EXPERT CONSULTATION ON INCREASING SMALL RUMINANT PRODUCTION

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Prospects for developing small ruminant production in humid tropical Asia

by C. Devendra
PROSPECTS FOR DEVELOPING SMALL RUMINANT PRODUCTION IN HUMID TROPICAL ASIA

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ABSTRACT

Prospects for developing small ruminant production in humid tropical Asia are examined in relation to the status, current contribution of both goats and sheep and the opportunities for extending the contribution from them. Both species are characteristic and important components of traditional small farm systems in the region in which they serve various important functions. The populations of goats and sheep are 73.3 and 92.6 millions, and represent about 16 and 8% of the total world population of these species respectively. The annual growth rate is 2.4 - 2.5% which is higher in comparison to buffaloes and cattle. Goats produced 16.6, 13.1 and 16.9% of the total world production of goat meat, milk and fresh skins, while sheep produced 8.2, 12.2 and 4.4% of the total world production of mutton, milk and greasy wool respectively. There exist four valuable breeds of goats and five breeds of sheep in the region. The management methods are village, extensive, semi-intensive, very intensive and integration with cropping systems. Of these, the village systems on small farms, intensive stall-feeding and integration especially with tree crops merit special focus. Of the systems, the highest priority needs to be accorded to the integration of tree cropping and small ruminants. Associated with these systems, these needs to be more intensive use of the total feed resources (forages, agro-industrial by-product, crop residues and non-conventional feeds). The opportunities for increasing the contribution from both species are associated firstly, with clear production objectives, better use of breeds, reproductive efficiency, effective utilisation of the feed resources, feed efficiency and appropriate choice of species. Secondly, these need to be supported by the development of suitable infrastructure, efficient production systems, continuing research and training. Both issues should provide for the most efficient use of the goat and sheep genetic resources in the Asian region.

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I. INTRODUCTION

Small ruminants form an integral and important component of the pattern of animal production in Asia. Both goats and sheep are reared widely, and a characteristic feature about their production is that they are essentially reared in a complexity of production systems on small farms where the emphasis is intensive crop production. The importance of small ruminants is primarily associated with their small size, which is significant and to the advantage of mankind for three important reasons: economic, managerial and biological (Devendra and Burns, 1983). Economic advantages include low initial investment and correspondingly smaller risk of loss from individual deaths. Managerial considerations favour their care by unpaid family labour and limited resource use for the supply of meat and milk in quantities suitable for immediate family consumption. Biological factors include possible preference over large ruminants, feed and reproductive efficiency, and in turn, economic use of the available land for maximum product output in terms of meat, milk, fibre and skins from both species. In terms of animal ownership, goats and sheep are of medium to low importance in Asia (Devendra, 1983a), with usually small numbers (1-5 head) being characteristic.

The fact remains, however, that despite the wide importance and apparent advantages, both species have not been accorded adequate attention, compared for example to cattle development. Inadequate emphasis and development are reflected in both species, and especially goats, not making an impact on food production despite wide recognition of their value during the last decade. It is therefore pertinent to consider the opportunities for further developing both species in the context of their potential and future importance. The intent in this paper is to examine the present status of both species, factors concerned with maximising productivity from them, and the prospects for developing increased contribution with special reference to humid tropical Asia.
II. POPULATION AND DISTRIBUTION

Table 1 presents the population of goats and sheep in humid tropical Asia. The population of goats and sheep of 73.3 and 92.6 million respectively in the humid region is relatively small compared to the total populations of 271.2 and 343.1 million goats and sheep in Asia. As a percentage of the total number of grazing ruminants (buffaloes, cattle, goats and sheep) in Asia, the proportion is also small and accounts for only 6.7 and 8.4% respectively.

Over the period 1969-71 to 1981, the annual rates of growth for goats and sheep in Asia were 2.5 and 2.4% respectively. It is significant to note that both rates were much higher in comparison to large ruminants (buffaloes and cattle).

Both species are widely distributed and particularly heavy concentrations are found in South India, Malaysia, Indonesia, South China and Fiji. The goat and sheep populations are very well adapted to high rainfall (over 15,000 mm), relative constancy of temperature and daylight, and high humidity. Within these populations, there exist a number of important breeds which merit particular focus. Table 2 summarises data on individual breeds, their country of origin, speciality and approximate adult live weight.
Table 1

THE POPULATION OF GOATS AND SHEEP IN HUMID TROPICAL ASIA (FAO, 1982)

<table>
<thead>
<tr>
<th>Species</th>
<th>Population (10^6)</th>
<th>As % of Total World Population+</th>
<th>As % of Total Grazing Ruminants in Asia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goats</td>
<td>73.3</td>
<td>15.5</td>
<td>6.7</td>
</tr>
<tr>
<td>Sheep</td>
<td>92.6</td>
<td>8.0</td>
<td>8.4</td>
</tr>
</tbody>
</table>

