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FEEDING SYSTEMS AND NUTRITION OF GOATS AND SHEEP

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ABSTRACT

The importance of efficient feeding systems and nutrition is discussed in the context of the effects of issues on the performance of goats and sheep in Africa. The justification for attention to these is associated with the issues of perennial seasonal feed shortages, fragile ecologies, environmental degradation and low productivity, and more particularly since there exists enormous scope for improving the prevailing low levels of production in both species. The objective of ensuring high performance is determined by three interrelated factors : the availability of nutrients, type of feeding system and the level of feeding management. Basic differences in the feeding behaviour and nutrition between both species, digestibility, significance of the level of dietary protein and dry matter intake are discussed. The feeding systems are of five categories and include village systems, very extensive and extensive systems, semi-intensive systems, intensive systems and systems integrated with tree cropping. There exist presently, real opportunities for improving the level of nutrition and maximising productivity in both species by the application of the available knowledge. These include inter alia more intensive use of crop-residues and agro-industrial by-products including non-conventional feeds, strategic use of concentrate supplements, use of proteinaceous feeds, and dietary urea, provision of water and mineral-vitamin supplements and improved husbandry practices. There is also a need to improve quantity and quality of available feeds, especially forages. These strategies together should provide for more complete use of the indigenous small ruminant genetic resources that are consistent with maximisation of essential food and non-food products from both species in Africa.

I INTRODUCTION

The nutrition of goats and sheep is the most important factor affecting performance of these species. This is because feed is the principle limiting factor in most parts of the tropics whereby small ruminants are seldom allowed to express their genetic potential. Thus, a generally low level of production is common in most parts of the tropics which is consistent with inefficiencies in the nutritional management on both species (Devendra, 1980). Evidence for significant increases in performance due to improved nutrition has been reported

in several studies : goats in the West Indies (Chenost and Geoffrey, 1971; Devendra, 1972); India (Sachdeva et al., 1974; Parthasarathy, Singh and Rawat, 1983), Malaysia (Devendra, 1979) and sheep in the eastern Mediterranean (Demiruren, 1972).

The limitations imposed by feeds are particularly serious in Africa where there are perennial seasonal shortages, fragile ecologies and potential environmental degradation. The problem is also exacerbated by competition for existing feed supplies and generally poor husbandry practices that further curtail high productivity from goats and sheep. A combination of efficient nutrition and sound management practices are thus imperative.

The objective of ensuring high performance through adequate control of nutrition is determined by three interrelated considerations : the availability of nutrients, type of feeding systems and the level of feeding management. The importance of all three aspects cannot be overemphasised. Inavailability of nutrients for example, causes undernutrition, irrespective of the type of feeding systems employed or the level of nutrition management, and leads to poor performance. Conversely, an abundant nutrient supply is futile if this is surplus to requirements and cannot be used efficiently in appropriate feeding systems to ensure and high performance.

This paper discusses basic differences in the feeding behaviour and nutrition between goats and sheep, the significance of digestibility, level of dietary protein and dry matter intake, prevailing types of feeding systems and the utilisation of feeds by both species. Particular emphasis will be given to the more applied aspects of feeding and strategies that can be pursued. This is justified by the enormous opportunities that exist for achieving higher performance by attention to improved nutrition and husbandry practices in Africa.

II COMPARATIVE DIFFERENCES IN NUTRITION BETWEEN GOATS AND SHEEP

It is useful to keep in perspective apparent differences in the comparative nutrition between goats and sheep. Table 1 attempts to summarise these features. It is emphasised that the list is by no

means complete, implying that there probably exist many other differences. However, the list does provide the main distinguishing features between the species, based on an understanding of the present state of knowledge.

(Table 1 here)

Some of the main differences are worth emphasising. These include in the goat, the bi-pedal stance, relatively higher activity, preference for more variety in feeds, and more selective and browsing tendencies compared to sheep. Other differences are related to taste, water economy, dehydration, salivary secretion, recycling of urea and digestive efficiency. Concerning the latter, it is not known with any certainty if real differences do exist in the utilisation of coarse roughages although present evidence does seem to suggest that goats do utilise coarse roughages much more efficiently than do sheep. Thus, the value of goats increases with decreasing quality of grazing. There is a need for lot more information on this issue and a better understanding of the several interacting factors inter alia : feed particle size, amount of salivary secretion, rumination, concentration of cellulose splitting micro-organisms, fermentation rate, absorption capacity, water turnover, recycling of urea, rate of passage and retention time (Devendra and Burns, 1983).

