usefully contribute to increased or more efficient production. Furthermore, even if the existing types are best adapted to their present low-input environments, the opportunities for environmental improvement that new technology may offer could favour other higher producing strains.

In most of the areas of interest, goats are raised in extremely small herds in which individual genetic improvement programs based on selective breeding are practically impossible to implement. However, the distribution and use of genetically distinct types is feasible and it is usually suggested that crossbreeding with introduced stock offers the best way of achieving improved productivity.

Introduced stock or their gametes can be used in several ways. The principal systems, which may also appear in combination, are continuous crossbreeding to utilise heterosis; establishment of a previously unavailable breed; and development of a new strain combining desirable characteristics of introduced and local stock.

A complex set of information is needed if sound decisions are to be made on which, if any, of these systems would be best to use and what would be the most efficient method for their implementation. From Dickerson (1973), the parameters required for each important characteristic are the means and variances of each breed and the contribution to any differences of additive gene effects; specific paternal and maternal effects; individual heterosis; maternal heterosis; and recombination loss.

These parameters can be obtained from crossbreeding experiments that involve comparisons of the parent breeds with F1 and F2 or backcross generations of their crosses. Clearly, the number of breeding groups will be unacceptably large if more than two or three breeds are being considered, so some initial judgments must be made on the basis of prior experience, information from animals already introduced and from the results of initial comparisons of the first generation animals.

It is important that experiments designed to provide these parameters be conducted in a way that will provide valid estimates. In particular, the different groups must be bred and reared in the same environment and adequate links between generations must be provided that are not confounded by age differences in the parent stock. Adequate genetic sampling of the various breeds is also important, particularly where introductions are restricted to one sex (usually males). In this case the total number of offspring compared is relatively unimportant as the number of sires used represents the effective genetic replication (James 1975).

It should be obvious that the various crossbreeding parameters are not needed if the object of introducing stock is to establish an enterprise (e.g. mohair production) for which no goats exist in a particular locality. In such cases the issues only concern technical and economic aspects of the different methods available for introducing, multiplying, and distributing the genetic material.

It would be unrealistic to expect to find many experiments that systematically provide the information outlined here. However there are very few published reports of studies that provide even a small part of the information required.

Mason (1981) and Devendra and Burns (1983) summarised the production levels that have been reported for many breeds for milk yield and composition, lactation length, body weight, fleece production and various components of reproductive performance. These data show very wide differences between breeds for all characteristics but as most of the studies involved only one breed, the differences would contain a component due to environmental influences. Nevertheless they do provide information on the relative ranking of breeds and the studies that did involve comparisons in the same environment showed rankings in the same order.

Such information can be used as a basis for choosing breeds to be introduced and examined in a research program. However practically no information is available on important adaptive characteristics or on comparative feed requirements for maintenance and production, which are important in husbandry systems where feed is limited (Norton, these Proceedings). Consequently it is not possible to recommend particular areas. It would seem to be important that future research into nutritional requirements should provide information on breed differences whenever possible and that such work should adequately partition within and between breed variation. Care should also be taken to avoid averaging data obtained from different breeds, Vercoe and Frisch (1982) showed that where groups of cattle differ in their metabolic rate and voluntary feed intake, genotype × environment interactions will occur in the extent of productivity above maintenance at different levels of nutrition. It would be reasonable to expect a similar situation with goats.

The information available from crossbreeding experiments (summarised by Ricordeau, 1981) indicates that significant heterosis may exist for weight and milk production in crosses involving European and African dwarf breeds, but not with crosses involving a limited number of other normal breeds. In each case the levels of heterosis were not sufficient to support a continuous crossbreeding system as the more productive parent breed, and backcrosses to it, were superior to the $F_1$s. Thus, even though half of any heterosis would be lost with subsequent crosses after the $F_1$, the establishment of the parent breeds would be a more useful enterprise.

Unfortunately there is no information on the various crossbreeding parameters applicable to existing breeds in most developing countries. However there are an increasing number of comparisons being made between local animals and their crosses with breeds that have already been introduced. Many of these studies are being carried out in villages and the results should have the advantage of being applicable to present husbandry practices, although they do not give information on potential improvement at higher levels of management. As might be expected in situations where the animals being compared have quite different mature sizes and environmental conditions can be severe, the results of such village comparisons do not always agree. For example, growth and fertility of Javanese Ettawah × local goats have exceeded local goats in some studies but not in others (Sitorus et al. 1982; Astuti 1983). Clearly, environmental differences could have caused such discrepancy but with this type of study the specification of breed type also makes interpretation difficult. In many cases the ancestry and breed composition of the crossbred animals is unknown and can vary considerably between villages. Similarly, where widespread and indiscriminate crossing has been practiced, it is often difficult to find animals of local breeds that have not had an infusion of the introduced type.

Future observational research of this type should aim to use animals of known ancestry and examine these under different nutritional and management levels. Future improvements in husbandry practices can often be found and may not necessarily involve a significantly greater cost or use of scarce resources (Wilson 1982). Furthermore, experience with other species, e.g. pigs and poultry in Bali, has shown that, where city markets are available, the increased value of higher producing stock more than offsets the greater costs and provides increased net returns to the farmer (I.M.Nitis, pers. comm.).

In addition to the information requirements outlined here, Pattie and Baker (1983) have shown that the returns to investment in crossbreeding depend heavily upon the way that new genotypes are produced and distributed. Efficient systems can only be designed if information is available on the structure of the population and its dynamics in terms of movement of stock and statistics on age, specific birth, death, replacement, sale and slaughter rates. At present there are few published data of this type relevant to goats in the tropical countries of our region. A standardised approach for obtaining such data has been recommended by the two Society for the Advancement of Breeding Research in Asia and Oceania (SABRAO) workshops on animal genetic resources.

## Improvement within Populations

Genetic improvement of goats by selection within existing tropical populations is generally thought to be almost impossible because of small herd size, severe environmental stresses and the lack of appropriate technology. Consequently most attention has focused on the use of introduced stock, which hopefully will perform better than local stock. However even when this is the case, it is unlikely that continuous crossbreeding would be feasible. Rather, the introduced stock would be used either to replace local types or to produce a synthetic strain combining desirable qualities of each. In both cases, once the immediate goal has been achieved, any further improvement will depend upon selection within the new type. In addition, many workers point out that there is little evidence available to indicate that the introduction of exotic animals will be better than selection within locally adapted indigenous stock, although genetic theory and experience with other species indicate that more rapid selection responses can be expected to follow any increase in genetic variation brought about by introducing new genotypes.

### Information on Genetic Parameters

The information needed to design optimum breeding plans for improvement within a population comprises: production and variability, lifetime performance and repeatability, heritability, genetic and phenotypic correlations between important characteristics and the effects of inbreeding. In addition, data on vital statistics, age distributions and population structure are needed for estimates of generation length and potential selection intensity. The latter data need to be determined for the population being considered but general estimates can be used for the genetic parameters if they have been calculated for similar types of stock in broadly similar environments.

Unfortunately the required parameters are not available for goats in the tropical countries of this region. Data from India show heritabilities for weight and gain ranging from 7 to 78%, and for multiple births a range similar to that for sheep (9–25%). However these estimates are characterised by large standard errors due to small population size (Taneja 1982) and the important genetic correlations have not been estimated. For mohair production, parameter estimates from Texas indicate moderate to high heritabilities for fleece and body characteristics but there may be negative relationships between fleece production and body weight and fertility (Shelton 1981). It is difficult to imagine that a large proportion of the required information will become available in the near future directly from the populations of interest. Herd sizes even on government operated farms are not large enough and if they were, it is doubtful that research priorities would allow their exclusive use for estimating genetic parameters. It is in this area that genetic research with feral goats in Australia may be of value to countries wishing to commence improvement programs.

The situation with milk production is somewhat different. There are extensive estimates of the relevant parameters for European milk goats and efficient breeding programs have been developed (Ricordeau 1981). While these parameters may not apply directly to tropical conditions and the breeding systems would not be appropriate, the European experience and technology provide a sound basis for developing milk producing systems if required. In the short term though, emphasis would normally be placed upon introducing appropriate milk breeds, evaluating them and establishing local strains. Data generated during this phase could then be used to design simplified selection systems appropriate to local husbandry conditions.

### Improvement systems

In countries where most goats are maintained in village husbandry systems comprising many very small 'herds', traditional selection programs will be unlikely to produce significant improvement. Reasonable selection intensities will only be possible if community or government buck breeding nucleus herds are established. Any genetic improvement in these herds would be spread through the population by distributing bucks to the villages and farms. Selection is not needed in the village herds as it will have negligible genetic effect and will not repay its cost. Obviously the success of such a scheme will depend upon efficient operation of the nucleus and the establishment of an infrastructure for the rapid and widespread distribution of males produced.

At present there are no research data available to enable the design of either the nucleus selection program or the distribution system. Despite this, notable improvements have been made with the development of the Boer goat in South Africa and the Fijian goat breeding scheme (Devendra and Burns 1983). In both cases new strains were produced by crossing introduced animals with local stock then selecting intensively for growth, body size and other important characteristics. Hill (1974) has provided numerical methods for evaluating alternative breeding schemes that take into account the flow of genetic improvement during the early years before selection responses become stable. However before these methods can be applied the data outlined above are needed.

## The Value of Modern Breeding Technology

Recent developments in breeding technology can have important implications for the way in which breeding programs are operated. The techniques that are available now or will reach commercial development in the near future are artificial insemination and freezing of semen, control of female reproduction, multiple ovulation with embryo preservation and transfer.

The important genetic consequence of these techniques is the more rapid introduction and distribution of new breeds or superior animals once they have been identified as desirable. Pattie and Baker (1983) have calculated the improvements possible with cattle breeding, and similar relative patterns of response should follow use of the new technologies with goats. These studies also showed that, although the introduction of new genes could be accelerated, they would have to be distributed rapidly through a large commercial population to repay the costs involved. Even then, significant benefits would not be realised for 10 to 15 years after the start of the program. An investigation into the use of the new controlled breeding methods for within-population selection programs indicated that useful improvements would be unlikely with the present techniques.

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# Nutrition of the Goat: A Review

**B.W. Norton***

OVER the last decade, there has been an increasing awareness of the significance of the goat in production systems in both tropical countries and Australia. In developing countries, it has now been recognised that the small size, high fertility, low management needs and the wide acceptance of goat meat make goats more suitable than cattle for introduction to poor farmers as a source of milk and meat for home consumption and income. In Australia, the export potential for goat meat and the capacity of our feral goats to produce cashmere has stimulated considerable interest in the development of a new grazing industry from the large numbers of feral goats found in our semi-arid areas.

Although Australian nutritional research with grazing cattle and sheep has an international reputation for its high standard, there is a paucity of information on goats from which recommendations can be made for the development of this new industry. Gall (1981) and more recently Devendra and Burns (1983) have reviewed the state of knowledge on goat production in temperate and tropical areas, and whilst many nutritional studies have been reported, the diversity of breeds used, the varying environments and feeds offered usually preclude any firm conclusions regarding the basic principles of goat nutrition. In Australia, goats are found in both the arid and high rainfall zones from southern Australia to the tropical north. Also, apart from some small flocks of pure breeds (Milch goats, Angoras), most goats of potential commercial importance for meat and cashmere production are of mixed breeding, having been derived from African, Asian and European breeds introduced to Australia during the early years of settlement.

The challenge facing Australian scientists in the next decade is to produce definite information on the nutritional requirements of meat, fibre and milk producing goats on pastures in the range of environments described previously. The production potential of superior genetic strains can only be realised in disease-free conditions where optimal nutrition is provided. There is presently an urgent need in Australia for information on the nutritional requirements of our goats for maximum productivity and on the extent to which poor nutrition affects productivity under grazing conditions. A similar need is found in most tropical areas where the adequacy of nutrition is probably the major limit to increased productivity.

The following review is not intended to be exhaustive, since a comprehensive review of goat nutrition has recently been published (Devendra and Burns 1983). However, it is pertinent to review briefly and critically the existing information with the intention of highlighting the areas of nutritional research still needed if a comprehensive model of goat requirements is to be developed in the near future.

## Voluntary Feed Intake and Digestive Efficiency

A major determinant of production level is the voluntary consumption of digestive nutrients, the components of which are voluntary feed intake and digestibility. Many reports in the literature suggest that goats are different from sheep and cattle, often having higher feed intakes and/or digestibilities of the same feed. These observations suggest that the direct translation of nutritional data collected from other ruminants may not be applicable to goats, and that separate tables of feed nutritive values may need to be prepared (Schneider 1947; Butterworth 1967; McDowell et al., 1974; NRC 1981).

Devendra (1980) has reported values ranging from 32 to 130 g dry matter intake (DMI)/kg$^{0.75}$d for the ad libitum intake of non-lactating goats consuming forages and forage plus concentrate diets. Lactating goats consistently have higher intakes than non-lactating goats. It would seem that digestible DMI may be a better expression of voluntary feed intake, since intake usually varies directly with diet quality. Voluntary feed intakes expressed as a percentage of body weight may also be misleading since small goats will have higher values than large goats at equivalent intakes per unit of metabolic weight. From the wide variation in values, it would seem important to determine the proportion of variation due to environment, breed and

* Department of Agriculture, University of Queensland, St. Lucia, Qld, Australia.

**Table 1.** Some measurements of digestion in sheep and goats fed high (12.2% CP) and low (5.1% CP) quality Pangola grass hay (from Watson and Norton 1982).

| Measurement | *Sheep* | | *Goats* | | *SE of Mean* |
|---|---|---|---|---|---|
| | *High* | *Low* | *High* | *Low* | |
| DM intake ($g/kg^{0.75}d$) | $47.8_a$* | $31.9_b$ | $49.5_a$ | $32.6_b$ | 2.8 |
| NDF digestibility (%) | $73.4_{ac}$ | $63.5_b$ | $75.3_a$ | $71.3_c$ | 1.2 |
| Mean Cr retention (k) | $9.4_a$ | $10.7_b$ | $12.1_c$ | $13.1_c$ | 0.4 |
| Rumen ammonia (mg N/l) | $141_a$ | $43_b$ | $145_a$ | $106_c$ | 11 |
| Plasma urea (mg N/l) | $149_a$ | $43_b$ | $155_a$ | $71_c$ | 10 |

* Mean values within a line with different subscripts differ significantly ($P<0.05$).

forage quality, and meaningful comparisons of voluntary feed intake between breeds can only be made if data are expressed as digestible energy intakes, preferably as a multiple of the maintenance requirement. In this way the capacity of different breeds to consume 'productive' energy from different diets can be assessed and related to measured production characteristics.

There appears to be general agreement that goats digest cellulose more efficiently than sheep and cattle, particularly when low quality diets are fed. This physiological adaption to low quality diets may be explained by the capacity of goats to retain feed particles in the rumen longer than sheep or cattle and to maintain higher levels of ruminal ammonia essential for the effective breakdown of cellulose by microorganisms in the rumen (Table 1). Further studies with goats have shown differences in ingestive behaviour (rate of eating, rumination and particle size reduction during chewing) and these behavioural and physiological differences indicate that it may no longer be relevant to directly translate information from sheep and cattle to goats. It would also seem that further comparative nutritional studies of goats with other ruminants will simply dilute the amount of information that could be collected on goat nutrition, and that the aims of these studies should be carefully considered before being undertaken.

## Energy Requirements

In 1981, the American National Research Council (NRC)/National Academy of Sciences released the first edition of 'Nutrient Requirements of Goats: Angora, Dairy and Meat Goats in Temperate and Tropical Countries.' The report states that research in goats is somewhat sketchy especially when one considers that there are over 400 million goats in the world. It also points out that in spite of similarities with sheep and cattle, goats have been observed to have differences in grazing habits, physical activities, water requirements, feed selection, milk composition, carcass composition, metabolic disorders and parasites. Thus, goats should be studied independently of other ruminants, but because of a lack of specific information, some of the assumptions used by NRC for goats have been taken from other ruminants. NRC recommendations must therefore be considered as a first approximation to requirements, and will be revised as new and relevant information becomes available.

For example, the conversion of digestible energy (DE) to metabolisable energy (ME) uses the factor derived by NRC (1980) for sheep and cattle (0.82), and it has been assumed that the efficiency of energy use around maintenance was 56%. In growing lambs, this value has been found to be around 80% (Walker and Norton 1970). Both of these assumptions need experimental justification if the energy requirements of goats are to be expressed on a comparable basis with other ruminants.

### Maintenance

Although only a few estimates of maintenance energy requirements of goats have been reported, there seems to be general agreement that the range of values for temperate breeds (365–465 kJ $ME/kg^{0.75}d$) is similar to that for tropical breeds (378–474 kJ $ME/kg^{0.75}d$). Studies with Australian feral goats consuming concentrate rations found a value of 386 kJ $ME/kg^{0.75}d$ for the maintenance requirement of goats varying from 13.8 to 27.9 kg liveweight (Norton 1982). NRC recommendations have been based on a value of 424 kJ $ME/kg^{0.75}d$ and may therefore represent up to 15% error when applied to particular breeds.

Research with tropical breeds of cattle has shown that they have significantly lower maintenance requirements (and basal metabolic rates) than do temperate bred cattle, and that this physiological adaption permits better survival on low quality rations and better resistance to heat stress. However, a further consequence of this adaption is poorer productivity from high quality rations compared with temperate cattle (Vercoe and Frisch 1982). A similar survival mechanism may exist in goats, and it would seem important to determine whether the reported differences in maintenance requirements between different breeds are real or simply experimental artifacts. This information is needed if goats are to be selected for productivity in different environments.

NRC (1981) have recommended up to a 75% increase in allowance for goats grazing open rangeland in cool climates. However, such recommendations would seem to add little to our knowledge of goat nutrition since goats in this situation are seldom hand fed, nor can their nutrient intake be controlled. Under range conditions, the size of the activity increment is related to the extent to which the forage available fails to meet the maintenance requirements, and range and pasture management techniques are aimed at decreasing activity increment (maintenance). Measurements of seasonal forage yields, consumption, stocking rate and the additional feed required for maintenance of productivity would perhaps provide more meaningful recommendations for rangeland goats in different environments than arbitrary estimates of activity increments.

**Production**

Again, only a few estimates of the energy requirements for growth have been reported, mostly from tropical areas but with different breeds of goats. NRC (1981) use the mean value (30 kJ ME/g gain) of these three estimates to calculate the energy requirements for growth, and a value of 56% for the efficiency of ME use for growth. Although it is well known that goat meat contains less fat than other ruminant meats, significant amounts of fat are stored in extra muscular sites (McGregor 1982). There is presently little reliable information on the composition of the carcass and body weight gain of goats given different diets, and if there are differences between breeds in their propensity to deposit fat, there will also be differences in the efficiency of energy utilisation for growth. The low efficiency of energy utilisation used by NRC does suggest that protein deposition dominated the weight gain. Similar deficiencies exist for information on the energy requirement for pregnancy and lactation, and considerable scope for further study of the energy requirements of goats is indicated.