+ 472.8 x 10^6 goats and 1157.7 x 10^6 sheep
Table 2

IMPORTANT GOAT AND SHEEP BREEDS IN HUMID TROPICAL ASIA

<table>
<thead>
<tr>
<th>Species</th>
<th>Country</th>
<th>Breed</th>
<th>Speciality</th>
<th>Approx. Adult Live Weight of Female (Kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. GOATS</td>
<td>Fiji</td>
<td>Fijian</td>
<td>Meat</td>
<td>30 - 35</td>
</tr>
<tr>
<td></td>
<td>Malaysia/Indonesia</td>
<td>Katjang</td>
<td>Prolificacy</td>
<td>22 - 23</td>
</tr>
<tr>
<td></td>
<td>India</td>
<td>Malabar</td>
<td>Prolificacy</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>China</td>
<td>Ma T'ou</td>
<td>Meat/Prolificacy</td>
<td>20 - 45</td>
</tr>
<tr>
<td>II. SHEEP</td>
<td>Sri Lanka</td>
<td>Jaffna</td>
<td>Hair</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Malaysia</td>
<td>Indigenous</td>
<td>Coarse Wool</td>
<td>22 - 24</td>
</tr>
<tr>
<td></td>
<td>Javanese thin-tailed</td>
<td>Indonesia</td>
<td>Prolificacy/Mutton</td>
<td>25 - 28</td>
</tr>
<tr>
<td></td>
<td>Priangan</td>
<td>Indonesia</td>
<td>Prolificacy/Mutton</td>
<td>27 - 30</td>
</tr>
<tr>
<td></td>
<td>East Java fat-tailed</td>
<td>Indonesia</td>
<td>Mutton</td>
<td>30 - 35</td>
</tr>
</tbody>
</table>
III. CURRENT CONTRIBUTION

The current contribution from both species is summarised in Table 3. Meat, milk, wool and fresh skins are the main products. Goats contributed 16.6, 13.1 and 16.9% of the total world production of meat, milk and fresh skins respectively, while sheep produced 8.2, 12.2 and 4.4% of the total world output of meat, milk and wool. These figures, while relatively small, do nevertheless reflect an important contribution from both species which have received only limited attention.

In addition to these, both species have other valuable miscellaneous functions. These include investment against the failure of crops, slaughter during festive occasions, recreation, supply of manure for fertilizer, sport and as experimental animals. In Sri Lanka for example, sheep are kept primarily for the production of manure and crop farmers pay shepherds to pen the sheep on their lands. Manure production represents the main income from rearing sheep (Buvanendran, 1978). Likewise the Priangan sheep in Java are bred primarily for ram fighting (Mason, 1978).

An indication of the economic importance of rearing goats and sheep is found in detailed studies on the subject recently reported in Indonesia (Knipscheer et al., 1983). This study reported that the involvement of rural households in West Java in raising small ruminants is large, that one out of every five farmers keeps sheep or goats, and participation by farmers can be as high as 30%. The estimated share of small ruminant income of the total income is indicated in Table 4. The contribution of the goat and sheep enterprise in the total farming income is substantial and was about 14, 17 and 26% for the three categories of lowland, upland and rubber plantations situation, respectively. The income share of the small ruminant enterprise increased as the farmer's resource base, especially land, decreased.
Table 3

THE CONTRIBUTION OF GOATS AND SHEEP TO MEAT, MILK, WOOL AND FRESH SKINS PRODUCTION IN HUMID TROPICAL ASIA
(F.A.O., 1982)

<table>
<thead>
<tr>
<th>Product</th>
<th>Goat Production $\times 10^3$ (tons)</th>
<th>% of World Production</th>
<th>Sheep Production $\times 10^3$ (tons)</th>
<th>% of World Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meat</td>
<td>351.0</td>
<td>16.6</td>
<td>513.0</td>
<td>8.2</td>
</tr>
<tr>
<td>Milk</td>
<td>1007.1</td>
<td>13.1</td>
<td>998.7</td>
<td>12.2</td>
</tr>
<tr>
<td>Wool (Greasy)</td>
<td>-</td>
<td>-</td>
<td>126.8</td>
<td>4.4</td>
</tr>
<tr>
<td>Fresh Skins</td>
<td>65.9</td>
<td>16.9</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Table 4

ESTIMATED SHARE OF SMALL RUMINANT INCOME OF TOTAL INCOME IN WEST JAVA
(Knipscheer et al., 1983)