Recently, attention has been drawn to the higher $\text{NH}_3\text{-N}$ in goats which has been attributed to greater rumen protein degradation as a result of a longer retention time of digesta in the rumen (Watson and Norton, 1982). Since goats drink less water than sheep per unit dry matter intake (Gihad 1976; Gihad, El-Bedawy and Mehrez, 1980; Owen and Ndosa, 1982 and Alam, Poppi and Sykes, 1983), it has further been suggested that the lower water intake may be the cause of the higher rumen NH_3N concentration (Alam et al., 1984).

III FACTORS AFFECTING THE AVAILABILITY OF NUTRIENTS

The availability of nutrients in quantitative and qualitative terms controls to a very large extent the level of performance by goats and sheep. It is determined by such other issues as area under uncultivated herbage, amount of crop residues, agro-industrial by-products

and non-conventional feed resources and the quality of individual feed ingredients.

The utilisation of the available nutrients is determined by two principal factors, firstly, the amount of dry matter intake (DMI), and secondly, the digestibility of the feed intake. With herbage for example, the manner in which the energy is utilised by ruminants is illustrated in Figure 1.

(Figure 1 here)

While digestibility and DMI are important factors concerning the release of available nutrients, there is a third important factor which is associated with both : the level of dietary protein. It is useful to discuss all three factors briefly.

(i) Dry matter intake

Although voluntary food intake (VFI) directly affects digestibility of temperate grasses, the relationship is less definitive for tropical species (Milford, 1967) due to the different lengths of time required to digest tropical feeds. VFI has been shown to decrease with decreasing digestibility of dry matter within species for Chloris guyana (Milford and Minson, 1968), Panicum species (Minson, 1971a), and also for legumes (Minson, 1971b).

Considerable variation in VFI intake are apparent between and within tropical grasses. Some of the differences are due to differences in digestibility, but other unrelated factors such as those recorded for Panicum varieties may be involved (Minson, 1971a). Rate of decrease in digestibility of younger tropical herbage is as high for temperate species (Minson, 1971a). It has also been shown that the decline in digestibility with age of tropical grasses was more rapid than tropical legumes which retained relatively high digestibilities at maturity (Milford and Minson, 1966). Differences in vitro digestibility have been reported between genotypes of Digitaria (Strickland and Haydock, 1978). Selection for high

in vitro digestibility was successful in producing a high in vivo digestibility of dry matter and superior VFI of Cenchrus ciliaris (Minson and Bray, 1985).

Studies of VFI of tropical grasses are derived from indoor feeding trials with cattle, buffaloes, goats and sheep mainly because of the difficulties and lack of reliable methods for estimating VFI under grazing conditions. Arising from these studies, the nutritive value of tropical grasses have been reviewed by Miller and Rains (1963); Hardison (1966) and Butterworth (1967); tropical legumes by Minson (1971b) and also tropical hays by Marshall, Bredon and Juko (1961). Minson (1971b) has also reported that tropical grasses decreases in dry matter digestibility at a daily rate of 0.1 to 0.2 digestibility units.

In view of rapid growth of herbage in tropical areas and variations in nutritive value, it is essential that to achieve high digestibilities and therefore VFI, grasses be used at an optimum stage of growth. In general, it is rarely possible to achieve digestibilities beyond 70%. In practical terms, adult ruminants (save the dairy goat) are unlikely to consume beyond 8% of their live weight as fresh grass for digestibilities of mature forage of the order of 40%.

Apart from the disadvantage concerning the restriction of energy uptake imposed by the bulk of tropical grasses, it is distinctly also possible for DMI to be limited by the feed-water content of, or the free-water on the ingested herbage, especially in the humid tropics. In the West Indies for example, the dry matter content of herbage during the wet season was very low as in Pangola grass (Butterworth, Groom and Wilson, 1961) with a dry matter content of 23.4% compared to 39.3% in the dry season such that the herbage contributes a high proportion of the total water consumed. Similar observations have also been made in Thailand (Holm, 1973). Inadequate dietary energy arises from reduced DMI and is likely to occur when the dry matter content falls below 25%.