## Protein Requirements

Devendra and Burns (1983) have reviewed the literature on the protein requirements of goats for maintenance and found values varying from 0.64 to 3.45 g digestible crude protein (DCP)/kg$^{0.75}$d. The lower estimates were found with diets low in N content, and probably represent the most realistic estimates of maintenance requirements. The higher estimates were obtained with diets that probably contained varying amounts of highly degradable feed proteins, and the variability of the estimates may reflect more the difference in dietary N quality than a variability in the true maintenance requirements of the different breeds studied.

The validity of expressing the protein requirements of ruminants in terms of DCP must be questioned, since, over the last decade, it has been realised that feed proteins may be only partly degraded in the rumen. In this case, feed protein will directly contribute to the amino acids available for absorption in the intestines, whereas completely degraded feed proteins act only as a source of ammonia, amino acids and energy for microbial protein synthesis. This fact has been incorporated into recommendations in the latest edition of ARC nutrient requirements for sheep and cattle, by categorising qualitatively feeds of high, medium, and low rumen degradable N (RDN) contents. The ideal feed protein should supply just sufficient RDN for optimal microbial activity and sufficient undegraded rumen N (UDN) to supplement the microbial protein supply to a level necessary to meet the tissue amino acid requirements for production.

However, the quantitative determination of RDN and UDN fractions in feeds requires the use of

**Table 2.** The effects of protein level on the intake, growth rate and fleece production in cashmere bearing goats (from Ash and Norton 1984).

| *Protein level (%)* | *Mean liveweight (kg)* | *Dry matter intake (g/kg LW/d)* | *Growth rate (g/kg LW/d)* | *Fleece growth rate (kg/100 follicles/d)* |
|---|---|---|---|---|
| 10.5 | $14.6_a$* | $27.6_a$ | $2.8_a$ | $12.8_a$ |
| 15.5 | $15.9_b$ | $31.0_a$ | $3.4_a$ | $17.2_b$ |
| 20.5 | $17.2_c$ | $38.2_b$ | $4.4_b$ | $17.1_b$ |

* Values with dissimilar subscripts within columns are significantly different ($P<0.05$).

sophisticated experimental techniques such as intestinally and ruminally fistulated animals and the use of radioisotopes. There is little supporting evidence that qualitative techniques (solubility, in vitro incubation, nylon bag digestibilities) are related to in vivo protein metabolism in the rumen, although this area of research will need to be actively pursued if meaningful descriptions of feed protein quality are to be provided in tables of feed composition and nutritive value. It may therefore be fortunate that there have been no studies reported of the protein requirements of goats for growth (Devendra and Burns 1983), and any future studies must now measure not only the protein intake and digestibility but also the amounts of protein (microbial and feed) made available for absorption at the small intestine. Only in this way will meaningful estimates of the protein requirements of goats be obtained. Studies of this type have been commenced at the University of Queensland with the aim of determining the protein and energy requirements of weanling goats. Cottonseed meal which is partially protected from degradation in the rumen was used in pelleted rations, and from the results shown in Table 2, increasing the protein content of the diet from 10.5 to 20.5% crude protein had a significant effect on both liveweight and fleece growth.

Equally meagre information is available for the protein requirements for pregnancy, lactation, and fibre growth in goats, and these areas are in urgent need of further study. Contrary to results with sheep and cattle, some results in the literature suggest that urea is used more efficiently than protein-rich concentrates for growth (Mba et al. 1974; El Shazely and Borhami 1975), although later reviews indicate that urea metabolism in goats is similar to that in other ruminants (Harmeyer and Martens 1980), and this view has been confirmed in Australian experiments (McGregor et al. 1982). The efficacy of urea use in goat rations does require further study particularly the levels used and susceptibility of the goat to ammonia toxicity.

## Mineral and Vitamin Requirements

Haenlein (1980) has reviewed the mineral requirements of goats in temperate regions. Devendra and Burns (1983) have collated the fragmentary data available from the tropics, and point out that the mineral and vitamin requirements of goats have been the least studied area of nutrition in goats. NRC (1981) has provided guidelines for the calcium, phosphorus, vitamin A and vitamin D requirements of goats. Under intensive feeding conditions, there is a need to know the requirements of goats, not only to provide the essential levels, but also to avoid metabolic disturbances caused by excessive intakes, for example urolithiasis in goats is closely related to calcium, phosphorus, and perhaps vitamin A intakes (Baxendell 1984).

Under grazing conditions, goats may avoid mineral deficiencies when given access to browse (Table 3), but have proved just as susceptible to cobalt ($B_{12}$) deficiency as sheep and cattle grazing improved tropical pastures (Norton and Hales 1976: Quirk and Norton 1982). Iodine deficiency in goats has recently been observed in southern Australia and it seems possible that other mineral deficiencies will become evident as goats become more intensively managed under commercial conditions. However evidence from sheep would suggest that deficiencies of the macro elements (Ca, P, Mg) would be unlikely to occur under grazing conditions. Cerebrocortical necrosis (CCN) has been sporadically observed in goats grazing tropical pastures particularly after heavy and persistent rain or during an interruption to the normal feeding pattern, such as introduction to concentrate feeds. Intramuscular thiamine injection has proved effective in alleviating the symptoms in most animals, and closer attention to management can avoid the occurrence of this metabolic disturbance.

**Table 3.** Liveweight change and fleece growth in Angora goats grazing native and Pangola grass pastures with and without cobalt supplementation (from Norton and Deery 1984).

| Pasture | Cobalt supplement | *Liveweight gain (g/d)* | | | | *Fleece wt (kg)* | |
|---|---|---|---|---|---|---|---|
| | | *Spring* | *Summer* | *Autumn* | *Winter* | *Autumn* | *Spring* |
| Native | + | 16 | $16_a$* | $-5_a$ | $-19_a$ | 1.11 | $0.67_a$ |
| | − | 15 | $0_b$ | $0_a$ | $-3_a$ | 0.95 | $0.64_a$ |
| Pangola grass | + | 16 | $20_a$ | $43_b$ | $39_b$ | 1.06 | $1.06_b$ |
| | − | 26 | $25_a$ | $24_c$ | $-84_c$ | 0.98 | $0.89_b$ |

* Values within a column with different subscripts differ significantly ($P<0.05$).

## Browse and Pastures in Goat Nutrition

A major difference between goats and other domesticated ruminants is their preference for browse, which increases survival by extending total forage availability. This catholic approach to plant selection makes the goat economically useful in weed control (Mitchell 1984), and a potential devastator of fragile ecological systems. Although both Australian and overseas studies have confirmed that goats are browse feeders in environments where sheep eat grass, the productive advantage, other than survival, has seldom been measured. The goats' preference for browse is often misinterpreted as a nutritional wisdom, and also cited as an essential aspect of any goat management system. As with pasture, the nutritive value of browse varies considerably, not so much with season, mainly with species. There is a need for quantitative data on the nutritive value (intake, digestibility and nutrient content) of shrubs and trees consumed by goats, so that meaningful programs of browse management for production can be developed.

Acacia species are a common browse species of goats in Australia, and yet little is known of their nutritive value for goats. Sheep only maintain weight when fed a sole diet of mulga (*Acacia aneura*, 12% crude protein), but if supplemented with small amounts of sulphur, feed intake and liveweight gains are increased (Hoey et al. 1976). Similar studies with goats are indicated from these findings. Table 3 shows the relative productivity of Angora goats grazing native pastures and acacia browse compared with goats on improved tropical pastures in Queensland. Whilst the availability of browse prevented the development of cobalt deficiency, the production of goats grazing the improved pastures was markedly superior. Similarly goats grazing a pigeonpea (*Cajanus cajan*) crop grew no better than goats grazing Pangola grass pastures despite higher protein availability; additional supplements of sorghum grain significantly increased growth rate suggesting that the digestible energy content of pigeonpea was low (Bint and Norton 1982). However, other studies with pigeonpea have indicated an alternate use of this crop for the control of intestinal parasites in goats. Where goats graze pigeonpea crops with plant densities greater than 2/square metre there is a significant decrease in faecal egg counts in untreated goats and would suggest that apart from nutritional considerations, the inclusion of browse in a goat management system may have other benefits. These studies suggest that whilst the consumption of browse may extend feed availability for goats, it may not necessarily be consistent with provision of optimum nutrition. High quality browse, such as *Leucaena* and *Gliricidia*, may have however an important role in the nutrition of grazing or grass-fed goats in the tropics and the identification and cultivation of other high quality browse species should be a priority for future research.

There appears to be little information on the management of goats (stocking rates, shelter needs, health etc.) grazing improved temperate or tropical pastures. This information is urgently needed if intensification of goat production in Australia is to occur. Goats have been found to be useful companion animals in sheep and cattle grazing systems. Where grazed with cattle, goats consume different sward components and where grazed with sheep on grass-clover pastures, goats preferentially select grass to white clover whereas sheep prefer the clover. In this case, goats may be used to maintain optimum pasture composition for sheep without competing significantly with them. However, as shown in Table 4, the same preferences are not shown for these species grazing tropical grass legume pastures. For *Brachiaria decumbens* pastures in both summer and autumn, both goats and cattle preferentially selected legume from the sward whilst sheep selected grass over legume. However, in *Paspalum plicatulum* swards, grass was preferentially selected by all species in summer, but in autumn, only sheep continued to select grass and the cattle and goats preferred legume. These observations suggest a number of management options for using sheep, cattle and goats to maintain productive balances of grass and legume in tropical pastures.

**Table 4.** The selection of legume and grass by goats, sheep, and cattle grazing *Brachiaria decumbens* (BD) and *Paspalum plicatulum* (PP) pastures containing tropical legumes. Values are % content in oesophageal fistula samples.

| | | *Summer* | | *Autumn* | |
|---|---|---|---|---|---|
| *Species* | *Component* | *BD* | *PP* | *BD* | *PP* |
| Cattle | Grass | 27 | 71 | 40 | 35 |
| | Legume | 64 | 13 | 50 | 51 |
| Sheep | Grass | 79 | 82 | 66 | 66 |
| | Legume | 11 | 6 | 25 | 20 |
| Goats | Grass | 11 | 51 | 34 | 7 |
| | Legume | 80 | 37 | 58 | 78 |

In the past decade, considerable advances have been made in tropical pasture research by Australian scientists, particularly in the selection of grasses and legumes suited to particular environments. This technology can be rapidly applied to the needs of goat producers in tropical and subtropical areas, and will find application in tropical countries where high quality pastures are required for commercial grazing enterprises, roadside and common grazing, and for the development of fodder banks for cutting and feeding to housed animals in cropping systems. Australian expertise has already contributed significantly to the improvement of pasture production in many developing countries, and has much to offer schemes designed to improve goat production at the village or smallholder level.

## Perspectives for Future Research in Goat Nutrition

Stimulus to research may come from either economic or altruistic motives. In Australia at present there is an economic incentive to increase the productivity of cashmere fibre from goats, and to investigate the profitability of export markets for goat meat and hides. However, we must first survey and evaluate the productivity (meat, milk, fibre) of our present goat population when raised under improved management conditions in different environments. Selection of productive goats will not be based on breed, but on objective measurement of the desired production traits. The times of potential nutritional crisis in the productive life of the goats can be readily identified as pregnancy, lactation, early post natal life, and immediately after weaning. Research activity in each of these areas will probably proceed on two fronts, i.e. (a) applied nutrition where best estimates of nutritional needs are provided as supplements to pasture and arising from the inadequacies of these estimates, (b) basic nutritional studies from which a fuller understanding of the physiology, biochemistry, and nutritional requirements can be gained.

Goat nutritionists face the exciting prospect of using the sophisticated research technology developed from sheep and cattle research to define quickly and precisely the major nutritional limits to improved goat productivity. Specifically, there is an urgent need to determine the nutritive value of pasture, browse, and agricultural by-products for goats by measuring intake, digestibility and nutrient content, metabolisability, efficiency of energy use, UDN and RDN contents, and the protein and energy actually absorbed by the animals. Concurrent studies of growth and changes in body consumption during growth would add much to the interpretation of these nutritional trials. Given sufficient financial support, an accurate and comprehensive dossier of nutrient requirements for goats in Australia could be compiled in less than a decade, providing not only the newly developing Australian goat industry with a sound production base, but also complementing and extending information on feed quality and goat production to developing areas of the tropics.

Although the social and cultural restraints to goat production in Australian and developing countries may be different, a common set of problems face research workers in both areas, for example, the need to evaluate the productive potential of indigenous goats, identification of the major biological restraints to increased productivity and the desire to provide predictive information for application at the practical level of goat production, be it village or farm. Australian expertise has much to offer in cooperative programs of goat research and development in tropical areas, viz. an accumulated experience of tropical pasture establishment and production, a sophisticated research technology developed from sheep and cattle research, and a practical appreciation of the problems of animal production in the tropics.

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# Growth, Development and Carcass Composition of Goats: A Review

**B.A. McGregor***

GOATS provide over 1.97 million tonnes of meat annually (FAO 1980) representing 3.5% of total world meat production. In developing countries goats provide 8.5% of total estimated meat production. Meat production is the most important function of goats in the tropics (Devendra and Burns 1973). However the general level of productivity of goats is low because their ability to survive in harsh environments is more important than achievement of optimum production. Consequently goats suffer from low planes of nutrition, poor husbandry and management, and inbreeding. Moreover, the goat industry has received little assistance from improved technology or marketing systems, and little attention from animal scientists.

In recent years a number of reviewers (McDowell and Bove 1977; Naudé and Hofmeyr 1981; Gall 1983; and Devendra and Owen 1983) have grappled with the interpretation of the published data. Naudé and Hofmeyr (1981) concluded: 'There is a dearth of information on meat production from goats. Interpretation of the relatively few published reports is complicated by the fact that there are so many breeds kept under such widely different conditions that comparisons are not always meaningful.' However much recent work has yet to be published in scientific journals and remains in reports that are not widely distributed. This review does not endeavour to be exhaustive (readers are referred to the reviews cited above) but aims to highlight the major factors influencing growth and carcass development and deficiencies in our current knowledge.

## Growth Rates of Goats

### Breed

One of the major influences on the growth of goats is the mature size of the sire and dam. Mature size in goats varies about five fold from 20 kg for dwarf African breeds to over 100 kg for improved Boer goats. Generally progeny of large breeds grow faster than the progeny of small breeds (Table 1). In some countries large breeds of goats have been used to crossbreed with small breeds to achieve faster growth rates (Table 2). This improved growth rate is largely due to the increased mature size of crossbred animals. Hybrid vigour (heterosis) may also be important in improving growth rates of crossbred goats. Inbreeding tends to reduce mature size resulting in inbred flocks exhibiting slower growth rates.

Thus an easy way of achieving faster growth rates is to breed larger goats either by selective breeding within breeds (heritability estimates for mature size and growth to weaning are high) or by crossbreeding with larger breeds. Goats also have a large variation in other characters of interest to meat production such as carcass fat cover, eye muscle area. Unfortunately mature size of many breeds is poorly documented (see review by Mason 1981). Social as well as food supply problems must be overcome to achieve full potential of these changes.

### Sex

Entire males grow faster than castrates which grow faster than females (Table 1). Again these differences reflect differences in mature size, with males having heavier mature size than females. Androgens also have a positive effect on protein anabolism. Using males for meat production can be risky because during the breeding season males often lose appetite and may stop growing or even lose liveweight (McDowell and Bove 1977). It is assumed that cryptorchids are intermediate in growth between entire males and castrates. Castrates treated with anabolic steroids (growth promotants) have grown faster than untreated controls (McGregor et al. 1984; see Table 1). Younger animals tend to grow faster than older animals.

### Nutrition

Kids fed on specially prepared milk diets and offered concentrates may reach rates of gain much higher than normally reared or weaned kids (Fehr et al. 1976; see Table 1). Seasonal conditions have a major influence on growth rate. In browse and rangeland country or on perennial pasture lands where does have

* Livestock Research Officer, Animal Research Institute, Department of Agriculture, Werribee, Vic., Australia.

**Table 1.** Mature size of some common breeds of goats (from Devendra and Burns, 1973 and others) and selected growth rates reported in literature.

| *Breed & location* | *Mature wt. kg.* | *Sex* | *Weight range kg* | *Growth rate g/d* | *Feed* | *Ref. No.* |
|---|---|---|---|---|---|---|
| Improved Boer | 100–110 | M | 3–30 | 291 ) | Concentrate and excellent | 1. |
| South Africa | | | 3–70 | 250 ) | grazing | |
| | | F | 3–29 | 272 ) | Highly selected meat goats | |
| | | | 3–52 | 186 ) | | |
| Damascus | 80–90 | M | 20–50 | 240 ) | Barley & soybean | 2. |
| Cyprus | | C | 18–40 | 210 ) | 20% CP | |
| | | F | 18–37 | 190 ) | | |
| Alpine | 80–90 | M | 3–22 | 219 | Milk replacer | 3. |
| France | | | 3–22 | 241 | Milk replacer & concentrates | |
| Saanen | 90–100 | M | 12–24 | 222 | Concentrates | 4. |
| Britain | 90–100 | C | 15–25 | 210 | Milk fed | 5. |
| Australia | | | | | | |
| Anglo-Nubian | 80–90 | | | | | |
| World wide | | | | | | |
| Jamnapari | 70–85 | | | | | |
| India | | | | | | |
| Angora | 50–60 | M | ? | 165 | 15% CP pellets | 6. |
| Texas | 50–60 | C | 27–31 | 154 | Spring pasture | 7. |
| Australia | | C | 16–27 | 122 | 16.5% CP pellets | 8. |
| | | C | 20–27 | 47 | Pellets & hay as above + zeranol | |
| | | | | 73 | | 9. |
| Feral | 45–55(?) | M+F | 2–10 | 175 | Does fed oats & lucerne | 10. |
| Australia | | M+F | 3–17 | 157 | Spring pasture | 11. |
| | | M+F | 17–24 | 122 | | |
| | | M | 15–24 | 88 | Pigeon pea grazing as above with | 12. |
| | | | | 119 | sorghum | |
| Beetal | 45–60 | | | | | |
| India | | | | | | |
| Barbari | 35–45 | M+F | 6–12 | 53 | Berseem clover + barley | 13. |
| India | | | | 29 | Berseem only | |
| Kambing/Katjang | 25–30 | M+F | 2–22 | 57 | Various | 14. |
| Malaysia & Indonesia | | | | | | |

1. Campbell cited by Naudé & Hofmeyr (1981)
2. Louca et al. (1977)
3. Fehr et al. (1976)
4. Owen & Mtenga (1980)
5. McGregor (1980)
6. Shelton & Huston (1966)
7. McGregor (unpublished)
8. McGregor (1984b)
9. McGregor et al. (1984)
10. McGregor et al. (1982)
11. Holst & Pym (1977)
12. Bint & Norton (1982)
13. Singh et al. (1980)
14. Devendra (1967)

a continuous supply of food of fairly uniform quality, kids grow steadily to weaning. Following removal of milk at weaning a setback in growth is usually followed by a period of slow growth over several years until mature size is reached. However in regions characterised by marked changes in pasture quality (dry tropics or Mediterranean climates) goats grow rapidly in the pasture growing season but then lose weight (sometimes almost as rapidly) in the non-growing season when forced to graze dead pasture residues. During the following pasture growing season they regain lost weight and grow further to their mature weight.