<table>
<thead>
<tr>
<th>Location</th>
<th>No. of Farms Surveyed</th>
<th>Annual Income Per Farm (1980)</th>
<th>Small Ruminant Income (1980)</th>
<th>Small Ruminant Income As % of Total Income</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cerebon (Lowland)</td>
<td>79</td>
<td>220 000</td>
<td>37 593</td>
<td>17.1</td>
</tr>
<tr>
<td>Ciburuy (Rubber Plantations)</td>
<td>66</td>
<td>180 000</td>
<td>46 671</td>
<td>25.9</td>
</tr>
<tr>
<td>Garut (Upland)</td>
<td>135</td>
<td>300 000</td>
<td>41 466</td>
<td>13.8</td>
</tr>
</tbody>
</table>
IV. MANAGEMENT AND FEEDING SYSTEMS

The management and feeding systems are those that have been described in detail for the humid tropics (Devendra, 1981) and include, (1) village systems, (2) extensive systems, (3) semi-intensive systems, (4) very intensive systems and (5) integration with cropping systems. It is proposed to discuss these systems briefly. Of these, the village, extensive and integration with crops systems are the traditional methods. The species may or may not be run together, but are widely owned by small farmers. The main reason for this is the fact that goats and sheep are essentially owned by small farmers who rear them for a variety of reasons within the totality of small farm systems where resources are meagre, mixed farm operations combining animals with crops are the rule, and where also animals generally take a secondary position next to crops.

(1) Village Systems

The village system of feeding is of two categories. One is tethering, where 1-5 head are involved in situations where there is intensive crop cultivation. The second alternative is to feed in situ the various crop residues available. In addition, in both systems, kitchen remnants are commonly given. A feature about this system is that it encourages goats to remain in the vicinity of the villages.

(2) Extensive Systems

Extensive grazing is common where there is access to grazing and marginal land using family labour involving mainly women and children. The flock sizes are larger (1-15 head) and animals, often goats and sheep belonging to several owners are run together and brought back in the evening. Stocking rates are usually in the range of 1-4 head/ha. Very extensive systems are rare, as with other parts of the humid tropics, presumably because of the availability of more forage and also crop residues.
(3) **Semi-intensive Systems**

Semi-intensive systems are a compromise between the more primitive extensive and intensive system. In this system there is usually limited grazing and stall-feeding depending on the availability of time, labour and also feeds. It is essentially a part-time operation like the village system. The duration of grazing is variable and is about 4-6 hours per day, usually in the late morning or evening. The goats are then housed and given some forages or crop residues. Very seldom are concentrates offered.

(4) **Very Intensive Systems**

Very intensive systems are of two categories: intensive use of cultivated forages or stall feeding. Although goats prefer to browse in comparison to grazing, they are nevertheless quite capable of making efficient use of cultivated pastures for meat or milk production and stocking rates of the order of 16-60 goats/ha are feasible depending on the type of grass used, level of fertiliser application and the presence or absence of legumes (Devendra and Burns, 1983).

Mainly because of the limited work that has been done in the Asian and Pacific region in this context, and in order to compare meat production from goats versus cattle, studies were recently completed to investigate their response and grazing behaviour to cultivated *Setaria setivalva* pasture fertilized with 150 kg of N, 40 kg P and 40 kg of K/ha/yr applied in three equal amounts. The average yield of dry matter was about 5-6 tons/ha. Four stocking rates were used: 20, 40, 60 and 80 goats/ha in a randomised block design, replicated thrice, involving Katjang crossbred kids with an initial live weight of about 10-12 kg. At the end of four months, the highest stocking rate rendered the paddock bare and this treatment had to be withdrawn. Table 5 summarises the main trends from the unpublished results (Chen and Devendra, 1984).
The effect on daily live weight gain was dramatic. Noticeable effects were found about three months after the experiment started, and the highest stocking rate only gave a daily live weight gain of 9.2 g/day. Daily live weight gain was significantly correlated to body length ($r = 0.209$, $P/0.01$), height at withers ($r = 0.232$, $P/0.01$) and heart girth ($r = 0.306$, $P/0.01$). The results suggest that the optimum stocking rate for Setaria pastures is about 40 goats/ha.

The second alternative system, stall feeding, requires high labour and capital investment. It is a system that favours situations where there is no land or more particularly, the availability of abundant supplies of crop residues and agro-industrial by-products. Probably because of the higher capital investment, it has not been adequately used as a system. In Fiji, it has been reported that goats fed sugarcane tops, stovers, straws, coconut cake, rice bran and molasses reached live weights of 23-25 kg in about 22 weeks with a daily live weight gain of 154 g, compared to 83 g in the extensive system (Hussain et al., 1983).