Numerous other nutritional influences affect the growth of goats including age of dam (first kidding does produce less milk than older does), month of kidding (in relation to seasonal conditions), birth type (singles obtain more milk than twins or triplets), pasture type, pasture availability, grazing pressure, and amount of supplementary feed provided.

Compensatory growth (rapid growth following a long period of weight loss or weight stasis) is exhibited by sheep and cattle but the appropriate experiments have not yet been carried out with goats. McDowell and Bove (1977) concluded that goats do not exhibit compensatory growth. McGregor (1984b) has observed that nutritionally deprived yearling goats can 'catch up' lost liveweight gain if given suitable conditions. In general it would appear that the degree of compensatory growth exhibited is dependent on the age or weight of the animal when under-nutrition is imposed; the younger the animal the less compensatory growth can be expected (Morgan 1972). Allden (1970) imposed growth restrictions on young sheep during two stages of early life and found after rehabilitation that the smaller animals ate proportionally less than their better grown mates and consequently took 4.5 years to compensate for their growth handicap.

**Table 2.** Comparative liveweights of indigenous Katjang goats and their crossbreds in Malaysia (kg). Weighted mean of males and females, (Devendra 1967).

| *Age (Months)* | *Katjang* | *Jamnapari × Katjang crossbreds* | *Anglo-Nubian × Katjang crossbreds* |
|---|---|---|---|
| At birth | 1.5 | 2.8 | 2.5 |
| 3 | 7.5 | 13.8 | 13.2 |
| 6 | 10.8 | 24.1 | 20.0 |
| 12 | 22.2 | 40.0 | 35.6 |
| Mean live weight gain (g/d) | 56.7 | 101.9 | 90.7 |

*Energy intake:* A major limitation to rapid growth rates of ruminating goats is their low energy intake. While lactating dairy goats (goats of large mature size) have achieved relatively high levels of energy intake, 3 to 4 × maintenance (Fehr and Sauvant 1980), many breeds exhibit limited energy intake (about 1.5 to 2 × maintenance compared to 4 × maintenance for sheep). It is therefore obvious why growth rates and food conversion efficiencies (kg of feed/kg of liveweight gain) of goats are lower than growth rates and food conversion efficiencies of sheep. Unfortunately little objective data is available relating the rates of growth of goats to their maintenance requirements. The NRC recommendations (1981) indirectly acknowledge the low potential growth rates of goats by providing nutrient requirements for growth rates up to only 150 g per day. The additional energy required to achieve this rate of growth is less than the maintenance energy requirements for goats above 15 kg liveweight on semi-arid rangeland or slightly hilly pastures. This indicates that goats may have difficulty in eating even twice their maintenance requirements. Indeed in four recent experiments with Angora goats fed grain–based diets the maximum intake achieved was 2.3 × maintenance. Some animals fed ad libitum ate only 1.3 × maintenance (McGregor 1984a). These figures can be compared to sheep which when offered grain based diets can grow up to 409 g/day (Fraser and Ørskov 1974) consuming 1043 g/day, about 3 × maintenance. Relatively fast gains in Angora goats can be obtained on spring pasture compared to animals housed and fed concentrates ad libitum (McGregor unpublished and 1984b; see Table 1). Our knowledge of factors influencing appetite, energy intake and growth of goats is limited and much further research is required to clarify the situation.

## General Development

Allometric growth equations indicate that during growth of goats from birth to maturity fat deposits develop twice as fast as the empty body while bone develops slower than the empty body. Muscles and the carcass develop at a slightly faster rate than the body (Owen et al. 1977; Wilson 1958b). Fehr et al. (1977) attempted to characterise the development of various tissues of kids from a dairy breed in relation to that of other domestic animals. They compared their results on kids with those obtained in cattle, sheep and pigs (Tulloh 1963) concerning the relationship between liveweight and the weight of bones, muscles, and fat during growth. The rate of development of the muscle masses of kids was similar to that of the pigs but greater than that of sheep. The proportion of bone mass of goats also resembled that of pigs. The relative mass of adipose tissue was definitely smaller in the kid than in the pig or lamb and was similar to that of cattle. Thus goats appear to be relatively late in maturing with fat tissues not reaching appreciable proportions of body weight until heavier liveweights are obtained when compared with sheep. Indeed sheep show several phases of growth from preruminant to fattening (Searle et al. 1972). These workers could not adequately describe the growth of sheep using the allometric equation and found that four linear equations (representing different phases of growth) were more accurate. Different phases of growth have yet to be recorded in goats.

The distribution of fat in goats is quite different from that of sheep (Lapido 1973, Table 3) with the major difference from an economic viewpoint being the much lower subcutaneous fat deposits. As Fehr et al. (1977) concluded, these results show clearly that the goat has particular carcass characteristics and that its growth cannot be directly equated with that of other species, especially ovine.

## Carcass Development and Composition

As goats grow they deposit more fat in their carcass, reducing the percentage lean and increasing the percentage fat (Table 4). In recent years studies using the regression approach have been undertaken on a variety of breeds [Kirton 1970 (see Table 5); Fehr et al. 1977; Naudé and Venter 1977; McGregor 1982]. Regression equations indicate that generally carcass weight increases 0.43 to 0.54 kg per kg increase in liveweight. Variation is related to size of goats and whether liveweight or empty body weight are used. Regression equations are also available to predict offal yields and carcass characteristics of goats (McGregor 1982). Growth rates of carcasses from goats when compared to sheep may be reduced by the relatively low levels of subcutaneous fat deposition (Table 3). Numerous factors influence carcass growth and are discussed later.

**Table 3.** Locations of separable fat in goats and lambs expressed as percentage of total separable fat (Lapido 1973).

| | *Goats* | | | |
|---|---|---|---|---|
| | *Small* | *Large* | *All* | *Lambs* |
| Subcutaneous | 14.0 | 14.2 | 14.1 | 29.7 |
| Intermuscular | 40.5 | 39.0 | 39.8 | 45.0 |
| Kidney, pelvic and heart fats | 15.7 | 15.2 | 15.4 | 10.6 |
| Visceral | 28.9 | 30.3 | 29.6 | 15.3 |

## Breed

There seem to be breed differences in carcass fat deposits with Dairy goats (Fehr et al. 1976; McGregor 1982) appearing leaner at any liveweight than Angora goats (McGregor, unpublished). This may indicate that the relationships that apply between mature size and carcass fatness of sheep and cattle, namely, that at any given liveweight animals of larger mature size may be leaner than animals of smaller mature size, will also apply to goats. However given that goats have a different partitioning of fat (little subcutaneous fat and relatively high visceral fat) compared to sheep and cattle (Table 3) the relationship between mature size and carcass fatness of goats may differ from that observed in sheep and cattle. More research needs to be carried out on genotype × diet × growth rate interactions with particular attention to nutrient partition.

**Table 4.** The carcass composition (%) of goat breeds at different liveweights.

| | | | *Live weight range (kg)* | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Breed* | *Sex* | *Tissue* | *15–20* | *20–30* | *30–40* | *40–50* | *50–60* | *Reference* |
| Botswana | C | Lean | 59.3 | 60.10 | 59.14 | 57.79 | | Owen et al. (1977) |
| | | Fat | 8.7 | 10.60 | 14.81 | 14.83 | | |
| Saanen | C | Fat | 10.13 | 16.98 | 21.15 | 23.34 | 24.70 | McGregor (1982) |
| Various | M | Lean | — | 59.34 | 60.29 | 59.11 | 62.61 | Lapido (1973) |
| Dairy | | Fat | — | 12.53 | 12.25 | 14.09 | 12.80 | |
| Alpine | M | Lean | 67.30 | 67.55 | 68.60 | — | — | Fehr et al. (1976) |
| | | Fat | 5.10 | 6.58 | 7.10 | — | — | |

**Table 5.** Regression constants[a] relating carcass components to liveweight of male and female New Zealand feral goats (after Kirton 1970). (Liveweight range males 7–36 kg, females 4–26 kg).

| *Component Y* | *Male goats* | | | | *Female goats* | | |
|---|---|---|---|---|---|---|---|
| | *Mean* | *C* | *m* | | *Mean* | *C* | *m* |
| Carcass kg | 9.31 | −0.233 | 0.459 | | 6.05[b] | 0 | 0.431 |
| Skin kg | 2.41 | +0.249 | 0.104 | S | 1.62 | +0.443 | 0.070 |
| Head kg | 1.87 | −0.075 | 0.093 | S | 1.27 | +0.159 | 0.066 |
| Liver g | 474 | +115.5 | 17.23 | S | 424 | +7.2 | 24.94 |
| Lungs g | 365 | +34 | 15.92 | | 304 | +36 | 16.03 |
| Stomachs kg | 0.77 | +0.084 | 0.033 | S | 0.65[b] | −0.089 | 0.052 |
| Caul fat g | 74 | +21.3 | 2.53 | S | 96[b] | −20.8 | 830 |

a. Regression equations of the form Y = mX + C where Y = predicted body component, X = live weight.
b. Pregnant goats have been omitted.
S Indicates significant difference ($P<0.05$), between male and female goats.

There may be breed differences in conformation of goat carcasses, certainly at the same carcass weight goats tend to have longer carcasses than sheep. However research has shown that conformation tends to be negatively related to meat yield as sheep with better conformation tend to be fatter (Kirton and Pickering 1967). Lean : bone ratios have also been used to compare breeds on carcass meat yields. Generally lean : bone ratios increase as empty body weight increases — observations consistent with allometric growth coefficients. Lean : bone ratios range from 2.7 : 1 for dairy goats (Lapido 1973) to 3.8 for Jamnapari and 4.9 for Barbari goats (Srivastava and Raizada 1968) and 4.7 for Boer goats (Naudé and Hofmeyr 1981). When Naudé and Hofmeyr (1981) compared Boer goats to South African Mutton Merino, Dorper and Merino sheep, Boer goats had longer carcasses and higher lean : bone ratios. This finding has also been supported by Owen et al. (1978) studying indigenous Botswanan goats and sheep.

However, lean : bone ratios can be misleading if one is attempting to evaluate carcasses for marketing, because fat is very valuable and saleable if it is desired by consumers and is in the right place. Lean : bone ratios are of some value if only lean meat is desired by consumers. Butterfield (1974) suggests that the most useful comparisons of lean : bone ratio are those made at the same level of fatness (or at equal muscle plus bone weights). When comparisons are made at equal fatness but at widely different weights, differences may be due only to the fact that the animals have proceeded to different points on their muscle and bone growth patterns. Butterfield's comments are very appropriate when lean : bone ratios of breeds with different mature size are being compared.

**Sex**

Generally at any particular liveweight entire males are leaner than castrates, which are leaner than females (Louca et al. 1977; Owen et al. 1978; Wilson 1958a; McGregor unpublished). However, these relationships may be distorted by variations in management (feeding, lactation, mating) and careful interpretation of published data is necessary. As goats gain liveweight, carcass weights for males increase faster than for females (Kirton 1970). Kirton also jointed his carcasses (Table 6). When the data on joints were compared at the same weight the males had heavier shoulder, neck, breast and shank (typical features of male sexual dimorphism) and females heavier leg, loin, ribs and flap.

**Nutrition**

The classic study of goat growth and development is that of Wilson (1958a; 1958b; 1960) who reported on some influences of nutrition on the East African Dwarf goat (mature size 20–25 kg). Wilson dissected the carcasses and has presented very detailed results on the development of individual organs and tissues from birth to 13.6 kg liveweight of male and female goats. Well fed kids took 20 weeks to reach slaughter weight compared to 48 weeks for poorly fed kids. Well fed kids had a significantly higher fat content and larger visceral organs than low plane kids. When development of body organs was examined on a fat-free carcass weight basis differences in size of organs were related to fat-free carcass weight only.

**Table 6.** Carcass composition of male and female New Zealand feral goats by joints (Kirton 1970; Kirton & Pickering 1967).

| *Component* | *Male goats % of side* | *Female goats % of side* | *Sheep % of side* |
|---|---|---|---|
| Leg | 29.8 | 31.3 | 32.8 |
| Loin | 10.2 | 11.5 | 11.0 |
| Ribs | 8.7 | 9.0 | 11.7 |
| Flap | 6.8 | 7.2 | 5.8 |
| Shoulder | 20.8 | 20.6 | 22.3 |
| Breast and shank | 13.7 | 13.0 | 9.0 |
| Neck | 9.7 | 7.3 | 4.3 |
| Carcass weight kg | 9.1 | 7.1 | 16.0 |

Our knowledge of the influence of nutritional management on total body, carcass and subcutaneous fat deposits in goats is, however, rudimentary. Gaili et al. (1972) fed Sudan desert goats on concentrate diets and obtained carcasses with up to 19.5% fat as yearlings and 29.7% fat as mature goats. However live and carcass weights are not presented. Table 7 presents some recent unpublished work (McGregor) that compared carcasses of similar size from yearling goats fed barley-based diets (CP 16%) for 19 weeks to animals run on pasture. Grain fed goats were nearly twice as fat as pasture fed goats. Grain fed does had carcasses with 31.9% fat (41.0% if kidney and channel fat are included). Significant increases in subcutaneous fat deposits were observed. Slow rates of liveweight gain of these grain fed goats (66 g/d females, 78 g/d castrates) were associated with massive fat deposition. It is obviously important to identify nutritional management that results in fast growing carcasses as well as those practices that result in overfat carcasses. It appears that concentrate feeding may present problems in carcass fatness of goats, making them more 'sheep like' and perhaps losing their lean meat marketing image.

Black (1974) supports the view that body composition may be manipulated through nutrition but points out that the most dramatic effects are likely to occur by altering the protein content of the diet. Black has calculated data from the milk fed lamb that by altering the intake of diets adequate in protein, the maximum difference in fat deposition is unlikely to exceed 5–8% of body weight. On the other hand, the differences in fat deposition resulting from alteration in protein content of diets theoretically may exceed 30% of body weight. It seems most unlikely that differences of this magnitude will be encountered in practice.

**Table 7.** Carcass and offal yields of Angora × Australian feral kids fed grain or pasture (McGregor, B.A., unpublished).

| | *Grain Fed* | | *Pasture Fed* | |
|---|---|---|---|---|
| *Component* | *Wethers* | *Does* | *Wethers* | *Does* |
| No. of animals | 3 | 3 | 1 | 1 |
| Liveweight kg | 29.2 | 28.7 | 33.2 | 32.1 |
| Fasted liveweight kg | 27.1 | 26.7 | 28.6 | 28.6 |
| Hot carcass weight kg[a] | 13.6 | 13.0 | 14.0 | 13.0 |
| Kidney & channel fat g | 639 | 1187 | 102 | 384 |
| Caul fat g | 1177 | 1790 | 362 | 932 |
| Carcass fat%[a] | 26.5 | 31.9 | 12.5 | 20.0 |
| Average fat cover 13th rib (mm) | 2.8 | 2.2 | 0.7 | 1.7 |

a. excluding kidney and channel fat.

We do not know the influence of liveweight loss, weight stasis and compensatory growth on carcass fatness, or fat partitioning of goats. McGregor (unpublished) found that three drought affected Angora goats with 6.6 kg carcasses contained 8.9% fat compared to normally grown goats of similar size with carcasses containing 18% fat. Whether goat carcasses are leaner than sheep carcasses may therefore depend on the breed of goat and sheep as well as nutritional management. At equivalent carcass weights, McGregor (1982) reported that pasture fed Saanen goats between 34 and 54 kg liveweight had carcasses with 7–19% more lean meat than Australian meat lambs. Owen et al. (1978) reported that Botswana goats were leaner than indigenous sheep and Boer goats were leaner than local goats. However Naudé and Hofmeyr (1981) report that Boer goats fed concentrate diets had fatter carcasses than South African Mutton Merino sheep and were fatter than Dorper sheep at carcass weights less than 13 kg. Boer goats had more total body fat than all sheep breeds excluding Dorpers heavier than 30 kg.

## Methods of Assessing Carcass Yield and Composition

### Use of Regression Equations

Regression equations relating carcass yield, offal yield and carcass composition to liveweight are available for several breeds (Kirton 1970; Fehr et al. 1977; Naudé and Venter 1977; McGregor 1982). The most important relationship relates carcass weight to liveweight — commonly referred to as dressing percentage. Numerous management factors influence dressing percentage from live goats. As many goat keepers and research workers obviously fail to recognise these factors, some are listed in Table 8. Thus in a given management system once dressing percentage has been determined empty body weight can be used to very accurately predict carcass and other offal yields of goats. However field workers are unable to accurately determine empty body weight and use either 24 hr fasted liveweight or liveweight (with subsequent loss of accuracy in prediction).

**Table 8.** Factors influencing dressing percentage of goats.

| |
|---|
| *Factors increasing dressing percentage:* |
| Liveweight — heavier animals are fatter |
| Age — Older animals tend to be heavier |
| Concentrate feeding — reduces gut fill, increases fat deposition |
| Milk fed kids — reduces rumen development and gut fill |
| *Factors decreasing dressing percentage:* |
| Weaning — reduces fat reserves, increases gut fill |
| Roughage feeding — increases gut fill, longer retention times |
| Lactation — reduces fat reserves |
| Mating — reduces buck's appetite resulting in weight loss |
| Dry pastures — causes weight loss especially fat reserves and perhaps more gut fill |
| Heavy fleeces — causes over-estimation of true liveweight. |

Representative examples of dressing percentage illustrating some of these points are shown in Table 9. Smaller goats dress out from 35 to 45% while larger goats dress out from 43 to 53%. The increase in dressing percentage with increasing liveweight is due to the relatively greater growth of fat and muscle compared to the rest of the empty body. According to Acosta (1979) castrates dress out 2.4% higher than males but this finding is not clear from other published reports. Unfortunately standardised methods of determining dressing percentage are often not used and so published reports can be misleading. It is obviously important that in each environment, with a given breed and management practice, that dressing percentage be determined over a range of liveweights. This will enable producers, market agents, and researchers to accurately estimate expected yields and therefore value of carcasses from live goats.