In considering the systems together, their relevance and potential contribution particularly in the context of intensity of land use and demographic pressures in Asia, the conclusion that emerges is that the village, intensive and integrated systems are the most appropriate. Goats and sheep already exist in village systems in most mixed crop-animal small farms. Intensive stall-feeding is justified by the presence of various types of crop residues and agro-industrial by-products. The integrated systems, especially with tree crops, remain unexplored. These three systems thus merit special focus and development.
Table 5

EFFECTS OF STOCKING RATE ON THE PERFORMANCE OF GOATS GRAZING SETARIA SPHACELATA VAR. SPLENDIDA PASTURES

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Goats/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20</td>
</tr>
<tr>
<td>Mean live weight gain (g/day)</td>
<td>43.2</td>
</tr>
<tr>
<td>Body length (cm)</td>
<td>103.3</td>
</tr>
<tr>
<td>Height at withers (cm)</td>
<td>53.2</td>
</tr>
<tr>
<td>Heart girth (cm)</td>
<td>59.1</td>
</tr>
<tr>
<td>Grazing time (min)</td>
<td>416.4</td>
</tr>
<tr>
<td>Resting time (min)</td>
<td>82.0</td>
</tr>
<tr>
<td>Distance walked (m)</td>
<td>852.1</td>
</tr>
</tbody>
</table>
Integrated Crop-Small Ruminant Production Systems

This is a traditional system throughout humid tropical Asia and elsewhere. Integrating goats and/or sheep with mixed cropping is classified as the village or smallholder system, and is the tropical equivalent of the temperate zone intensive arable system. The system is closely associated with the different patterns of crop production and makes intensive use of stubbles and crop residues, returning dung and urine to the land.

Two types of production systems are common within the integrated crop-small ruminant system. These are (i) a semi-intensive system and (ii) integration with tree cropping, notably coconuts, oil palm and rubber. These systems are worthy of brief discussion.

(i) Semi-Intensive System

The semi-intensive system refers to situations where there is a combination of limited grazing and stall feeding. It is a compromise between very extensive and intensive systems. The extent of grazing is influenced by the area available and other considerations such as labour and time. The use of labour is a part-time operation and may be undertaken by unpaid family labour or by shepherds. The former often involves children and farmers' wives. In the latter case, it is not uncommon for the shepherd to herd the animals belonging to several farmers for grazing. The flock sizes are generally small and not more than 1-8 animals.
In this system goats and sheep utilise all available feed resources and include wayside crop residues, stubbles especially from cereal cultivation (maize, rice and wheat), and any other residues from crop production such as sweet potato (*Ipomoea batatas*) vines and/or sugarcane (*Saccharum officinarum*) tops. The level of nutrition is generally low and both species consume whatever is available. With crop residues, it is doubtful if they acquire enough nutrients beyond maintenance needs, grazing as they do for not more than 4-6 hours every day. This is usually done late morning or late evening to avoid the wet ground in the morning, and also because it is in the late afternoon or evening that unpaid family labour is available to attend to the animals.

Inability to meet the daily maintenance needs explains the reason for the traditional husbandry practice of stall feeding some form of tree leaves in the evening. Usually, the farmers harvest these leaves and take them back with the returning goat and sheep flocks. Sometimes, it is also common as in Pakistan and India, to lop certain trees to provide a source of supplementary forages for the animals. In this context, tree leaves play a most useful function and several types exist which are of value to both species, notably, acacia (*Acacia spp.*), leucaena (*Leucaena leucocephala*), cassava (*Manihot esculenta* Crantz), jackfruit (*Artocarpus heterophyllus*), gliricidia (*Gliricidia maculata*), and sesbania (*Sesbania grandiflora*). The value of tree leaves has been emphasised (Devendra, 1983b). Concentrates, salt and mineral licks are usually not given.
(ii) Integration with Tree Cropping

Associated with the semi-intensive and intensive systems, is integration with tree crops notably coconuts, rubber and oil palm. Although the system is not new, integration with these tree crops to ensure more complete utilisation of the land has not been given adequate attention. The advantages of the system are: (a) increased fertility of the land via the return of dung and urine, (b) control of waste herbage growth, (c) reduced use of weedicides; (d) reduced fertilizer wastage, (e) easier management of the crop and (f) distinct possibilities of increases in crop yields, consistent with greater economic returns, including sale of animals and their products. The integration of livestock with rubber cultivation has been described (Tan and Abraham, 1980).

Table 6 brings together information on type of forage under coconut and rubber cultivation in terms of vegetation and approximate yields of dry matter. It also provides an indication of the stocking rates of either goats or sheep. Attention is directed to the importance of legume mixtures in rubber plantations, notably, Calopogonium caeruleum, C. mucunoides, Centrosema pubescens, Mucuna cochinchinensis and Peuraria phaseoloides. Oversowing with legume mixtures is more common in larger estates.
### Table 6