Very few regression equations are available relating sample joint dissection of goats to carcass composition

**Table 9.** The effect of liveweight on dressing-out percentage in goats of different breed types (Figures in parentheses refer to dressing-out percentages calculated on an empty body weight basis).

| | | Liveweight range (kg) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Breed* | *Sex* | *8–15* | *15–20* | *20–30* | *30–40* | *40–50* | *50–60* | *Reference* |
| Botswana | C | | | 43.2 (51.5) | 44.2 (52.8) | 45.2 (53.0) | 48.3 (55.8) | Owen et al. (1977) |
| Saanen, Toggenburg Nubian, Alpine | M | | | 47.1 (54.1) | 50.5 (58.1) | 50.1 (56.9) | 51.9 (58.4) | Lapido (1973) |
| Jamnapari | M | 48.1 | 49.7 | 52.2 | — | — | — | Pant et al. (1974) |
| | F | 44.6 | 43.9 | 43.0 | — | — | — | |

M = males, C = castrates, F = females.

over a range of liveweights (Fehr et al. 1977; Naudé and Hofmeyr 1981). As goats have relatively little subcutaneous fat deposition more sensitive indirect measures of carcass fatness may be kidney and channel fat and caul fat. Further research is obviously required to document carcass and offal yields, carcass composition:liveweight, and indirect measures of carcass composition for all goat breeds over a range of liveweight and management treatments.

## Jointing into Retail Cuts

This method relies on there being a price differential for different carcass joints and so is irrelevant in markets that do not discriminate between joints. However it overcomes one of the problems of lean:bone ratios as it includes subcutaneous and some intramuscular fat in the saleable portion.

Kirton (1970) found that feral goats appeared to have a higher proportion of 'less valuable' cuts such as neck, breast, and shank than lambs (Table 6). This is probably related to the lower level of fat deposition on the leg, loin, and ribs of goats compared to lambs and also to the heavier carcass weight of lambs. Indeed the hind legs of goats are usually the leanest joints (Devendra 1966; Owen et al. 1978; Arganosa et al. 1977). However Kirton's observations contrast with those of Owen et al. (1977) who found Botswanan goats had higher yields of leg than indigenous sheep although loin yields were lower.

## Condition Scoring

This method is used to assess the carcass development of live goats before slaughter. The assessor feels the backbone and lumbar processes behind the last rib for coverage and depth of flesh and scores the goat from 1 to 5. Goats scoring 3 or above are ready for market. This method is independent of liveweight. Assessors can become very proficient and repeatable in their determinations. Condition scoring is being promoted in Australia (McGregor 1983; Mitchell 1983). The relationships between condition score, carcass development and market price is good. However, the relationships between condition scores and carcass fatness of different goat breeds is not documented.

## Classification Schemes for Goat Meats

Development of classification and grading schemes specifically for goat meat is uncommon. De Boer (1983) concluded that as most goats are used for subsistence needs or sold in rural areas or at informal markets, the demand for classification schemes in developing countries is limited. This is surprising as De Boer (1983) and Devendra and Owen (1983) report that goat meat sells for 20% more than beef in Kenya, 50% more in Iran, 10–30% more in Indonesia, Malaysia and the Philippines, and Naudé and Hofmeyr (1981) report goat meat sells for 10% more than beef in South Africa.

In some countries, attempts to use sheep grading schemes (USA, Britain, and South Africa) have resulted in goats being graded at the low end of the scale. This invariably occurs as goats have shallow subcutaneous fat deposits (usually less than 2 mm) and long leggy carcasses. A grading scheme specially developed for export goat carcasses, based on age, conformation and finish, has been used by the Botswana Meat Commission (Joubert 1973). In Monterey, northeast Mexico, kid carcasses are sold at varying prices according to the quantity of abdominal fat (renal and perinephric) they contain. The carcasses with the most fat are usually those in most demand.

Kidney fat in young milk-fed kids is one fat deposit which exists in sufficient quantity to enable it to be used in grading schemes for this type of carcass. In the German Democratic Republic, official grade standards for goats, based on age, carcass weight, meatiness and fat cover have been laid down (German Democratic Republic Official Standard, 1976) but such grading standards for goats are rare. Mitchell (pers. comm.)

stated that export grading standards for carcasses are being developed in Australia to help grade the 4000 tonne p.a. export trade to Asian and Caribbean countries.

Obviously grading systems will need to be improved as production and trading in goat meat increases. Systems incorporating weight, length, eye muscle area, subcutaneous fat cover and kidney fat deposits need to be investigated. Inclusion of these measures and their relative 'value' will depend on market requirements (lean meat or fat meat). Classification schemes will need to accurately predict meat yields from carcasses otherwise they will be of no value to butchers and consumers. Perhaps there has been no requirement for classification of goat meat because yields have been very high owing to the lean nature of goat carcasses. This situation will change as we learn more about nutrition and management of goats and use different breeds for meat production.

Much remains to be learnt about correct management of goats before and during slaughter. Stress problems resulting in dark cutting meat as well as carcasses showing symptoms similar to PSE pigmeat have been observed in Australian goats transported long distances or subject to nutritional stress (McGregor, unpublished). Grading is of little value if abattoir practices result in cold shortening, a problem easily overcome with electrical stimulation.

## Growth and Body Composition: Future Needs

Numerous studies are in progress, or have recently been completed and remain unpublished. However, major deficiencies in our knowledge of growth and carcass composition of goats exist. Research projects must be aimed at providing new information to enable more efficient meat production in terms of food utilisation, and management practices need to be developed to produce optimum growth and carcass development.

Subjects requiring urgent investigation are:

• genotype × environment interactions. The mature size of many goat breeds is poorly documented. Growth potential of genotypes in various nutritional environments and when crossbred need to be studied and documented.

• documentation of carcass and offal yields of different genotypes under various management practices. Documentation of genotype × liveweight × total fat content is needed. Definition of differences in fat partitioning between genotypes is also required.

• definition of the influence of energy intake on growth rates and body composition of kid and ruminant goats. What role do supplementary feeds have to play in growth and carcass development?

• definition of growth phases of goats. Do goats exhibit different phases of growth? What is the optimum time for marketing each genotype to minimise fat deposition but to still achieve optimum marketing? Is lean meat production nutritionally more efficient when more kids are bred and slaughtered at light weights or when fewer kids are bred and slaughtered at heavier weights?

• relationships between patterns of growth and carcass composition. What influences do nutritional restrictions and compensatory gain have on carcass composition and nutrient partitioning of goats?

• definition of carcass quality of goats for local and export markets.

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# Leather and Skin Production From Goats

**P.J. Holst***

THE leather industry embraces three distinct, but interdependent stages (Barat 1975). These are the production of skins and their preservation, the tanning and finishing of the skins into the various types of leather, and the manufacture of the leather into consumer articles. While the goat leather industry involves developed countries importing raw, or partially processed skins from developing countries, it also includes the simple community artisan/craftsman transforming a raw product into musical instruments, liquid containers, clothing, and shelter material. Indeed, considering the versatility and importance of goat leather, it is surprising that so little quantitative information is available for each stage of the industry.

## The Quality of Goat Skin

The tendency of all tanning processes is to make blemishes and skin damage more apparent and as such, affect the value of the product (Holst 1982a).

Factors that affect quality are the (a) basic structure of the skin; (b) damage done while the animal is alive; (c) damage incurred during slaughter and flaying; and (d) preservation.

*Basic Structure* The judging of the quality of a leather from microscopy was described in 1957 (Anon.) and, together with Tancous et al. (1959), importance was attached to (a) the general appearance of the grain; (b) the angle of weave, boldness and compactness of the fibre bundles; (c) the splitting and separation of fibres and fibrils; and (d) the presence of fat deposits.

To understand this further, French (1946) comments that the arrangement of the hair follicles and their size impart a pattern to the grain, the fineness and compactness of the fibrils in the grain layer affect the smoothness of the grain surface, and the degree of glandular development influences the tightness of the grain. The anatomical features of the corium largely determine the utilising properties of the leather.

* New South Wales Department of Agriculture, Cowra, N.S.W., Australia.

In comparison with sheep skins, the non-angora goat skin has a characteristically deep grain, the grain layer is less glandular, and the fibres are bigger and more compactly woven. Thus a desirable goat skin produces a leather that is firm, durable, and has an attractive appearance.

Not unexpectedly, the trade (Tancous et al. 1959), recognises that season of year, sex, age, condition and breed of goat contribute to the variation in quality of skin. A goat with its fixed complement of follicles will have a finer grain when young, compared to when it is aged; and a coarse-haired goat will produce a grain appearance different from that of a fine-haired goat.

Although all grades of sound goat skin are usable, there is a premium for fine grained leather with satisfactory physical properties. To a large extent, any visual assessment of the grain is influenced by the dermal sheaths associated with the primary follicles, with grain fineness depending on their diameter, density, uniformity and clarity. Thus, both density of primary follicles and variation in diameter of guard hairs are important.

*Damage Pre-slaughter* Various forms of mechanical damage to the live goat can reduce the value of the subsequent leather. Obvious examples are scratches, branding, wounds, and ectoparasite scars.

Skin diseases, either parasitic or fungal in origin, affect subsequent leather quality either directly through scarring or indirectly through skin tissue reaction or infection. While there are no data for Australia, Green (1956) reports that in Kenya, the mites *Demodex folliculorum* and *Sarcoptes scabiei* are damaging, while similar mites, *Demodex caprae* and *Psoroptes caprae* occur on Australian goats. Mange and ecthyma are common in Malaysia (Anon. 1979).

*Damalinia caprae* and *Linognathus stenopsis* lice do occur on goats in Australia and while not directly damaging, encourage wounds through irritation and subsequent rubbing. Unexpectedly, scurf, the common bran-like deposit on the epidermis of some goats, does not appear to be important (Green 1956).

*Damage at Slaughter* Considerable damage is caused by careless flaying, in particular by those cuts located in the centre of the skin above the shoulder region. Such cuts are perhaps the most serious impediment to utilising goat skins in Australia but these can be overcome through mechanical hide pullers and education. The problem is worldwide (Barat 1975), but is less where animals are slaughtered at an abattoir.

*Preservation* The object of curing skins is to prevent them from decaying before they are tanned. Changes due to curing have to be reversible, and the basis of most methods is dehydration. Methods include air drying, salt and to a lesser extent, freezing.

### Classification of Skin

A systematic and uniform method of global classification of goat skins is not available. (Figueiredo et al. 1982). From experience, skin processors and importers know much about their purchases from the origin of the skins and breed of the goat. Pricing is then based on a simple grading system to assess the extent of damage by disease and careless handling, e.g. blemishes, cuts, putrefaction etc. A typical system involves four grades and a reject category.

On the other hand, selection involves the choice of skins according to their suitability for a particular purpose. It is influenced by weight, thickness, size, age, grain equality etc.

### Breeds and Leather Quality

The following breeds of goat are recognised as having basically good quality skins; Maradi, Improved Boer, Somali, Black Bengal, Moxoto, and Sahil (Devendra and Burns 1970). Fibre colour appears to be unimportant, but all these breeds have short, fine hair.

Skinner (1972) lists three classes of goat skins:

1. fine-fibred skins from short-haired goats in hot areas — suitable for the production of glazed kid leather;
2. medium-fibred skins of an intermediate grade — suitable for shoes;
3. coarse-fibred skins, which are large, thick and heavy, and are obtained from long-haired goats in colder areas — suitable for luggage.

Reliable information on skin and fibre and the relationship to goat skin/leather quality are not readily available. Burns (1965) undertook a preliminary study on the Maradi goat of Nigeria, which is accepted by the trade as having excellent skin quality, and concluded that the lowest possible overhair (guard) density in the coat was a possible criterion in selecting for skin quality. Groups were poorly balanced for age, liveweight and physiological condition. Her conclusions differ from that of Holst (1982b), who believes that guard hair diameter and primary follicle density are important for fine grain appearance.

It is obvious that quantiative data are lacking on the physical and aesthetic properties of leather quality. This is not surprising when it is considered that the skins entering the world market are from traditional suppliers with little change in husbandry, breed, age at slaughter etc., and that the processors themselves are conservative and traditional. The industry does not recognise the need to improve/modify existing breeds by selection or to make changes in management areas, such as age/sex structure of the herd, slaughter age, etc. However, it is recognised that correct management procedures for the ante- and postmortem periods are known, and are of economic importance to the supplier and the processor.

### Research on Goat Skins in Australia

Australia exports 300 tonnes of non-processed goat skins annually, and this represents essentially all the feral goats slaughtered in the country. Demand for these skins has not been great, and in the absence of a domestic goat skin processing industry, returns to the producer have been minimal. Local processors have in the past attempted to utilise these skins, but have been frustrated by the variable quality of the skins arising from poor flaying and preservation, and skins that reflect the diversity of the animals slaughtered (Holst 1981).

Current research involves collaboration between three institutions on the following topics:

- study of a range of goat skins on the international market so as to compare physical and aesthetic properties.
- study of factors affecting goat skin quality — age, sex, growth rate, surface area etc.
- analysis of histological and metrological data to establish selection criteria for the selection of superior leather producing animals for use in a genetic program.

### Goat Leather Production in the Tropics

Countries located in the tropics already produce much of the world's goat skins and most of the 'premium' goat skins. The challenge is to achieve the full economic and cultural potential of this industry. This is not simply a matter of increasing the price of the raw material, which De Boer (1982) considers unlikely and difficult, but to continue the trend of processing skins to the pre-finished stage (Barat 1975), reduce wastage and depreciation of skins, and to assemble data for the technical understanding of goat skins. The aim is not to produce high value 'premium' skins, so much as to make full use of what the animal/situation/environment produces.

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# Diseases of Goats

**S.A. Baxendell***

This review deals with some of the diseases in the commonly recognised groups, viz. genetic, parasitic, metabolic, viral, bacterial, and protozoan.

## Genetic Diseases

Apart from many rare conditions that have been recorded in individual goats, there are four main genetic problems:

### Cryptorchidism

This occurs in all breeds but is more common in Angoras and Anglo-Nubians. Male kids should be born with two testicles in the scrotum.

### Testicular Atrophy

This was generally associated with the recessive hermaphroditic factor. It has been seen in a few Angora herds in South Africa and in dairy bucks.

### Hermaphroditism (Intersexuality)

Many combinations of external genitalia and internal reproductive organs have occurred. The most common abnormality is a doe with an enlarged clitoris and buck-like behaviour. Sterile bucks are also common. Polledness in goats is considered to be a simple dominant character (P) with full penetrance but which also has a recessive masculinising effect with complete penetrance in females and incomplete penetrance in males. All the genetic female homozygote polled goats (PP) are infertile. More than half the homozygote polled (PP) bucks are partly or completely sterile. Provided mating programs ensure that at least one parent is horned, hermaphrodites will not be a problem.

### Beta-mannosidosis of Anglo-Nubians

This is a lysosomal storage disease that has been recorded in both Australian and American Anglo-Nubians. This condition is now in New Zealand as a result of importing Australian Anglo-Nubians. Healy et al. recorded this condition in 1981.

* Queensland Department of Primary Industries, Brisbane, Qld. Australia.

Affected kids are usually born alive but are unable to stand or straighten their legs. These kids are the offspring of two carrier parents and are referred to as 'spastic' by goat breeders. A carrier has half the normal levels.

## Parasitic Diseases — External

### Lice

Lice infestation is the most common external parasite problem and goats that are debilitated for another reason, e.g. worms, are most commonly affected. There are two basic types: the biting louse, e.g. *Bovicola caprae* and the sucking louse, e.g. *Linognathus stenopsis.*

The biting louse is a small red louse that burrows into hair follicles and causes severe itching. The sucking louse is a larger blue louse that is more visible. It feeds by piercing the skin and is most commonly seen on the neck, shoulders, and in the udder region.

The clinical signs include broken hairs and loss of hair, especially near the shoulders, excessive scratching and rubbing, loss of milk production, weight loss, and anaemia in severe cases.

Lice are obligatory parasites and must live and breed on their host — the goat. There is no need, therefore, to treat the goat's housing or bedding. Best results occur if the treatment is repeated in 10–14 days to kill those lice that have hatched from eggs laid in the goat's hair. Many preparations are commercially available and these include dusting powders, e.g. rotenone or derris dust (ideal for milking goats and kids), carbaryl powder, malathion powder, flea powders used for dogs and cats, spraying or dipping liquids, e.g. coumaphos (Asuntol), Diazinon, 'pour-on' or 'spot-on' organophosphate preparations, and neck collars impregnated with insecticides that are available for dogs.

### Sarcoptic Mange

This mange is caused by the mange mite, *Saroptes scabei* var. *caprae*. These mites live in burrows under the skin and lay their eggs in these protected tunnels.

The clinical signs include excessive scratching, scabby scaly patches on skin with hair loss, and excessively thickened skin. The head and neck are most commonly affected, but sometimes the legs are also affected. There is loss of production and condition. Multiple skin scrapings at the edges of the skin lesions sometimes reveal the mites.

Treatment is difficult as both the mite and its eggs are protected within the goat's skin. Successful treatments have been weekly washes with 2% Neguvon and frequent washing and dipping with coumaphos (Asuntol).

Jackson et al. (1983) reported that recurrences occurred despite five treatments of benzene hexachloride lotion scrubbed into the lesions. This treatment had been effective in other goats in the herd.

Three to 5 weeks after initial contact, goats become hypersensitive to the mites. Inflammation and small itchy nodules appear around the eyes, on the ears, and on the muzzle. In many animals, these signs become less serious in a few weeks but some goats develop hair loss, skin thickening, and self mutilation. As well as treatment for the mites, corticosteroid cream is used to control the itching and a bucket fixed to the goat's head must also be used to prevent the animal from chewing the affected areas.

### Demodectic Mange

This mange is caused by the mange mite, *Demodex caprae*. These mites burrow into the goat's hair follicles and sebaceous glands. The method of infection is unknown — infection early in life of animals with a low immune response is a possibility. This condition affects the price paid for goat skins.

The clinical signs include a lack of irritation and raised blebs or nodules in the skin ranging in size from pin head to hazelnut on the neck, front legs, shoulders, head, and eyelids. These nodules contain a thick greyish waxy pus or occasionally a liquid. Numerous demodectic mites can be seen in this pus if a microscopic examination is made.

This condition does not spread rapidly from goat to goat. Treatment is often unsuccessful, but lancing the pustules, painting with iodine and frequent washing with malathion or coumaphos have been tried. Recent research in India found that two treatments of 0.5% malathion 5 days apart were successful.

### Chorioptic Mange

This mange is caused by the mite *Chorioptes caprae*. The period between contact with an infected goat and clinical signs in contact goats can be several months.

The clinical signs include severe irritation and scratching with resultant hair loss and small crusty scabs on the lower legs and sometimes the belly. Mites can be seen with a hand lens or under the microscope.

This mite cannot survive many weeks off the goat and the treatments recommended are dipping twice at a 2 week interval in coumaphos (Asuntol) and painting the affected areas with an organophosphate compound.

### Psoroptic Mange

This mange is caused by the mite, *Psoroptes communis caprae*, which is a different mite from that which affects sheep.

The clinical signs include scratching, irritation, and headshaking. The ears, and occasionally the poll and legs, are affected. There is very little visible skin change, except for some scabs. Treatment is by washing or spraying with Gammexane or gamma benzene hexachloride.

### Ear Mites

The ears of goats in USA, New Zealand, and Australia have contained two types of ear mites: *Psoroptes cuniculi* and *Raillieta manfredi*. These mites can cause a local external ear infection similar to that caused by ear mites in dogs. There may be a discharge in the external ear canal. Treatment consists of any of the preparations used for ear mites in dogs or a mixture of one part rotenone to three parts mineral oil (paraffin) with six to eight drops given every 3 days. Cottew and Yeats (1981) investigated whether ear mites can transfer mycoplasmas between goats.

### Fleas

Infestations of goats with dog fleas, *Ctenocephalides canis*, and stickfast fleas, *Echidnophagia* spp., have occurred. Young kids are most commonly affected. Part of the flea's life cycle occurs off the goat, so bedding should be burnt and the goats, their housing and yards should be sprayed with 1% malathion or 0.5% diazinon, using a knapsack or garden spray. All cracks and crevices should be thoroughly treated. The whole procedure is then repeated a week later.

## Parasitic Diseases — Internal

Goats share many internal parasites with sheep and can also be infected with cattle parasites. Le Jambre (1978), a parasitologist from N.S.W., showed that goats can be infected with *Ostertagia ostertagi* and can develop Type II disease with scouring, ill thrift, and death.

Australia is fortunate in not having many of the parasites found in Southeast Asia and Africa, but we still have a fair number of parasites that affect goats.

Chevis (1980) summarised all the internal parasites of goats in Australia. Table 1 has been adapted from his paper.

**Gastrointestinal Parasites**

Goats throughout the world are very prone to gastrointestinal parasites which are generally considered to cause the most important diseases of the Australian goat industry. In Queensland, they are the most common cause of death of dairy goats. While climate and high stocking rates are more important predisposing factors in goats than sheep, goats have a basic inability to resist gastrointestinal parasites. In the wild, goats are natural browsers and cover great distances, so that exposure to worm larvae would be slight. In both goats and sheep there is a relaxation of any immunity while in late pregnancy and early lactation. Very young goats, very old goats, and goats weakened by other diseases, e.g. caprine retrovirus, are very prone to parasitic diseases. Resistance to gastrointestinal parasitism is possibly genetic in the goat.

*Haemonchus contortus* is the most important parasite of goats in Queensland. It causes severe anaemia, occasionally with bottle jaw, sudden death even in very fat goats, loss of condition, and reduced milk production. This parasite is a prolific egg layer; each female can produce up to 10,000 eggs/day. While the prepatent period is generally regarded as being less than 3 weeks, in practice this is often markedly reduced because of the existence of hypobiotic fourth stage larvae that hibernate in the gut wall. These young parasites can use large quantities of blood so that death from anaemia can occur just before the egg count rises. This commonly occurs a week or so after drenching with the adults being removed and massive numbers of larvae coming out of the gut wall.

*Trichostrongylus* spp. are the next most important group of parasites in goats. They damage the intestinal lining causing inappetence, ill-thrift, loss of production and diarrhoea, which is often foul smelling and black (hence the common name for the parasite, black scour worm).

Diagnosis of the helminthiasis, as opposed to mere parasite infestation is slightly more difficult. Faecal egg counts are generally used, although Clarkson (1982) recommended discarding the use of faecal egg counts because of unreliability, and used instead serum albumin (normal range 26.2–43.8), serum copper (normal range 0.7–1.2 mg/L), pepsinogen (a level of 3 iu/L indicating severe infection) and haemoglobin levels (normal range 6.5–9.5 g/dL). Information in Table 2 (Anon. 1982) shows the significant faecal egg count that can be used to diagnose helminthiasis.

Even diagnosing these diseases as the cause of death by a postmortem is difficult especially under field conditions. Ingesta and sometimes tapeworms hide these small worms making worm counts difficult unless the digestive tract is examined back in a laboratory. The following worm counts (eggs per gram) were given by Baldock (1984) as a guide to determine their significance:

| | | |
|---|---|---|
| *H. contortus:* | 500 | — subclinical |
| | 1000 | — anaemia in young goats |
| | 2500 | — death in young goats |
| *T. colubriformis:* | 4000 | — subclinical |
| | 8000 | — diarrhoea in young goats |
| | 20000 | — death in young goats |

**Table 1.** Internal parasites of goats in Australia.

| *Predeliction Site* | *Parasite* | *Common Name* |
|---|---|---|
| Rumen and reticulum | *Paramphistomum* spp. | Conical flukes |
| Abomasum | *Haemonchus contortus* | Barbers pole |
| | *Ostertagia* spp. | Small brown stomach worm |
| | *Trichostrongylus axei* | Stomach hair worm |
| Small intestine | *Trichostrongylus* spp. | Black scour worm |
| | *Nematodirus* spp. | Thin necked intestinal worm |
| | *Cooperia* spp. | Small intestinal worm |
| | *Moniezia* spp. | Tapeworm |
| | *Bunostomum* spp. | Hookworm |
| Large intestine | *Oesophagostomum* spp. | Large bowel worm, module worm |
| | *Chabertia ovina* | Large mouthed bowel worm |
| | *Trichuris ovis* | Whip worm |
| Liver and lungs | *Echinococcus granulosus* | Hydatids — cysts |
| Nasal sinus | *Oestrus ovis* | Nasal bot |
| Lungs — bronchi | *Dictyocaulus* spp. | Large lungworm |
| — pulmonary tissue | *Protostrongylus* spp. | Small lungworm |
| | *Muellerius* spp. | |
| Liver | *Fasciola hepatica* | Liver fluke |

**Table 2.** Significant faecal egg counts in young sheep and goats expressed as eggs per gram of faeces (EPG).

| *Location in host* | *Parasite* | | *Main clinical effect* | *Sig.*[a] | *Dan.*[b] |
|---|---|---|---|---|---|
| | *Scientific name* | *Common name* | | | |
| Abomasum | *Haemonchus* | Barbers pole worm | Anaemia | 500 | 2000 |
| | *Ostertagia* | Small brown stomach worm | Diarrhoea | 200 | 2000 |
| | *Trichostrongylus axei* | Stomach hair worm | Diarrhoea | 500 | 3000 |
| Small intestine | *Trichostrongylus* | Black scour worm | Diarrhoea | 500 | 3000 |
| | *Cooperia* | Small intestinal worm | Diarrhoea | 500 | 3000 |
| | *Nematodirus* | Thin-necked intestinal worm | Diarrhoea (immatures) | 200 | 1000 |
| | *Bunostomum strongyloides* | Hookworm | Anaemia Diarrhoea (rare) | — Eggs in faeces not quantified | — |
| Large intestine | *Oesophagostomum* | Nodule worm | Mucoid | 100 | 1000 |
| | *Trichuris* | Whip worm | Diarrhoea (rare) | Eggs in faeces not quantified | |
| Bile ducts | *Fasciola* | Liver fluke | Anaemia (chronic) | 200 | 500 |

a. Significant — The lowest egg count that may indicate a significantly harmful infection.
b. Dangerous — A high count that indicates significant production effects and may indicate pending fatalities.
Note: Above counts are for animals with normal food intake and faeces of normal consistency. Approximate correction factors that apply are:-
Fasting >12 hours × 0.5
Soft and unformed faeces × 2
Diarrhoeic faeces × 3

Treatment of helminthiasis in goats is even more difficult than in sheep. Recent research from New Zealand indicates that goats metabolise anthelmintics faster than sheep and need a larger dose rate. Also goat owners tend to underestimate the weight of their goats. The frequency of drenching that is often necessary with goats often leads to widespread anthelmintic resistance. Green et al. (1981) reported that this was widespread in Queensland. *Haemonchus contortus* is generally the parasite that becomes resistant but recently, resistance in *Trichostrongylus* spp. has been recorded.

The current recommendations are that goat keepers use a third generation benzimidazole e.g. oxfendazole or a levamisole/morantel drench. Whichever drench is chosen it should be used for one year and then the goat owner should use a drench of the opposite family. If *Haemonchus contortus* is the main problem, naphthalophos (Rametin) can be used although toxicity can be a problem. Alternatively the long acting drench, closantel (Seponver) can be used quite safely and effectively. Australian research on the use of anthelmintics is quite extensive and some very useful publications are produced. Ivermectin, although not registered for use in Australia yet, has proved very effective for goats in New Zealand, although it cannot be used on milking does.

Management decisions should also be used in conjunction with anthelmintics to control helminthiasis. Options include reducing stocking rates, going into a feedlot non-grazing situation (at least in the worst months), rotational grazing, and alternate grazing (preferably with horses, but cattle are acceptable). In the Northland of New Zealand the most common recommendation is rotational grazing using electric fencing with follow up grazing of adult cattle. This is combined with monthly drenching and Ivermectin in the dry period.

## Metabolic and Associated Diseases

Pregnancy toxaemia and cerebrocortical necrosis are probably the two most important diseases in this group, however other common metabolic diseases also occur in goats. Ketosis, either primary or secondary, occurs occasionally in goats in early lactation. While rarely fatal, it can markedly reduce milk production. Other clinical signs include inappetance, an acetone smell on the breath, and urine that is positive for ketones. Treatment is initially with glucose followed by 120 ml of glycerine drenched twice a day for 5–7 days. Injections of multivitamins and corticosteroids, e.g. 3 mg betamethasone are helpful. Control is by ensuring an adequate energy-rich good quality diet for does in early lactation.

Bloat also occurs in goats but less frequently than in dairy cattle. An abomasal bloat in young kids on milk replacer diets has recently been seen in Queensland. In New Zealand a similar condition seen in kids shows up as a rapidly fatal twisted bowel syndrome. The aetiology of these two conditions is as yet unknown.

## Pregnancy Toxaemia

Pregnancy toxaemia is a metabolic disease that occurs when nutritional intake is less than requirements. In a herd situation if a few does are showing signs of pregnancy toxaemia, many more are avoiding the disease at the expense of producing small weak kids or reduced production.

The predisposing factors include the number of foetuses (some breeds e.g. Anglo-Nubians, produce more kids than others), lack of exercise, overfat does, stress, undernutrition, and any indirect cause of undernutrition, e.g. foot rot.

The clinical signs can begin to occur 4 weeks before kidding. Initially, there is inappetence and laziness. Eventually, the goat cannot rise, has swollen feet and stops eating completely. Often, just prior to death the doe attempts to kid. Nervous signs occur in the later stages in sheep but have been noticed in goats by only one author.

The diagnosis is confirmed by testing the urine with reagent strips or tablets for the presence of ketones. Then a decision must be made as to whether the pregnancy toxaemia is primary or secondary. Any concurrent disease must be diagnosed and treated.

Treatment consists of providing an energy source with glucose or glucogenic agents and stimulating gluconeogenesis (the provision of glucose from protein) by the use of glucocorticoids. Specifically 60–120 ml of glycerine is given orally twice daily. Alternatively, propylene glycol or sodium propionate preparations that are used for sheep can be given to goats on a body weight basis. Dexamethasone (25 mg) can be given with the above treatment and this brings the survival rate up to 85% in sheep. This drug acts as a glucocorticoid and helps prevent shock. The use of long acting corticosteroids will induce kidding, but this is often beneficial. In mild cases a low dose, 5 mg of Dexamethasone, is given in the last 2 weeks of pregnancy to induce kidding within 48 hours. Alternatively, in milder cases that can survive surgery, a caesarian is performed. A non-sterile caesarian under local anaesthesia can be performed on does given no chance of survival and the doe destroyed as soon as the kids are removed. Exercise, force feeding, vitamins A, D and E, multivitamin B injections and anabolic steroids are also helpful.

Control is achieved by providing a rising plane of nutrition in the last 6 weeks of pregnancy, making sure that does are not overfat at mating, encouraging exercise, and carrying out early diagnosis and treatment. Elimination of this disease is an unrealistic target.

Current research into the disease in Australia is limited to recording successful treatments in sheep, and occasionally goats.

## Cerebrocortical Necrosis (Polioencephalomalacia)

Cerebrocortical necrosis (C.C.N.) occurs when tissue thiamine levels are too low. This can be due to a variety of different reasons, which are summarised in Fig. 1.

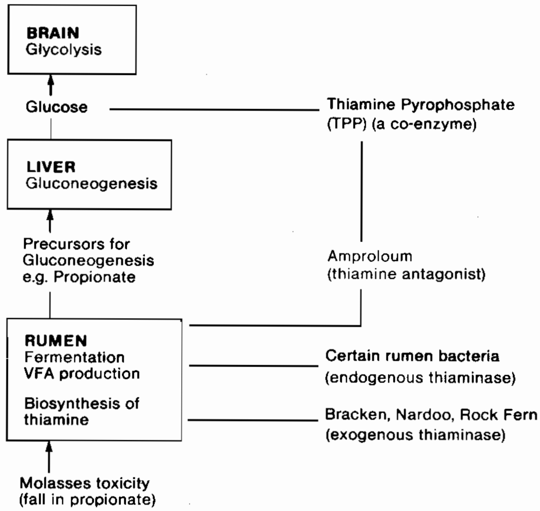


**Fig. 1.** Diagram of the aetiology of C.C.N. (from Edwin et al. 1979)

Excessive grain rations, or changes in the amount or type of ration, can be predisposing causes, as also can mouldy feed and a cobalt deficient diet.

Clinical signs include stargazing, twitching, recumbency, nystagmus, apparent blindness, and circling. These are followed by opisthototonus, clonic convulsions, and death. The main gross postmortem findings include softening of the dorsal cerebellum (due to cerebral oedema), less pronounced sulci, flattened gyri, yellow discolouration of the cortex, and fluorescence of the brain under U.V. light. Histologically, there is necrosis of most of the cerebral cortex with shrunken acidophilic neurons and vacuolation. Neutrophilic infiltration of the cornea and the presence of protein in the anterior chamber of the eye have also been recorded.

Treatment found effective in Australian Angoras consists of 550 mg thiamine given intravenously, then

220 mg intramuscularly daily until cured. American workers suggested higher doses, i.e. 6.6–11 mg/kg intravenously every 6 hours for 24 hours or until cured. There is a 100% mortality without thiamine. Treatment will not be successful unless given daily. Also, treatment may prevent death but the blindness sometimes cannot be reversed.

Control is based on eliminating any predisposing factors, e.g. bracken fern, cobalt deficiency, coccidiosis, amprolium administration, etc. Chick et al. (1981) reported the cessation of clinical signs in a large mob of sheep after the whole flock was given a subcutaneous injection of 200 mg thiamine hydrochloride. In the previous 4 weeks, 70 wethers had to be treated with thiamine. Australian research has been limited to recording outbreaks and their control.

### Urinary Calculi

This condition occurs in wethers and bucks of all breeds throughout the world. The clinical signs include anorexia, depression, grinding of the teeth, standing with legs stretched out and straining to urinate. Eventually, the scrotal sac fills with urine and then death occurs. Often a reasonable amount of urine dribbles from the penile sheath in affected males and this usually means that a stone is present in the urethral process.

Treatment consists of extruding the penis for examination with or without a light xylazine anaesthesia. If a stone is present in the urethral process, this is removed at an angle. Catheterisation is not possible. If removal of the urethral process does not correct the urinary obstruction, radiology and then surgery are necessary.

Control is very difficult. The calculi should be analysed to find the mineral content, and the pH of urine should also be analysed. If the urine needs to be acidified, up to 15 g of ammonium chloride can be given orally to each goat daily. If the urine needs to be alkanised then sodium bicarbonate can be used. The diet should be investigated to decrease the content of the minerals found in the stones or to adjust the mineral balances, e.g. if phosphate stones are a problem, calcium carbonate should be added to the grain ration at a rate of 1 kg to 100 kg of grain. General control measures include increasing water intake by improving its quality and availability and by adding salt (1 kg per 100 kg) to the grain ration.

Research in Australia has been limited to the reporting of outbreaks and their treatment. The University of Sydney had problems in penned bucks used for semen studies. The calculi were composed of $Mg\ NH_4\ PO_4$ and affected males had a urinary pH of eight. A temporary emergency measure was to starve the bucks. This reduced their urinary pH to between four and five. Their diet was changed to a high roughage, low protein, salt-containing feedlot pellet and their watering facilities were improved. When outbreaks of urinary calculi occur they have to be treated on first principles because the calculi and the reasons for their formation vary so greatly. The recording of the successful control of outbreaks is very helpful if all the details are given.

## Viral Diseases

### Caprine Retrovirus (C.A.E.)

Caprine retrovirus infection is also called Caprine Arthritis Encephalitis (C.A.E.), big knees, chronic progressive pneumonia, leukoencephalomyelitis and progressive pneumonia/arthritis complex of goats.

This disease occurs in the USA, Europe, Canada, Japan, U.K., and India. It has been recently recorded in New Zealand from Australian imported goats. The causative virus is very similar to the maedi-visna virus in sheep.

There are three main forms of this disease:-

#### Arthritis

Usually this shows up as an enlargement in both carpal joints as early as a few months or as late as a few years of age. Several weeks after the first kidding is the most common time. Affected goats have intermittent lameness, a rough coat and often develop a wasting condition. Other joints in both the front and hind legs can become affected, especially the stifle and the hock joints. X-rays of affected joints show soft tissue swelling around the joint and mineral deposits around the joint lining.

#### Encephalitis

Young kids of between 2 weeks to 5 months of age may suffer from a viral brain infection but this condition is rare. Affected kids show lameness and weakness and this progresses to a paralysis and usually death. A fever, circling, and a dislike of being touched may also occur. Granulomatous encephalitis, a similar disease of adult goats, first recorded in West Germany, has been diagnosed by postmortem in a goat in Western Australia.

#### Pneumonia

Adult goats are affected by a progressively worsening pneumonia that does not respond to antibiotics. These animals are often in severe respiratory distress and pant with the least amount of exertion. Wasting is again part of this syndrome and the knee joints can be slightly enlarged in some cases.