**PLANT SPECIES, DRY MATTER PRODUCTION AND STOCKING CAPACITIES OF HERBAGE UNDER COCONUT AND RUBBER**

<table>
<thead>
<tr>
<th>Tree Crops</th>
<th>Vegetation</th>
<th>Estimated Stocking Rate (Goats or Sheep/ha)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coconuts</td>
<td>Natural cover^1</td>
<td>800-1200</td>
<td>3-5</td>
</tr>
<tr>
<td>Rubber</td>
<td>Natural cover^2</td>
<td>500</td>
<td>2</td>
</tr>
<tr>
<td>Rubber</td>
<td>Natural cover^2 legumes^3</td>
<td>1400</td>
<td>6</td>
</tr>
<tr>
<td>Rubber</td>
<td>Pure legumes^4</td>
<td>2600</td>
<td>12</td>
</tr>
<tr>
<td>Coconuts</td>
<td>Cultivated grasses</td>
<td>14 000-16 000^5</td>
<td>64-73</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 000-14 000^5</td>
<td>45-64</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7 500-10 000^7</td>
<td>34-35</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7 500^8</td>
<td></td>
</tr>
</tbody>
</table>

1. **Axonopus** spp., *Paspalum conjugatum*, *Ischaemum timorense*, *Imperata cylindrica*, *Digitaria marginata*, *Lantana* spp. and *Mikania cordata*

2. **Axonopus compressus**, *P. conjugatum*, *Ottochloa nodosa*, *M. cordata*, *Nephrolepsis bisserata*, *Gleschaenia linearis*

3. *C. pubescens*, *C. mucunoides*, *P. phaseoloides*

4. *Cajanus cajan* and *D. pubescens*

5. Guinea *ass* (*Panicum maximum*)

6. *P. maximum*, *Brachiaria dictyonura*, *Koronivia* and *Pennisetum purpureum*

7. *Paspalum plicatulum*, *P. conjugatum*, *P. maximum*, *B. brizantha*, *B. milliformis*, *Cori*, *Ischaemum aristatum* Batik; and *P. purpureum*

8. *D. decumbens*, *B. mutica* or local mixture of *Ruellia prostrata*, *Mimosa pudica*, *Blechum pyremidatum*, *A. compressus*, *Cryptococcus trigonum*
The presence of legumes is of definite advantage, and it has been calculated that the amount of N utilised by the animal and also excreted in the faeces and urine increases with increasing presence of legume cover (Table 7). Recent evidence of the economic benefits of integrating goats with oil palm production, is presented in Table 8, based on data from Malaysia over four years, 1980-1983.

Many of the Pacific island territories, notably Papua New Guinea, New Hebrides, Fiji, Solomon Islands and Western Samoa, have large land areas under coconuts, implying that there is much potential for integrating goats or sheep into them. Reynolds (1979) has reported the yields for various cultivated grasses and estimated the stocking rates for cattle. On the basis of 3% of body weight (20 kg), the dry matter yield data for the very high, high, medium and low levels of production can support between 64-73, 45-64, 34-45 and 34 goats or sheep/ha respectively (Table 6), which in terms of biomass production must rate very competitively with cattle production.

Likewise in Malaysia for example, the case history concerns an oil palm estate which allocated a portion of the grazing land within the estate to the workers for grazing their animals. For the first two years (1980 and 1981), only cattle were owned and grazed, but in the years 1982 and 1983 goats were also introduced in addition to cattle. This was done in view of their economic importance and capacity to supply of both meat and milk in the estate.

The comparison of the grazed area and non-grazed area involving both young and mature trees is valid in that it involved the same area of 71-135 ha, and more particularly, the fact that both areas were of the same soil type. The total cattle and goat populations were both about 80 and 220 animals respectively. It can be seen in Table 8 that the differences in yield over the four years in favour the effect of grazing cattle and goats
Table 7

UTILISATION OF THREE SYSTEMS OF GROUND VEGETATION BY INDIGENOUS SHEEP UNDER RUBBER IN MALAYSIA (Chee and Devendra, 1981)

<table>
<thead>
<tr>
<th>System</th>
<th>Vegetation</th>
<th>Dry Matter (kg/ha)</th>
<th>Crude Protein %</th>
<th>Crude Protein kg/ha</th>
<th>N Content</th>
<th>N Retained</th>
<th>N Unutilised</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Natural cover</td>
<td>500</td>
<td>11.4</td>
<td>57</td>
<td>9.1</td>
<td>0.5</td>
<td>8.6</td>
</tr>
<tr>
<td>2</td>
<td>Natural cover and legumes</td>
<td>1400</td>
<td>15.0</td>
<td>210</td>
<td>33.6</td>
<td>1.6</td>
<td>32.0</td>
</tr>
<tr>
<td>3</td>
<td>Pure legumes</td>
<td>2600</td>
<td>24.4</td>
<td>619</td>
<td>99.0</td>
<td>4.9</td>
<td>64.4</td>
</tr>
</tbody>
</table>

1A 70% digestibility of crude protein and a 7% retention of nitrogen by the grazing animal is assumed.
TABLE 8

The effect of mixed cattle and goat grazing on the yield of fresh fruits in oil palm cultivation (Devendra, 1985a).