The caprine retrovirus is transmitted from infected does to offspring early in life. Colostrum and milk are two important methods of spread. The virus is also associated with the white cells of the blood for very long periods of time. Semen does not appear to be a method of spread. The virus does not seem to cross the placenta readily and most kids are affected after birth. Only limited spread of the virus occurs under extensive grazing conditions.

The best method of control of this disease is to remove all goats showing clinical signs and all carriers that are diagnosed by blood test (AGID or ELISA). Due to the very high incidence in the majority of herds, this is usually not possible until a control program has been undertaken for several years. In the meantime, infected animals should be isolated from the rest of the herd and, especially, from young kids. These animals could be milked in the same sheds as the rest of the herd provided isolation is maintained.

The most important point in a control program for caprine retrovirus is to remove newborn kids from affected or carrier dams at birth and to rear these kids on cow's colostrum and cow's milk or artificial replacements. The feeding of pooled colostrum and milk to kids should be prevented. There should be separate utensils, storage, refrigeration and washing facilities for goat's milk and for milk and equipment used to feed kids. Also, to prevent cross infection, all injections should be made with sterile needles and tattoo letters should be boiled before use.

Current research into caprine retrovirus infection in Australia is based in NSW and W.A. In W.A., besides looking at the basic characteristics of the virus, the researchers have been monitoring local goat dairies and helping them control this disease. They hope to have their first free herd in late 1984. They are using both the AGID test and the ELISA test and find that they collaborate well. This research has been reported by Ellis et al. (1983a, b).

New Zealand has performed a very large survey of dairy goats to determine the incidence of caprine retrovirus in goats. McDiarmid (1983) showed that the caprine retrovirus was introduced by the importation of Australian goats. The AGID test is now being used to control and, hopefully, eventually eradicate the disease from New Zealand.

## Bacterial Diseases

### Enterotoxaemia

Enterotoxaemia affects goats worldwide and goats of all ages. *Clostridium perfringens* type D is present in the gut of normal sheep and goats, and in the soil. The disease is either peracute, with the goat found dead or in terminal convulsions, or more commonly acute. In the acute form there is an initial yellow-green pasty diarrhoea that later becomes watery with bits of mucous, bowel lining and sometimes blood. The goat is down, crying out in pain and cold to touch. A chronic form has been recorded by some authors.

The most consistent findings on postmortem are straw coloured pericardial fluid that clots on exposure to air, subendocardial haemorrhages, an inflamed mucosa in the first few feet of the small intestine, glucose in the bladder. The brain is very useful for a histological diagnosis if it is removed soon after death. A 100% conclusive diagnosis is very difficult. *Clostridium perfringens* is a normal inhabitant of the gut, so, unless also isolated from the kidney, its presence is hard to interpret. Vaccinated goats can have toxin isolated from the 10 ml chilled sample of reddened small intestinal contents submitted.

Treatment, even with intravenous fluids, pain killers and antibiotics is usually unsuccessful. Oral sulpha drugs are usually recommended. Control is by 6-monthly vaccinations after an initial two injections. As goats are very prone to tetanus also, pulpy kidney tetanus vaccines are generally used if necessary, e.g. in a liver fluke area, '5-in-1' clostridial vaccines.

Recent research by the Commonwealth Serum Laboratories at Parkville, Victoria, has indicated that a 2 ml dose subcutaneously is just as effective as the previously recommended 5 ml dose. This research should be directly applicable to Southeast Asia if Commonwealth Serum Laboratories vaccines are used.

### Johne's Disease

While not present in Queensland, this disease is recognised in three other states of Australia, and is generally considered to occur worldwide. Losses in affected herds have been reported at between 2 to 10% annually. This would mean though that only one or two goats in the herd would be showing clinical signs at any given time. Goats are generally affected between 2 and 5 years of age and the clinical course of the disease is approximately 4–6 weeks. Stress is a major triggering factor.

Clinical signs include gradual chronic weight loss, progressing to emaciation, weakness, and death. Diarrhoea is not a feature in the goat. Johne's disease is often misdiagnosed as caprine retrovirus infection, gastrointestinal parasitism, or copper-cobalt deficiency.

Diagnosis is extremely difficult with Johnin testing, rectal scrapings and compliment fixation testing not being recommended. In the USA an AGID test is proving useful, as is right flank laparotomy to remove a mesenteric lymph node for culture and acid fast stained impression smears. Faecal culture is the best method but this takes at least 8 weeks.

Postmortem signs in the goat are less distinctive than in cattle and include enlarged oedematous caseated mesenteric lymph nodes, localised peritonitis, grossly thickened roughened mucosa with fibrin tags anywhere from the duodenum to the ileocaecal area, and corded and knotted lymphatics. Histopathology, impression smears and cultures will be necessary to confirm the diagnosis.

*Myobacterium paratuberculosis* bacteria are intermittently excreted from the faeces of infected animals. These bacteria can survive for up to 12 months under moist, shaded conditions. Goats become infected by ingesting these bacteria with their food and water, generally very early in life. It remains to be determined whether transmission by milk or semen, or in utero infection occurs in goats, as is the case in cattle.

There is no treatment. Control is very similar to that for caprine retrovirus infection, i.e. removal of kids immediately after birth and raising them in isolation from adults for at least 12 months. All milk, hay, grain, pasture and water for kids should be free of faecal contamination. Once or twice yearly all the goats should have their droppings sampled and sent for bacterial culture. Any positive goat should be destroyed together with any offspring raised on an infected doe. Sheds and yards should be cleaned and disinfected frequently and, ideally, spelled for 12 months or used for horses.

### Other Bacterial Diseases

Caseous lymphadenitis (CLA) has become more widespread with Australian goats over the last 5 years. External abscesses in the superficial lymph nodes, especially about the head and neck, are the main clinical signs. Morbidity is high in herds where goats with draining abscesses are not isolated and treated. Mortality is rare and is due to internal abscesses rupturing, e.g. within the lungs.

Recent Australian research into CLA has been conducted by the Murdoch University of Western Australia. This has involved a postal survey of goat breeders and some initial work on vaccination. The Commonwealth Serum Laboratories is also undertaking some research on goats in connection with their new vaccine for caseous lymphadenitis, 'Glenvac'.

Research into goat mastitis involving the recording of bacterial type and antibiotic sensitivity and the detection of subclinical mastitis has been undertaken in Australia in the last few years.

Infestation with *Dermatophilus congolensis* has been reported in goats in Australia and in many other countries, including India and Fiji. In sheep, this bacteria causes mycotic dermatitis (lumpy wool) or alternatively, strawberry foot rot. This disease has been treated topically with a number of preparations including 0.5% zinc sulphate and Bordeaux mixture, and more recently by the injection of penicillin-streptomycin or long acting tetracycline.

Foot rot and foot abcess, while being a common problem in Australian sheep, are uncommon problems in goats. Imperial Chemical Industries (ICI) have recently released a foot rot vaccine that contains five serotypes of *Bacteroides nodosus* for use in Australian sheep flocks either alone or preferably combined with foot paring and weekly foot baths of 5% formalin.

## Protozoan

### Coccidiosis

Coccidia are frequent intestinal parasites of goats and are of the genus *Eimeria*. Some of these coccidia, e.g. *Eimeria arlongi* are also found in sheep but it is debatable as to whether cross infection occurs between sheep and goats. Coccidiosis is a worldwide problem being found wherever goats are kept intensively, are stressed, or where different age groups are kept confined together. The clinical signs include diarrhoea, lack of thrift, loss of production, and sudden death. Control involves improving hygiene (in particular the use of slatted wire mesh floors instead of bedding), reducing stocking rates and stress, early diagnosis and treatment of scouring goats and others in contact. Daily treatment with sulpha drugs or amprolium (50 m/kg orally) for 3–5 days, and the use of coccidiostats when necessary, is effective. Amprolium can be added to the drinking water at a rate of 60 ml per 20 L for 5–7 days. An alternative coccidiostat is monensin, mixed in a commercial grain ration or pellet at the rate of 20–30 mg/kg.

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# Fibre Production from Goats in Australia

**B.J. Restall***

ALTHOUGH large herds of feral goats have been present in Australia for many years, the commercial exploitation of this species is a recent development.

The opportunistic harvesting of feral goats for export as frozen and chilled carcasses has gradually increased from the early 1950s to the present when we export some 5 million tonnes at a value of approx $7 million. As well, there has been a revival of interest in Angora goats to the point where the production of mohair is in excess of 100 tonnes.

Of perhaps greater importance for the future is the commercial interest in the capacity of the feral goat to produce cashmere, a luxury textile fibre, and the realisation that goats can play an important role in land management through the control of weed and scrub invaders of pasture lands.

These developments indicate that we are poised to begin a new substantial animal industry. The source of stock for this industry, whether it concerns production of mohair, cashmere, or meat, will be the considerable feral herds that have established themselves in the semi-arid areas of Australia, and which comprise a valuable genetic resource of one of the world's most versatile domestic animals.

## Historical

It is not known when goats were first introduced to the Australian mainland, but it is known that Captain Cook carried goats and made periodic releases at various places. Other early introductions may have occurred in the 17th century from either shipwrecks on the coast of W.A. or deliberate releases on to the mainland and offshore islands by Dutch mariners to aid future shipwreck victims.

In the 19th century various acclimatisation societies introduced Angora, Dairy and cashmere type goats. These goats played an important part in the settlement of inland Australia, providing milk and meat before the advent of refrigeration and improved transport. By the turn of the century considerable herds of Angora goats had built up and were thriving.

The developing and well organised wool industry soon replaced the interest in Angoras and by the 1940s the Angora had all but disappeared. Improved transport and refrigeration, permitting wide distribution of fresh meat and milk, sounded the death knell for the outback goat herds that were still common up until the 1950s. Early goat herds were shepherded rather than fenced so when they were no longer needed they were simply released.

In the vast semi-arid areas of our continent these escapees and releases found an environment that suited their needs and became the basis of our present day feral herds. Based as they are on a mixture of dairy types (probably the Old English milk goat, now extinct in England), and fleece types (Angora and cashmere breeds), and having been subject to a considerable period of natural selection, they represent a unique genetic resource in the world today.

The harvesting of feral goats for meat export began during the 1950s. The decline in the profitability of sheep enterprises in the late 1960s and early 1970s led to renewed harvesting activity and a revival of interest in the Angora goat. Recent changes in the world supply pattern of cashmere fibre have led to an intense commercial effort by a processor from the U.K. to establish a cashmere industry in Australia. This is creating considerable interest amongst graziers wishing to diversify.

These developments have brought us to the point where once again we are experiencing an expansion in the exploitation of the goat, and the very real possibility of establishing a substantial and permanent place for this species amongst our domestic livestock.

This review will be concerned with non-milk goat types; milk goats are dealt with elsewhere.

## Non-milk Goats

Our non-milk goat animal resources comprise the Angora goat, represented by some 50,000 pure or near purebreds, and the feral goat population estimated to be somewhere between 0.5 and 5 million head. The products from these animals include mohair, cashmere, skins, hair, and meat.

* NSW Department of Agriculture, Wollongbar, NSW, Australia.

It will be from these animal resources that the future goat industries of Australia will develop. Any expansion in on-milk goat production will rely heavily on use of the feral herd to provide stock for upgrading and selection.

## Non-milk Goat Products

### Mohair

Since antiquity the fleece of the Angora has been sought for its textile properties. Mohair fibres are lustrous, strong and resilient, and the scale structure allows the production of yarns and fabrics that resist soiling. Fibres from adult fleeces have a diameter of 30–40 μm, and are relatively even along their length.

Fabrics made of mohair are considered to give warmth without weight, and to resist wear. Consequently end uses include rugs, blankets, furnishings and men's tropical suitings. The lustrous characteristic of the fibre when dyed results in richly coloured fabrics, which are used for the manufacture of women's apparel. However the latter is a fashion-dependent market and is subject to periodic variations in demand that result in considerable fluctuations in the price paid for raw mohair.

Mohair quality is determined by the fibre diameter, fibre length and contaminants such as vegetable material, dirt, medullated fibres, and kemps, which affect the dyeing properties of the yarn. Australian mohair has a mean fibre diameter some 3–4 μm finer than that from either South Africa or the USA, and the yield from the fleece is higher. These advantages are offset by the considerably lighter fleece weights of the Australian product and its higher kemp content (Table 1). Nevertheless these are faults that should be gradually eliminated by selective breeding.

Systematic studies of the Australian Angora goat are rare and existing information has been collated by Evans (1980). It seems that the Australian Angora is of similar size to those elsewhere in the world with one report indicating that 15-month-old males can grow to 36 kg with good management. Some of the problems said to be peculiar to the Angora in the USA (Shelton 1981) are evident in Australia, for example, susceptibility to cold stress and internal parasitism. However, unlike its overseas counterparts, the Australian Angora appears to have a high reproductive rate with weaning rates of 140% (Stapleton 1981).

Studies of Angora fleece production are similarly limited, but Stapleton (1978) reported a number of significant phenotypic correlations that suggest that goats with high fleece weights will have long staples and coarse fibres. Fleece weights and staple length appear to increase with age up to the third shearing, and as expected, males and wethers grow more fleece than females.

Genetic information on the Australian Angora is non-existent although studies are under way in the South Australian Department of Agriculture.

The world production of mohair (mainly from South Africa, USA, and Turkey) has been very variable, dropping from some 30 million kg in 1966 to only 12 million in 1974. Since that time production has crept up to about 16 million kg of which Australia produces less than 1%. A recent survey shows that there are 4000 Angora goat keepers in Australia and that 120,000 kg of mohair were produced in 1982. Any expansion in Australian mohair production will depend very heavily on an increase in world demand.

The International Mohair Association projects a future demand of up to 30 million kg, and Stapleton (1981) has estimated that Australia could expect to contribute 5 million kg to that total. Production of this order would necessitate an expansion of the Angora goat population from the present level of 60,000 to 1.6 million animals, a considerable increase.

Another authority (Evans 1980) considers that Australia's future production could be as high as 11 million kg; both of these estimates project a bright future for mohair production in Australia. However, the populations of Angora goats in the USA and South Africa fluctuate widely apparently in response to price variations (Shelton 1981) and a similar phenomenon may occur here in the future.

**Table 1.** Fleece quality characteristics of mohair from USA, South Africa, and Australia (from Evans 1980).

| *Origin* | *Clean fleece weight (kg)* | *Scoured yield (%)* | *Staple length (cm)* | *Fibre diameter (μm)[a]* | *Kemp (%)* |
|---|---|---|---|---|---|
| USA | 0.9–2.0 | 81.1 | 13.2 | 32.3 | 1.8 |
| South Africa | 0.9–1.8 | 83.1 | 13.9 | 33.4 | 1.6 |
| Australia | 0.8–1.3 | 91.7 | 11.7 | 29.8 | 4.5 |

a. μm designates micron.

## Cashmere

Cashmere is a name used in the textile trade for a type of fibre produced by goats predominantly found in Central Asia. It is a fine (<16 μm) wool-like fibre possessing an exceptionally soft handle; its fineness and strength allow it to be spun into very fine, soft yarns used to produce luxury knitwear. A detailed discussion of the characteristics of cashmere has been presented by Couchman (1983).

Animals that produce cashmere have two coats, an outer coarse guard hair and a fine undercoat that is shed at the end of winter. Most goats, even dairy types have two coats, but the undercoat or down varies considerably in quantity and fineness. Nordic goats, used primarily for milk production, are reported to have a dense woolly undercoat (Trohdahl et al. 1981). Other goats like the Don of the USSR produce a prodigious undercoat that is too coarse (around 19 μm) to be considered cashmere. It would seem that there is no such thing as a distinctive breed of cashmere goat, but rather various types, descending from common origins, that show considerable variation in their undercoats. Only undercoats of mean fibre diameter of 15.5 μm have been purchased as cashmere by processors.

A very thorough discussion of the evolution of fleece bearing goats, including cashmere types, has been given by Evans (1980).

World production of cashmere is approximately 3000 tonnes per annum, mainly coming from China, Mongolia, Iran, and Afghanistan. About 60% of this production is bought by the one processor, Dawson Intl. in Scotland, who produces luxury knitwear, and more recently, worsteds for suitings. Other processing countries include Italy, USA, Belgium, and Japan.

China, the world's major producer with an annual production of some 2000 tonnes, has begun to industrialise its cashmere industry and is producing its own yarn, which has resulted in the Scottish processor seeking alternate supplies of cashmere in Australia. They have a stated target of 1000 tonnes (Bell 1983).

The interest of the processors in Australia stems from the discovery by Smith et al. (1973) that a proportion of our feral goats had undercoats identical to cashmere. More detailed studies of the feral herd have revealed that about 80% of the goats produce a commercially recoverable undercoat that can be classified as cashmere (Restall and Pattie 1983).

In 1982 the processors purchased 8 tonnes of Australian down, almost an eightfold increase on the previous year, and in 1983 purchased over 15 tonnes. It is estimated that this harvest came from approximately 500 producers, most of whom were located in NSW. Given the productive capacity of our goats and the quantities required by the processors, we have the potential to develop an industry involving some 6–8 million goats.

At the present time the textile industry only recognises two types of goat fibres, viz. cashmere and mohair. Interest in the crossbreeding of Angora and feral goats has resulted in animals producing a crossbred fleece, popularly termed "Cashgora", which is too coarse for cashmere processing, has some lustre, and has been used as a substitute for fine, kid mohair. Japanese processors have purchased these fibres and have begun market tests. Should they prove successful, another opportunity for exploiting our goat resources will arise.

A number of speculative breeders are carrying out crossbreeding exercises that may form the basis of a future coarse down industry.

## Fibre Production from Australian Feral Goats

The potential of the Australian feral goat to produce cashmere is unknown and studies of the fleece characteristics of these animals is complicated by the presence of a coarse guard hair coat and the seasonal growth and shedding of the undercoat or down. This presents problems in both harvesting the total growth of down and in measuring its characteristics. Separation of the two fleece types is difficult and time consuming and consequently fleece measurement is expensive.

Full-scale fleece measurement of the feral goat herd at the Agricultural Research Centre, Wollongbar, began in 1981; the goats are shorn standing so that the fleece is a mixture of the two types of fibre. Complete fleece measurements for 418 unselected feral does shorn in 1981 have been subjected to analysis of variance to estimate differences between age groups. The unselected feral herd at Wollongbar comprises animals of mixed age and colour, and at the time of the 1981 shearing they had kidded at varying times of the year. The average fleece characteristics for these does are shown in Table 2.

**Table 2.** Average fleece characteristics for 418 unselected feral does with residual (within-group) standard deviations and coefficients of variation after analysis.

| *Character* | *Mean* | *Residual standard deviation* | *Coefficient of variation (%)* |
|---|---|---|---|
| Total fleece weight (g) | 265 | 93 | 35 |
| Yield (%) | 19 | 8.3 | 43 |
| Down weight (g) | 49 | 26 | 53 |
| Diameter (μm) | 15.4 | 1.1 | 7 |
| Mid length (mm) | 31 | 8.1 | 26 |

The does produced an average of 49 g of down with a diameter of 15.4 μm. This down is fine enough to be classed as cashmere but the production is low; the range in down weights varied from less than one gram to 212 grams. There were low to moderate correlations between down weight and total fleece weight, fibre diameter and length but none was sufficiently high to indicate a useful indirect measure of down production.

There were no consistent age trends in either down production or diameter. However, both pregnancy and lactation reduced down production with lactation having the most severe effect. Does that kidded in April were both pregnant and lactating during the down growing season, and they produced only half the down of does not kidding at all.

The growing season for down is as yet undefined but casual observations suggest that there is considerable variation both in the length of the growing season and in the growth rate. Some animals can be seen to be growing down in October–November while others appear to have a rapid growth commencing as late as February–March. In either case the down production could be expected to be reduced if pregnancy or lactation occured during the growth period.

Goats with white down produced less than those with coloured down but this was not associated with any differences in fibre diameter or length. Does with short guard hair produced less than two thirds the down grown by goats with medium or long guard hair. This difference was associated with shorter down and, for the medium length group, finer fibres.

Guard hair would seem to provide protection for the down against weathering and contamination with vegetable material but losses due to these two factors have yet to be determined.

Fleece production has also been measured on the 9 and 18 month old progeny from the random matings of the unselected feral herd. These young animals have been raised wholly in the Wollongbar environment. Body, neck and belly were shorn separately on a proportion of these animals and the production from the three areas determined. The results for the two age groups are given in Tables 3 and 4.

The fleece parameters show considerable variation but the down weights of 77 and 88 g, for the 9 and 18 month animals respectively, are greater than their dams. Most of the fleece production comes from the neck and body with only 2% or less coming from the belly. In both groups the fibre diameters are fine, with low variation between animals, and are in the cashmere range.

The density of follicles in the skin is an important component of fleece production and complete measurement of follicle populations has been carried out on 493 adult female goats in the breeding herd. The results are shown in Table 5.

**Table 3.** Fleece production from 9-month-old progeny of unselected feral goats.

| | *Males* | | | *Females* | | |
|---|---|---|---|---|---|---|
| *Parameter* | *Body* | *Neck* | *Belly* | *Body* | *Neck* | *Belly* |
| Fleece weight (g) | 190 | 54 | 19 | 154 | 34 | 14 |
| CV[a] | 30.8 | 23.1 | 21.0 | 23.0 | 27.1 | 25.8 |
| Yield % | 32.3 | 31.9 | 19.1 | 28.8 | 25.6 | 12.4 |
| CV | 42.6 | 47.6 | 54.0 | 39.3 | 54.9 | 56.7 |
| Down weight (g) | 60.0 | 17.4 | 3.6 | 48.0 | 9.6 | 1.8 |
| CV | 41.1 | 50.0 | 52.2 | 60.0 | 80.7 | 64.8 |
| Diameter (μm) | 14.5 | 14.2 | 13.9 | 14.1 | 13.7 | 13.5 |
| CV | 7.0 | 7.7 | 5.8 | 11.3 | 10.3 | 7.4 |

a. CV = coefficient of variation.

**Table 4.** Fleece production from 18-month-old progeny of unselected feral goats.

| | *Males* | | | | *Females* | | | |
|---|---|---|---|---|---|---|---|---|
| *Parameter* | *Body* | *Neck* | *Belly* | *Total* | *Body* | *Neck* | *Belly* | *Total* |
| n | 10 | 10 | 10 | 61 | 10 | 10 | 10 | 41 |
| Fleece weight (g) | 305 | 88 | 19 | 322 | 255 | 54 | 18 | 270 |
| CV | 49.2 | 46.5 | 34.5 | 34.3 | 35.8 | 36.7 | 35.1 | 23.4 |
| % | 74 | 21 | 5 | | 78 | 17 | 5 | |
| Yield % | 24.9 | 20.7 | 7.5 | 29.7 | 31.5 | 26.8 | 9.6 | 29.2 |
| CV | 49.1 | 69.8 | 92.8 | 42.1 | 34.5 | 51.4 | 64.3 | 40.3 |
| Down weight (g) | 67.8 | 15.9 | 1.4 | 88.9 | 78.2 | 14.1 | 1.6 | 79.1 |
| CV | 52.9 | 65.1 | 98.9 | 48.3 | 38.9 | 52.0 | 48.8 | 47.8 |
| % | 80 | 19 | 1 | | 83 | 15 | 2 | |
| Diameter (μm) | 14.3 | 15.0 | 14.0 | 15.0 | 16.2 | 15.9 | 14.7 | 15.3 |
| CV | 5.0 | 7.6 | 7.1 | 7.9 | 6.0 | 8.1 | 5.1 | 8.2 |

**Table 5.** Skin follicle statistics for 493 unselected feral does.

| *Follicle density* | *Mean* | *Range* | *S.D.* | *Coef. Var.* |
|---|---|---|---|---|
| Primary/mm² | 2.07 | 0.77–3.81 | 0.40 | 19.5 |
| Secondary/mm² | 11.92 | 4.45–22.26 | 2.76 | 23.1 |
| Total/mm² | 13.99 | 5.52–24.89 | 3.00 | 21.5 |
| S/P ratio | 5.80 | 2.50–10.28 | 1.13 | 19.4 |

**Table 6.** Fleece components and their relative contribution to differences in down weight in 279 unselected feral does.

| *Component* | *Mean* | *S.D.* | *Coef. Var.* |
|---|---|---|---|
| Down weight (g) | 47.0 | 29.11 | 61.9 |
| Diameter ($\mu$m) | 15.4 | 1.16 | 7.6 |
| Length (mm) | 30.8 | 9.05 | 29.4 |
| Body weight (kg) | 33.0 | 5.66 | 17.1 |
| Cover score (3–12) | 9.7 | 2.52 | 25.9 |
| Secondary foll. dens./mm² | 11.7 | 2.48 | 21.2 |

| *Component* | *% contribution* |
|---|---|
| Diameter | 6 |
| Length | 47 |
| Body weight | −1 |
| Cover of down | 43 |
| Density | 5 |

The secondary follicle densities are about half those previously reported (Holst and Maddocks 1981) and this may be due to differences in measurement technique, or in age of the animals when measured. With our technique, counts are made within random set areas of skin to ensure that follicle grouping does not influence the measurement. Although low, both secondary density and S/P ratio show a wide range and potentially useful variance.

The production of down is a function of the size of the goat, the extent of skin growing down fibres, the density of fibres, and their length and diameter. Complete fleece, skin and body weight data from 279 adult female goats have been used to analyse the relative importance of the various components of down production. The means and between–animal measures of variation for each component are given in Table 6 together with their relative contributions to the variation in down weight.

Of the variance in down weight, 54% could be attributed to the components examined here. Variation in length and cover were clearly the most important sources of variation in down weight amongst those studied. However there still remained a large proportion of variance unaccounted for by these components. This could be due to measurement errors, to non–linear relationships between the components and down weight, or to incorrect constants used to relate body weight to surface area and to derive variation in fibre weight from variation in diameter and length.

While length and cover are the most important components at this stage the relative importance will change if selection alters any one of them. One objective would be to breed goats that grow down over a large proportion of their bodies. This would eliminate cover as a source of variance, so other components would become relatively more important. The actual changes that will occur cannot be predicated until genetic parameters are available, but it is useful to examine the phenotypic relationships between components as these indicate the effects of culling within the existing animals. These relationships are given in Table 7.

**Table 7.** Phenotypic correlations between components of down weight.

| *Component* | *Down wt* | *Diam* | *Length* | *Body wt* | *Cover* |
|---|---|---|---|---|---|
| Diameter | .170 | | | | |
| Length | .619 | .366 | | | |
| Body weight | −.046 | .211 | −.044 | | |
| Cover | .569 | −.209 | .330 | −.106 | |
| Density | .107 | −.294 | −.070 | −.346 | .139 |

Strong correlations between length, cover, and down weight reflect the results of the components analysis. There are also moderate correlations between length, diameter, and cover and negative relationships between diameter, body weight, and density. Thus, culling on down weight while restricting the diameter could be expected to leave animals with longer and denser fibres producing down over a larger proportion of their bodies. However, if attention was also paid to body weight, the increase in density would not be achieved.

## Research on Fibre Production from Goats in Australia

Several substantial studies of fibre production from Australian goats are currently being undertaken. The Department of Agriculture in South Australia is investigating the inheritance of fleece and body characteristics in Angora goats, while the Victorian Department of Agriculture is studying growth and nutritional aspects in the same species. These two exercises appear to be the only major studies of Angora goats in this country. With the anticipated expansion of the mohair industry there is a real need for genetic information from which efficient selection programs can be devised. If the advantages of the Australian Angora (high yields, fine fibre diameter, high reproductive rate) are to be retained while the relatively low fleece weights are improved, a knowledge of the mode of inheritance of the characters is essential.

The Australian feral goat is under investigation in a number of centres. The Departments of Agriculture in NSW, Vic, S.A., and W.A. are conducting studies of feral goat production with animals from a number of feral herds. The Department of Primary Industry in Queensland has a research program elucidating the physiological basis of down growth and its environmental control. The University of Sydney, Department of Animal Husbandry, has conducted studies of reproduction in goats for some years, especially in the area of control of reproduction and manipulation of gametes, and it possibly leads the world in this area. Important studies of goat behaviour and health are being carried out by the University of Melbourne.

The major study of the inheritance of growth and fleece characters is being conducted by the NSW Department of Agriculture in collaboration with the University of Queensland. Jointly they run 2000 animals in a comprehensive series of detailed studies that are providing a systematic appraisal of the productive potential of the Australian feral goat.

Studies of fleece production from the feral goat are complicated by the presence of the coarse guard hair coat and the seasonal growth and shedding of the undercoat. This presents problems in harvesting, in assessing total growth of down and in measuring its characteristics. Separation of the two fleece elements is difficult and time consuming and consequently fleece measurement is expensive. There is an urgent need for research on new measurement techniques to overcome these problems.

The down production of the feral goat is very variable and the average production, even in selected herds, is low (100–150 g). Because the production of down in Australia will have to be a commercial proposition, ways of improving production must be sought. Because the biology of down growth is so poorly understood, there is an enormous amount of research to be done, covering such areas as:

- the biology of the skin and follicle development
- the hormonal and environmental control of down and hair growth
- the nutritional requirements for down production
- the inheritance of fleece characteristics
- the genetic and phenotypic relationships between fleece production, growth and carcass composition, and milk production.

The latter topic is of particular importance if dual purpose enterprises are required as seems likely in both Australia and overseas.

The Australian feral goats are distributed between several large, geographically isolated herds, which are yet to be fully characterised. The possibility of genetic differences between these herds suggests that they be studied initially as separate identities. At some future time they may be involved in a genotype × environment interaction study. The question of the nature of down growth in various environments is pertinent in regard to the widespread view that a cold environment is needed for cashmere production.

### Cashmere Production in Goats in Tropical Areas

Although the majority of the world's goats reside in tropical areas, fibre production has not been of prime importance. In both the dry and humid tropics goats are primarily involved in subsistence agriculture with little opportunity to develop trade in goat products (Devendra 1981).

The hair and skins of goats in these areas have always been used for domestic purposes but their value has been small relative to the value of meat and milk. However, many of the goat breeds found in the tropics have undercoats that might be developed for various uses.

Of the two specialty goat fibre types, only the Angora has been transferred out of its traditional home to establish a fibre industry. The experiences with this goat in South Africa, USA, and Australia suggest that it is suitable for exploitation in semi-arid tropical areas rather than the humid tropics.

The luxury fibre cashmere has always been produced in its traditional homelands so there is little information on its production elsewhere. However the change in world supply patterns has opened up new opportunities for this fibre in the tropics. The evidence from Australia suggests that goats can produce cashmere in both the semi-arid and the monsoonal humid tropics. Research in the Queensland Department of Primary Industries is studying the pattern of down growth in a subtropic environment where there are no large seasonal temperature variations. Under these conditions down growth follows a seasonal pattern that appears to be controlled by day length.

In countries where subsistence agriculture still pertains there may be little opportunity to exploit the capacity of the goat to produce a saleable down. However, the product is extremely valuable and easily harvested, especially where labour is available and cheap. As such it could provide a valuable addition to village incomes if marketed on a cooperative basis.

The exploitation of down under these conditions is dependent on the absence of any antagonism between down production and the production of the essential meat and milk. Much more research is needed before we know whether or not such an animal can be developed from existing goat resources.

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# Milk Production from the Goat

**I.H. Rayner***

In the more effective utilisation of available land and its plant production to provide better nutrition for the expanding human population, production of milk and meat from the goat is likely to become even more important than it is at present. This statement is based upon the following premises:-

• Large increases in animal production will be required. The critical driving force in this regard is likely to be consumer demand, rather than (without suggesting that they would oppose it) the views of human nutritionists and government planners. Satisfactory levels of human nutrition can be assured only if real incomes are higher than bare subsistence. As income rises, demand for animal products increases faster than that for other foods. Consumers prefer the higher status meat and milk products.

• To the limits of the situations which they are peculiarly adapted to exploit, this increased demand for animal products should be supplied from ruminants. As agricultural resources are more fully utilised, ruminants will undoubtedly perform this function, regardless of whether their employment is organised by market forces or rational government planning. Monogastrics are energetically more efficient, but their feeds must generally be diverted from direct human consumption and transported to them. The ruminant's important capabilities are using fibrous materials unsuitable for human consumption, and harvesting of their feed from situations that could not otherwise be used for agricultural production. Their role as fibre convertors may be taken over by industrial microbial processes in situations where the material, such as crop residues, can be economically transported to the factory. However, there will remain vast resources of plant material that can be harvested and effectively utilised only by grazing and browsing animals.

• Of the domesticated ruminants, goats are certainly the most efficient for some widely occurring situations, and may even, in general be superior to the more commonly used cattle and sheep, in terms of production per hectare or energy consumption per unit of product on a long-term herd basis.

In extreme conditions the environment has dictated the genus of domestic animals used. Thus goats are favoured under arid conditions or where the topography is very steep and broken. Similarly, reindeer and camels are not challenged in arctic and tropical deserts, respectively. However, the choice of grazing animal for less extreme situations has been determined by custom, prejudice and current product markets, rather than considerations of technical efficiency in production of human food. The question requires further research, but it has been claimed (Raun 1982) that the goat is a more energetically efficient producer of meat and milk than the cow, even under conditions of good grazing for the latter. If this difference is confirmed as real and quantitatively significant, and the demand for animal products to feed the human population becomes sufficiently strong, goats may, in the long-term, displace cows.

On better established grounds than energetic efficiency, the goat has some special advantages. It is highly prolific (average litter size varying from 1.0 to 2.3 across breeds) and considered to be more readily usable (on grounds of size, ease of physical handling and restraint, purchase cost, and feed requirements) on small farms than the cow or buffalo (Devendra and Burns 1983). Sufficient goat populations to provide the basis for increased utilisation exist in most countries. The range of genetic material available and the apparently high heritability of most production–relevant traits (Steine 1976; Mukundan and Bhat 1978) also offer the prospect of readily developing genotypes to suit particular situations. Given adequate evaluation and selection procedures, use of artificial breeding, together with the goat's intrinsic high fecundity, should give very rapid genetic improvement.

• In most situations where goats are used for either meat or milk production it will be technically more efficient — and likely to be economically warranted — to produce both. This follows from the fact that, once lactation has commenced, the further requirements for milk production are only the additional feed to provide for a sufficient milk yield, and its harvesting. The only circumstances in which milk production is not economical are likely to be sparse grazing and remoteness from a milk market. This assumes that the strain of

* Dairy Cattle Husbandry Branch, Queensland Department of Primary Industries, Brisbane, Qld. Australia.

goat used is capable — given sufficient feed — of producing milk in excess of the kids' needs. The development of suitable populations should not involve any major problems.

## General Considerations

### Advantages of Goat Milk

Production and use of goat milk in affluent societies is increasing because of consumer preference, which is frequently due to its special health and nutritive value. This special demand for goat milk is likely to occur in all societies if milk from the alternative domestic species is available.

### Technical Efficiency

The argument that the goat is more efficient for milk production than the cow or buffalo has been strongly expressed by Devendra (1980). The marginal energy requirement per kilogram of milk production is similar for the goat and cow, and the goat has a slightly higher maintenance energy requirement per kilogram of bodyweight. The lower immediate daily energy requirement of the goat for each kilogram of milk is attributed to its high yield in relation to body weight. A simple calculation based upon standard nutritive allowances and illustrating this point for modest levels of production is set out in Table 1. Acceptance of this or a similar calculation depends, of course, upon the validity of the comparative yields for the particular situation of interest. It certainly appears that the goat will more efficiently utilise available fodder for milk production where it will support only low or moderate yields in either species, but there are insufficient reliable experimental and observational data to reliably quantify their comparative performance at more adequate levels of nutrition.

**Table 1.** Energy requirements[a] of the milking goat and cow.

| | *Goat* | *Cow* |
|---|---|---|
| Liveweight (kg) | 50 | 400 |
| Yield of 3.5% butterfat milk (kg) | 3 | 12 |
| Energy requirements (mega calories of net energy) | | |
| Daily for maintenance (no activity) | 1.08 | 7.6 |
| Daily for production | 2.07 | 8.28 |
| Daily total | 3.15 | 15.88 |
| Per kg of milk (Mcal of NE) | | |
| Maintenance | 0.36 | 0.63 |
| Production | 0.69 | 0.69 |
| Total | 1.05 | 1.32 |

a. Estimated from values published by the National Academy of Sciences in the Nutrient Requirements of Domestic Animals Series (Anon. 1971, 1981).

Comparative energetic efficiency on a daily basis provides only part of a sufficient intra-species comparison. Because of its higher fecundity and shorter gestation period the nutritional cost of reproduction is likely to be comparatively lower in the goat. However, the cow may be favoured by a longer average lactation length so that, on an annual basis, the difference in maintenance requirement per kilogram of milk produced is reduced.

The labour requirement per kilogram of milk is likely to be higher for the goat than the cow. For each situation the importance of this difference depends upon the availability and cost of labour. In extreme situations it will be possible to use for goat dairying, but not with cows, labour that otherwise could not be gainfully employed. Suitable equipment, when economically warranted, can also greatly improve the labour efficiency of goat dairying and narrow the gap between the goat and cow, which, in the simplest situation, depends upon the comparative speed with which milk can be harvested by hand from either.