<table>
<thead>
<tr>
<th>Year</th>
<th>Grazed area (yield of fresh fruit bunches/ha/yr, mt)</th>
<th>Non-grazed area (yield of fresh fruit bunches/ha/yr, mt)</th>
<th>Difference (fresh fruit bunches ha/yr, mt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>30.55 (C)$^+$</td>
<td>25.61</td>
<td>4.94</td>
</tr>
<tr>
<td>1981</td>
<td>17.69 (C)$^+$</td>
<td>15.87</td>
<td>1.82</td>
</tr>
<tr>
<td>1982</td>
<td>25.12 (C + G)$^{++}$</td>
<td>22.97</td>
<td>2.15</td>
</tr>
<tr>
<td>1983</td>
<td>23.45 (C + G)</td>
<td>18.29</td>
<td>5.16</td>
</tr>
<tr>
<td>Mean</td>
<td>24.20</td>
<td>20.69</td>
<td>3.51</td>
</tr>
</tbody>
</table>

$^+$ C - cattle
$^{++}$ C + G - cattle + goats
was 2.15-5.16 mt fresh fruit bunches/ha/yr with a mean value of 3.51 mt of fresh fruit bunches/ha/yr. When translated into the total hectarage grazed and sale value per ton of fresh fruit yield, the economic advantage is conspicuously substantial. The result in economic terms similar to the findings in West Java of integrating goats and sheep with rubber. (Table 4).

Given this advantage, and when one considers the large area under such tree crop as coconuts, oil palm and rubber in some countries in South East Asia and the Pacific islands, the potential carrying capacity and offtakes of meat (goat meat and/or mutton) from the land is therefore enormous.

In Malaysia for example, the combined total hectarage under rubber and oil palm is approximately 4.3 millions. Even if only half of this crop area is utilised by animals, and assuming a carrying capacity of 3 animals/ha, the total number of animal equivalents is of the order of 5.2 million, which is substantial. Herein lies a potential for substantial increased production from small ruminant that remains to be more fully exploited.

V. PROSPECTS FOR DEVELOPING INCREASED PRODUCTION

Given the current pattern of small ruminant production and the relatively low level of contribution, it is appropriate to consider the potential prospects for increasing the contribution by both species. Present indications are that there exist very good prospects for their development and therefore increasing productivity. It is essential in doing so to keep in perspective the individual characteristics and capacities in both goats and sheep which should be considered in the context of production objectives.
Production Objectives

If complete utilisation of the goat and sheep genetic resources is to be achieved commensurate with maximising productivity from both species, clear production objectives are essential. It is also essential to relate the production objectives to market demand and market outlets. The following considerations are pertinent, adapted from Turner (1972):

Characteristics of the Products

(i) Meat (goat meat and mutton)

Quantity - Total amount of lean meat in the carcass (measured by live weight before slaughter).

Growth rate, in the case of lambs, is related to efficiency of production.

Total number of animals available for slaughter; this is likely to be more important than amount of meat in each animal.

Total weight of offspring weaned/year/female is important.

Quality - Quantity and distribution of fat (excess undesirable).

(ii) Milk

Quantity - Total yield, lactation, length, persistency and number of lactations.

Quality - Milk composition (butter fat and solids non-fat).

(iii) Carpet Wool

Quantity - Clean wool per head.

Quality - Average fibre diameter (coarse fibre desirable).

Presence of a proportion of medullated fibres (hair).

Absence (or a very small proportion) of kemp (shed fibres, or ones with the medulla occupying 90% of the diameter).

Staple length. Percentage of clean scoured yield.
Reproductive Efficiency

There is no doubt that improvements to reproductive efficiency can significantly contribute towards increasing numbers born and the output of products. Reproductive rate is that all too important factor and the build up of numbers is associated with the following components:

(i) Age at first mating (females)
(ii) Productive life span of males and females
(iii) Annual mortality in the breeding flock
(iv) Number of young female reared per 100 breeding females. This is influenced in turn by:
   a) Percent of breeding females failing to bear
   b) Percent of breeding females producing multiple births
   c) Frequency of parturition, and
   d) Mortality rate up to first mating

With reference to Table 2, there are at least three breeds of goats and two breeds of sheep that are distinctly prolific, and much more use can be made of these breeds.

Increasing fertility or number of offspring born per female per kidding or lambing is important because this influences significantly the margin of profits. This point is demonstrated in Table 9 for goats. It can be seen that the gross margin of profits increases according to the fertility level, type of feeding system, per flock or per breeding doe. Lifetime productivity is essential and females must be retained in the flock long enough (5-7 years of age) in order to express their genetic capacity.

Effective Use of the Feed Resources and Feed Efficiency

Effective use of the total feed resources (forages, agro-industrial by-products and non-conventional feed
Table 9

ESTIMATED GROSS MARGIN OF PROFITS PER ANNUM FROM KATJANG GOATS FOR MEAT PRODUCTION WITH VARYING LEVELS OF FERTILITY
(Devendra, 1976)

<table>
<thead>
<tr>
<th>Fertility level (% kids weaned/does mated)</th>
<th>80</th>
<th>100</th>
<th>120</th>
<th>140</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Goat Flock</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flock size (breeding does)</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Increase due to kids born</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>Less mortality</td>
<td>6</td>
<td>8</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Net increase in numbers less culls</td>
<td>15</td>
<td>16</td>
<td>17</td>
<td>18</td>
</tr>
<tr>
<td>Cost of goats ($ Malaysian)</td>
<td>840</td>
<td>960</td>
<td>1020</td>
<td>1080</td>
</tr>
<tr>
<td>Cost of cull goats ($ Malaysian)</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>Less cost of foundation does ($ Malaysian)</td>
<td>600</td>
<td>500</td>
<td>600</td>
<td>600</td>
</tr>
<tr>
<td>Total gross revenue ($ Malaysian)</td>
<td>390</td>
<td>510</td>
<td>570</td>
<td>630</td>
</tr>
</tbody>
</table>

Cost of production

(i) On cultivated grass with labour
(ii) On uncultivated grass with family labour

<table>
<thead>
<tr>
<th></th>
<th>59.10</th>
<th>63.10</th>
<th>67.10</th>
<th>71.00</th>
</tr>
</thead>
</table>

I. Gross margin of profit ($ Malaysian)

(i) Grazing cultivated grass:
Per flock: 330.90 446.90 502.90 559.00
Per breeding doe: 33.10 44.70 50.30 55.90
Per month: 27.60 37.20 41.90 46.60

(ii) Grazing uncultivated grass:
Per flock: 390.00 510.00 470.00 630.00
Per breeding ewe: 39.00 51.00 57.00 63.00
Per month: 32.50 42.50 47.50 52.50

1 10% among breeding does and 15% among kids
2 25% culling per annum
3 $60 (Malaysian) per goat weighing about 20 kg
4 Cost of cultivated grass is 1.8 cents (Malaysian) per kg fresh weight
5 No cost attached; both components are considered free
resources) by goats and sheep is a definite means of increasing performance per animal and output per unit area of land. These are not being used effectively presently and this is reflected in the poor level of performance in the animals.

In many situations dietary protein rather than energy is the main limiting factor. Thus supplemental proteins go a long way to meet the requirements as well as promoting high animal performance. Good quality protein sources such as groundnut cake and a soyabean meal are generally expensive, are in short supply and necessitate that the bulk of them ought to be retained for non-ruminant feeding. An alternative realistic approach is the use of good quality leguminous forages as sources of supplemental N. Leucaena, for example, provides a valuable source of supplementary energy and protein (Devendra, 1982; 1983c) and is an economical way of improving performance in utilising especially lignocellulosic crop residues and agro-industrial by-products.

In addition to various forages, humid tropical Asia is endowed with an abundant variety of various agro-industrial by-products (Verma, 1983) and non-conventional feed resources (Devendra, 1986). The latter for example, account for about 194 x 10^6 mt from field and tree crops, and constitute approximately 45% of the total availability of by-products from both types of crops. Some of these can obviously be used by both species.

The opportunities for more efficient use of the available crop residues and agro-industrial by-products are enormous and every effort must thus be made to make wider use of these either in combination with grass or in complete diets commensurate with the recommended levels of nutrients (see for example, N.R.C. 1981). Additionally, some of these crop residues and/or
agro-industrial by-products can be improved by the use of one or several alkalis such as calcium hydroxide or even urea.

The justification for particular emphasis on improved feeding and management is seen in the low level of performance: in goats, for example, the importance of poor versus good nutrition on the reproductive performance of Barbari and Jamnapari goats. In both breeds, the total number of kids was improved by between 66.6 - 73.9% and twins between 34.3 - 38.6% (Sachdeva et al., 1979) by improved feeding. A parallel situation has been reported for meat production in Katjang goats where live weight at slaughter, hot carcass weight, dressing percentage and weight of meat were improved by as much as 53.8, 79.3, 7.1 and 47.1% respectively (Devendra, 1979).