Seasonality of production, due to a limited annual breeding season governed by photoperiod, is a problem with temperate strains of goats. However, these strains can be induced to breed out of season, and the problem does not occur with tropical strains. The problem should be readily overcome by giving it due attention in breeding programs to develop more productive goats for tropical situations.

Devendra (1980) tabulated roughly comparable data of lactation yields of tropical and subtropical breeds (Table 2). As he points out, most of those estimates are probably exclusive of milk suckled by kids, so actual yields could be considerably higher. In view of their wide range (20–562 kg/lactation) these provide little guide to the yield that may be expected in any particular situation. Such predictions must depend upon extrapolation from other situations, which have been sufficiently specified to ensure that they are similar, together with informed judgment to take account of factors specific to the target situation.

A comparison of the gross composition of goat, cow, and buffalo milk (Devendra and Burns 1970) is given in Table 3. In general, goat milk is at least equivalent to cow milk in gross composition and nutritional value for humans. It has lower fat and total solids than buffalo milk. The detailed composition of goat milk and the factors causing variation in composition have been reviewed by Ramos and Juarez (1981). Goat milk differs from cow milk and these differences may be important for some consumers, and in the manufacture of milk products. The effects of nutritional and other environmental influences in causing variations in the composition of goat milk appear similar to their effects with the cow.

**Table 2.** Milk yield and lactation length of tropical and subtropical goats.

| *Breed* | *Country* | *Lactation yield kg* | *Daily yield kg* | *Lactation length days* |
|---|---|---|---|---|
| *Non-seasonal breeders:* | | | | |
| Barbari | India, Pakistan | 150–228 | 1.6 | 180–252 |
| Black Bedouin | Israel | | 1.3–2.0 | |
| Black Bengal | Bangladesh, India | 25–30 | | |
| Boer | S. Africa | | 1.3–1.8 | |
| Chapper | Pakistan | 75 | 0.7 | 105 |
| Chegu | India | 40 | 0.4 | 100–110 |
| Criollo | Venezuela | 60 | 0.2–0.6 | |
| Damani | Pakistan | 104 | 1.0 | 105 |
| Dera Din Panah | Pakistan | 200 | 1.5 | 130 |
| Ganjam | India | 50 | 0.5 | 100 |
| Jakharana | India | 122 | 1.0 | 115 |
| Kamori | Pakistan | 228 | 1.8 | 120 |
| Kashmir | India | 20 | 0.2 | 100 |
| Katjang | Malaysia | 90 | 0.6–0.8 | 126 |
| Maradi | Niger | 75 | 0.5–1.5 | 100 |
| Nubian (Sudanese) | Sudan, Egypt | 70 | 1.0–2.0 | |
| SRD (Creole) | Brazil | | 0.1–1.0 | |
| West African Dwarf | Nigeria | 38 | 0.3 | 126 |
| *Seasonal Breeders:* | | | | |
| Angora | Turkey | 35–68 | 0.5 | 123–164 |
| Beetal | India, Pakistan | 140–228 | 1.2 | 208 |
| Damascus | Cyprus | 500–560 | 2.0 | 190–290 |
| Gaddi | India, Pakistan | 40–50 | 0.8 | 90–100 |
| Jamnapari | India | 200–562 | 1.5-3.5 | 170–200 |
| Kilis | Turkey | 280 | 1.0 | 260 |
| Malabari | India | 100–200 | 1.0 | 181–210 |
| Mamber | Israel | 350–450 | 1.5 | |
| Marwari | India | 90 | 0.9 | 106 |
| Najd | Iran | 250 | 1.0 | 250 |
| Sirohi | India | 116 | 0.9 | 134 |

Source: Devendra 1980.

**Table 3.** Average composition of goat's milk in comparison with the milk of Indian and European cows, and Indian buffaloes.

| *Species* | *Fat* | *Protein* | *Lactose* | *Ash* | *S.N.F.*[a] | *Total Solids* |
|---|---|---|---|---|---|---|
| Indian cows | 4.8 | 2.8 | 4.6 | 0.74 | 8.1 | 13.5 |
| European cows | 3.7 | 3.4 | 4.8 | 0.73 | 8.9 | 12.7 |
| Murrah buffaloes | 6.8 | 3.9 | 5.7 (including ash) | — | 9.6 | — |
| Goats | 4.9 | 4.3 | 4.1 | 0.89 | 9.3 | 14.2 |

a. Denotes solids not fats.

Source: Devendra and Burns 1970.

## The Milch Goat Industry in Australia

The commercial goat industry in Australia is quite small. There are currently 38 registered goat dairy farms in Queensland and 2712 cow dairy farms. Statistics are not available for all Australian states, but the proportion of goat to cow dairy farms is probably at least similar on a national basis. It is thus estimated that there are 284 goat dairy farms in Australia, with an average of 40 mature females per herd.

The number of households in Australia that keep goats for milk production for private consumption — with limited sale of surplus milk in many cases — is not known. Probably there are at least as many goats used privately for milk production in Australia as are employed in the commercial industry. Goats have traditionally been used for household milk production on farms in the semi-arid regions of Australia. Their private use by households in near urban areas also appears to be increasing. This increase is due to consumer preference, often on health grounds, in situations where it is feasible to keep one or more goats on the home site and goat milk is not conveniently available commercially.

Milk yields of goats, which were recorded in Queensland in 1982–83 by the production recording service operated by the Department of Primary Industries, are shown in Table 4. It will be noted that the average of about 550 kg/lactation for goats 2 years and older is quite modest when compared with the lactation yield in excess of 2000 kg, which has been achieved by highly productive goats — including a few in Queensland — under very good conditions.

It is interesting to notice that the relationship between performance under commercial conditions and potential yield under very good conditions is of the same order for both goats and cows in Queensland. For cows, yields in excess of 10,000 kg per lactation are frequently demonstrated under conditions, such as in Europe and North America, where milk price and production costs justify the use of high levels of energy-dense rations in controlled environments. In Australia and New Zealand, with cows depending mainly on grazing with a minor contribution from concentrates or conserved pasture, average lactation yields of 3000–3500 kg are quite profitable and represent satisfactory use of the feed resource. The goat yield of 550 kg is similarly in the range of 27–30% of the yield achieved under very good conditions.

**Table 4.** Yield of performance-recorded goats in Queensland, 1982–83.

| *Age at kidding (yr)* | *No. of goats* | *Average milk (kg)* | *Average fat (kg)* | *Average lactation (days)* |
|---|---|---|---|---|
| 1 | 120 | 219 | 8 | 96 |
| 2 | 91 | 616 | 22 | 255 |
| 3 | 63 | 575 | 21 | 248 |
| 4 | 49 | 569 | 21 | 254 |
| More than 4 | 59 | 429 | 16 | 213 |

Source: Queensland Department of Primary Industries.

## Research into Goat Milk Production in Australia

Apart from the limited work that will be reported by other contributors (in the fields of nutrition and reproduction) there has been no well–organised work on milk production from goats in Australia. This has been simply due to the relative unimportance of commercial goat dairying in Australia compared to cow dairying and our other major livestock industries. In this neglect of the goat milk industry we have not differed greatly from other developed countries.

We would now like to change this situation and commence an effective research program aimed at overcoming the important barriers to the improvement of goat milk production. When I say 'we' I am able to speak for the Queensland Department of Primary Industries in this regard and I have no doubt that other research institutions in Australia would be quite willing to devote some effort to goat dairying. We have, in preliminary discussions, established that the James Cook University in North Queensland is willing to collaborate in this endeavour.

Our recent interest in goat research is as simply explicable as our past neglect of this industry. There has recently been a rapid expansion in commercial goat dairying in Australia and this expansion will probably continue. It is occurring in response to a growing demand for goat milk and goat milk products. Our domestic industry thus needs and now warrants research support.

The second stimulus to research is our growing concern and increased capacity, with ACIAR now supplementing other funding sources, to assist developing countries with work for which we can contribute expertise, combined with other project requirements such as animals and facilities.

While they are largely independent in origin, the combination of these two factors is quite important. In the case of goat dairying, it is possible to conduct, in collaboration with other countries, a larger, better and more productive research program for both the Australian and other countries' industries than if the needs of either were researched independently. This is not to say that one can expect anything like a complete congruence of needs and associated projects. We will need to perform some works specifically for the Australian situation, and we will be willing to collaborate — if we can usefully contribute — in research for other countries, which may not be applicable to our domestic industry.

There must, however, be many needed research projects concerning goat dairying that are directly relevant to both Queensland and other tropical countries.

## Conclusions

It is clear that there is a large potential for increased use of goats as the most effective animals for milk production in many situations, particularly in tropical countries. The full extent of this potential is uncertain.

It is possible that further genetic development of goats to improve their productivity, and development of suitable goat production systems will result in goats becoming the animal of choice for milk (and associated meat) production, not only in the poorer environments in which they are traditionally employed, but also in situations where cows are now preferred.

Queensland research institutions are well situated to collaborate in the research needed to provide a sound basis for development of the goat dairying industry in tropical countries. We now need to perform research, which could in many cases employ the same projects, for our domestic industry.

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# Goats in Land and Pasture Management

**T.D. Mitchell***

GOATS have only recently begun to gain an air of credibility in many areas of the world. Many of us have been fed the image that goats are only a poor man's cow, will live on anything and are the major cause of desertification in the world. We, of course, know differently; we have viewed the evidence available and have determined that goats remain one of man's most useful allies.

### Range Impact

A review of the usefulness of goats in the management of scrubby range sites is presented in *Goat Production,* edited by C. Gall. The relevant chapter is written by L.B. Merrill and C.A. Taylor of Texas A&M University, in which they review much of the work published while relying heavily on USA material. The chapter clearly highlights that goats have wide tastes; that they consume some plant species that are different from those consumed by other livestock; when their choice is not limited, they eat more browse than do other stock; and they tend to consume more fibrous material than sheep and cattle.

There are differences in the diet preferences of different types of goats. This was reported by Merrill and Taylor (1981) where they observed that Angora and L.C. Meat (Spanish) goats grazed three species of grass to different heights. They also discussed effects on other species and indicated that as meat goats are taller than Angoras, they can browse to a greater height. The author reported that goat managers in South Africa and Texas considered that Angoras and meat goats had different diets that resulted in differences in range effect.

In a study conducted in a mixed scrub and grass community in South Africa, du Toit (1972) made several observations concerning the effect of goats and sheep on coppice regrowth and grass production. The results indicated that in a mixed bush/grass community cattle have higher production when grazed with goats than when grazed with sheep; that the inclusion of goats in a grazing system for a bush/grass community will give 'far superior' utilisation than with either sheep or cattle alone; and that there is considerable scope for the use of goats to maintain scrub at a desirable level.

These observations are supported by Teague et al. (1981), who state that maximum red meat production and economic return is achieved by running both grazing and browsing animals in a thorn bush/grass community. They recommend that cattle should be the grazers and goats should be the browsers in these plant communities.

Green (1983) reports on the effect of goats in two different grass/scrub communities in the Cobar area of western New South Wales. In a mulga dominated community there was a high degree of use of mulga with low mulga death rates, while other less common species were also heavily used and had higher death rates. The density of scrub on this site is such that livestock management is greatly affected. Following the defoliation of scrub by goats, visibility is greatly increased which allows for improved livestock management.

At another site, Green (1983) observed that goat browsing had caused a high death rate of narrow-leaf hop bush, which is the dominant scrub species on that site.

Similar reports from other areas such as Mexico, South America, and Africa can be found in publications such as the *Proceedings of the Third International Conference on Goat Production and Diseases.*

### Competitive effects of Goats

In a Standing Committee on Agriculture (SCA) Technical Report, titled *Goats for Meat and Fibre in Australia* (1982) a fairly comprehensive description and review of the current knowledge of our feral goats was included. This information linked the distribution of feral goats with scrubby vegetation complexes and dog or vermin proof fences.

The distribution of goats is clearly associated with factors such as accessibility, vegetation type, freedom from predators and availability of shelter. On the mainland, many sites that are desirable in those factors for goats are also inhabited by yellow-footed rock wallabies or euros (both native macropods). Competition for space under caves and on cliffs between goats and these species has been recorded; its effect on their

* NSW Department of Agriculture, Dubbo, NSW, Australia.

population is not known (Lim, Mahood and Siefer 1980, as cited in the SCA Technical Report 1982).

Also, several studies are reported that indicate that goats prefer a different diet from that selected by sheep, cattle, red kangaroos, yellow-footed rock wallabies, and euros.

Henzell (1981) reports that the impact of sheep in most pastoral environments is much greater than that of the feral goats present.

Reports of island populations of feral goats, indicate that these environments are often greatly disturbed when feral goat populations are not managed in any way (Pickard 1976 as cited in the SCA Technical Report).

Under managed conditions, several reports, for example Anon. 1973; Polocek 1976; and Taylor 1982, indicated steady or even increased deer populations where goats were included within range management systems that were designed to improve range condition. Goats and deer are both considered to be browsing animals and as such do compete for portion of their feed.

## Weed Management

Although reports of the effectiveness of goats in controlling weeds such as blackberries were made in the Agricultural Gazette of NSW around the turn of the century, little use of this practice has been made until recently. Blackberry is a major weed of some of the better pasture lands of New South Wales. In 1980 Mears (pers. comm.) estimated that about $7 million was spent on its control in that year within New South Wales. Goats are now being recommended (Mitchell 1983) as a control of blackberry. The use of goats is proving to be an economically acceptable alternative to other controls (Carberry and Davies 1983).

Blackberry is also a major problem in many pine forests where it creates an impenetrable barrier that has to be destroyed before any forest management can be undertaken. Goats have been used successfully to control blackberries in pine forests with minimum forest tree damage (Edwards 1981) thereby lowering costs in forest management.

Systematic studies on the use of goats to control other weeds include a report by Campbell et al. (1979) where serrated tussock, galvanised burr, and variegated thistle were subjected to goat grazing. The results indicated that goats could be useful in the management of these species under specified conditions. Observations by the author and others confirm that goats can be useful in the management of pastures to maintain a high level of productivity, under many conditions.

## Research

A pasture research project that compares different treatments of sheep and Angora goats is being conducted by Mr B. McGregor. This project is in an annual subterranean clover and grass pasture, in a Mediterranean climate environment.

Observations on the effect of goats in managing scrub species on existing sites in the Cobar district are continuing. Activity in research into the role of goats, cattle, and sheep and various management practices in semi-arid rangelands of New South Wales will increase from 1984 with the establishment of a research unit at Cobar whose priorities in these areas are high.

Research into some aspects of weed control, such as the effectiveness of goats in serrated tussock (*Poa* sp.) control is to begin during 1984, while some work on the use of goats in the management of natural forest species is in the early planning stage.

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# Participants

## Africa

Dr L.J. Lambourne
International Livestock Center for Africa (ILCA)
P.O. Box 5689
Addis Ababa
Ethiopia

## Indonesia

Drh Beriajaya
Research Institute for Animal Science
Balai Penelitian Ternak (MPT-Ciawi).
P.O. Box 52
Bogor

Dr I.C. Fletcher
Research Institute for Animal Production
Balai Penelitian Ternak (BPT-Ciawi)
P.O. Box 123
Bogor

Dr I.M. Nitis
Professor
Faculty of Animal Husbandry
Udayana University
Jalan Sudirman
Denpasar
Bali

Dr M. Rangkuti
Research Institute for Animal Science
Balai Penelitian Ternak (BPT-Ciawi)
P.O. Box 210
Bogor

Drh M. Sabrani
Fakultas Pasca Sarjana
Universitas Gadjah Mada
Yogyakata

## Malaysia

Mr Mohd Khusahry Mohd Yusuff
Malaysian Agricultural and Research Institute (MARDI)
G.P.O. Box 12301
Kuala Lumpur 01–02

## Pacific Islands

Mr S.W. Brown
Ministry of Agriculture and Fisheries
P.O. Box 358
Suva
Fiji

Mr M. Makika
Livestock Officer
Veterinary Livestock Department
Honiara
Solomon Islands

Mr G. Simpson
Principal Veterinary Officer
Veterinary Livestock Department
Honiara
Solomon Islands

## Philippines

Dr H.B. Ovalo
Superintendent of Philippines Goat and Sheep Center
Bureau Metro
Manila

Dr A.Y. Robles
Project Leader
National Goat Research Program for the Philippines
University of the Philippines, Los Baños
Laguna 3732

## Thailand

Dr Somkiat Saithanoo
Faculty of Natural Resources
Prince of Songkla University
Hadyai 90110

Dr Sirawat Sarabol
Animal Breeding Division
Department of Livestock Development
Phya Thai Road
Bangkok 1040

**Australia**

Dr S.A. Baxendell
Division of Dairying
Department of Primary Industries
161 Breakfast Creek Road
Newstead 4006
Qld

Dr J.W. Copland
Research Coordinator
ACIAR
G.P.O. Box 1571
Canberra City 2601
A.C.T.

Dr A.R. Egan
Professor, School of Agriculture and Forestry
University of Melbourne
Parkville 3052
Vic.

Dr J.L. Falvey
MPW Rural Development Pty Ltd
187–189 Canterbury Road
Blackburn 3130
Vic.

Dr H.G. Holmes
School of Agriculture and Forestry
University of Melbourne
Parkville 3052
Vic.

Dr P. Holst
Department of Agriculture
P.O. Box 242
Cowra 2794
N.S.W.

Dr P.S. Hopkins
Director
Sheep and Wool Branch
Department of Primary Industries
41 George St
Brisbane 4105
Qld

Dr B.A. McGregor
S.S. Cameron Laboratories
Department of Agriculture
Werribee 3030
Vic.

Mr T.D. Mitchell
Department of Agriculture
P.O. Box 865
Dubbo 2830
N.S.W.

Dr N.W. Moore
Associate Professor
Department of Animal Husbandry
University of Sydney
Camden 2570
N.S.W.

Dr B.W. Norton
Department of Agriculture
University of Queensland
St Lucia 4067
Qld

Dr J.M. Obst
Director
Pastoral Research Station
Department of Agriculture
Hamilton 3300
Vic.

Dr W.A. Pattie
Department of Animal Production
University of Queensland
St. Lucia 4067
Qld

Mr I. Rayner
Director
Dairy Cattle Husbandry Branch
Department of Primary Industries
161 Breakfast Creek Road
Newstead 4006
Qld

Dr B.J. Restall
Department of Agriculture Research Centre
Wollongbar 2480
N.S.W.

Dr J.G. Ryan
Deputy Director
ACIAR
G.P.O. Box 1571
Canberra City 2601
A.C.T.

Dr J. Sabine
Waite Agricultural Research Institute
University of Adelaide
P.O. Box 1
Glen Osmond 5064
S. Aust.

Dr I.D. Smith
Department of Animal Production
University of Queensland
St. Lucia 4067
Qld

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