Associated with the use of the crop residues and agro-industrial by-products is more effective use of the available land. In many parts of humid tropical Asia, there exist large areas of land. Under such tree crops as coconuts, oil palm and rubber, the waste vegetation under this land is considerable. Considering the potential carrying capacity that is feasible (Table 6,), the offtake of meat (goat meat and/or mutton) from the land is therefore enormous. In Malaysia, for example, the total land under rubber and oil palm is approximately 4.3 million hectares. Even if only half of this land is used and assuming a carrying capacity of 3 goats or sheep per hectare, the total number of animals that can be supported is about 6.5 million. Herein lies a potential that remains to be more fully explored.
Improvement Through Selection

Associated with improved systems of feeding and management, progress can obviously also be achieved through selection for appropriate traits. The case for selection is based not only on identifiable inherent traits in individual breeds, but also on the fact that these animals are fully adapted to the environment in which they serve a number of useful functions.

In cognisance of the breeds mentioned in Table 2, not enough attention is being given to intensive selection and it could therefore be expanded. If significant improvements in goat and sheep production are to be achieved, then a first consideration should be selection and thorough assessment of the potential of individual breeds in the environment to which they are adapted. Subsequent efforts to seek further improvement through crossbreeding with temperate breeds must surely be based on this initial assessment. With regard to sheep, in relation to indigenous flocks, Turner (1978) has discussed the steps necessary for bringing about desirable improvement.

Choice of Species

While the husbandry of goats and sheep is complementary, both species have some distinct characteristics, and it is important that these are recognised in the choice of animals appropriate to individual production systems. Both species are often run together in traditional management systems, but where there is a specific demand for products from one or the other species or when the prevailing situation favours a particular species, the appropriate choice is therefore realistic. Goats for example, favour drier conditions and where there is abundant browse. Sheep, by virtue of their less
inquisitive habits are perhaps more suited to situations where there is herbage for grazing.

Unlike the semi-arid and arid regions where multi-species (sheep, goats, camel, but rarely cattle) are reared together in essentially nomadic and transhumant pastoralist systems, the situation in humid tropical Asia is that, while goats and sheep are run together, use of individual species is a distinct possibility for both practical and economic reasons. The choice of individual small ruminant species and indeed breeds within species is an important consideration.

The following factors influence the choice of species:

(i) Feeding behaviour
(ii) Relative price of meats
(iii) Availability of animals
(iv) Market outlets for meats
(v) Biomass production

The relative price of meats is an important consideration and also the market demand for these. Biomass production is dictated by age at first breeding, interval between parturitions, litter size, lifetime productivity and mortality.

(6) Development Strategies

A number of development strategies merit attention. These include inter alia:

(i) Increased resource use: both species are generally neglected in comparison to the allocation of funds for cattle development. Poor infrastructure and financial support are serious limitations. The financial allocation is usually very inadequate, probably because of low priority and a negative attitude to the species.
(ii) **Development of strong infrastructure:** this is essential not only within individual countries, but also at the sub-regional and regional level. The injection of appropriate technology assistance from developing countries and international agencies will be most helpful. Strong support services are essential.

(iii) **Developing the avenues of production:** all the avenues of production must be examined critically and exhaustively. Priority should be given to the development of production systems that integrate both species with mixed cropping especially in small farm systems. This will also alleviate the level of poverty and health of subsistence farmers and the landless.

(iv) **Continuing research:** this is vital to sustain and stimulate increased contribution from both species. It should focus on the breed characteristics, genetic potential, feed resources, feeding and nutrition, physiology, breeding and genetics, improved management practices, prevention and control of disease, carcass quality and processing.

(v) **Linkages:** an interdisciplinary systems approach is important and desirable, involving different disciplines and different laboratories. The linkages are useful in promoting close contact and encouraging progress.

(vi) **Training:** this is also an important requirement to ensure progress and the effectiveness of the overall development strategy.
VI. CONCLUSIONS

Although the pattern of agricultural production is predominantly crop-oriented in humid tropical Asia, small ruminants (goats and sheep) form an important component within complex mixed animal-crops operations. They are reared widely in mainly small farm systems which form the pivot of traditional agriculture. In these circumstances, they produce meat, milk, fibre and skins and also perform a variety of other miscellaneous functions such as dung production. It is especially important to note that the contribution to small farm income is substantial and that the rate of growth of both populations is higher than that of large ruminants in Asia, implying that their importance is considerable, worthy of much more attention and development.

The current contribution and existing methods of management and feeding systems are described. Attention is drawn to the existence of valuable attributes. There exist considerable opportunities for increasing the contribution from both species and the prospects for this should focus on production objectives, better use of the breeds, selection, reproductive efficiency, effective use of the feed resources and feed efficiency, and appropriate choice of species. Of these, the highest priority needs to be directed to integrated tree cropping - small ruminant systems, intensified use of the available feed resources and increasing numbers by improved reproductive efficiency. The justification for increasing offtakes by this means, among other things, is seen in the substantial market outlets for meat from small ruminants in the Near East region. The development strategies include increased resource use, creation of infrastructure, examining the production systems, continuing research, linkages and training. These together should provide for the most efficient use of goat and sheep genetic resources.
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