(ii) The significance of digestibility

A primary consideration concerning DMI is digestibility. Digestibility of a feedstuff is affected by stage of maturity of the crop, botanical composition, dry matter intake and dietary supplements, processing and chemical treatment. In general, ruminants eat more of a feedstuff the more digestible it is (Blaxter, 1962a), so that high digestibility increases DMI. Increasing digestibility means that higher proportion of the food is absorbed and digestion is more complete, with the end products of digestion the volatile fatty acids (VFA), showing a lower proportion of acetic acid the lowest and energetically least useful VFA, and higher proportion of the more useful acids : propionic and butyric acids.

The significance of digestibility becomes more apparent by the demonstration that the efficiency of utilisation of DOM eaten ($OM \text{ intake} \times \text{digestibility}$) increases as the feedstuff becomes more digestible (Armstrong, 1964). Up to 60 to 70% digestibilities, increasing digestibility encourages increasing DMI and increasing efficiency of utilisation of the VF constituents.

(iii) Level of dietary protein

The protein content of tropical forages is in general low (French, 1957; Bredon and Horrell, 1961; Butterworth, 1967). The protein content falls rapidly with growth and reaches a low level before flowering. During the dry season, the crude protein levels fall to very low critical levels, even below 7% in the dry matter.

The level of protein in the diet affects voluntary intake of food (Campling, Freer and Balch, 1962; Blaxter and Wilson, 1963; Elliott and Topps, 1963) and low protein diets are not readily eaten by ruminants. In sheep, a 7% crude protein level begins to limit intake (Milford and Minson, 1968).

Although energy, and not protein is the limiting factor in animal production in temperate regions (Holmes, 1951; Crampton, 1957), nitrogen is clearly a primary deficiency in many parts of the world (Moir, 1963). In the tropics both factors are often limiting and seriously impair animal performance. When nitrogen is deficient for the rumen population or lowers the level of nitrogen reserves in animals (Egan and Moir, 1965), it will also limit energy release and or food intake. The value of an optimal level of dietary protein is therefore obvious as it has a stimulating effect on food intake and digestibility of energy (Smith, 1962; Elliott and Topps, 1963).

IV FEEDING SYSTEMS

There exist several feeding systems for both goats and sheep. However, these can be conveniently grouped into five categories as follows :

- (i) Village Systems
- (ii) Very Extensive and Extensive Systems
- (iii) Semi-intensive Systems
- (iv) Intensive Systems
- (v) Systems Integrated With Tree Cropping

(i) Village Systems

The village system is a traditional method of rearing goats and sheep especially in the humid tropics. It is probably the most important system of management. The goats and sheep are usually maintained in small areas of land (1 to 3 ha) which is used primarily for crop production to provide food for the village peasants mainly in subsistence agriculture. The need for supplementary income and the value of goats or sheep for various reasons largely explain the importance of goats in this system.

The village profile is reflected by many households, which may be scattered or clustered within the village setting depending on the intensity of crop cultivation. In forest zones and forest fringes, the number of households is low, about 2 to 5. As the intensity of cultivation increases, the households tend to be more closely integrated and may reach 300 to 400 as is evident for example, in parts of Nigeria.

The village system of feeding is of two categories. Firstly, there is tethering, in situations where a few goats are involved (1 to 5 heads), and where there is limited grazing due to intensive crop cultivation. The second alternative involves feeding the goats in situ with the various crop residues that are abundantly available from crop cultivation. In both systems, the goats are fed in addition, kitchen remnants and possibly also some concentrates. Feeding kitchen waste is significant and this can include examples such as rice, vegetable and fruit wastes and cassava peelings. Probably because of the availability of both crop residues and also concentrates, goats and sheep in this system of feeding tend to perform much better than in the more extensive system. A feature about this feeding system is that it encourages the animals to remain in the vicinity of the villages and this pattern is evident for example, in Nigeria and parts of India.

(ii) Very Extensive and Extensive Systems

The very extensive system is based on grazing of large areas of unproductive or marginal land, which is unable to support crop production. It also includes those areas that are sub-arctic because of altitude or latitude. The main areas are northern parts of Africa and the Sahel, many parts of the Near East region and the northern parts of Pakistan, India, the Himalayan region and Australia. The annual rainfall in these parts is less than 500 mm. The vegetation is very sparse, made up mainly of browse plants and stocking

rates are usually below 0.1 ruminant livestock unit (1 ruminant livestock unit, RLU = Buffalo = 0.8 Cattle = 0.1 Goats or Sheep). Because of the very dry conditions and type of herbage available, the available land is more suited for goats and sheep, especially the former. Control of numbers and management is essential in order to prevent deterioration of the environment and also of soil erosion.

By comparison, extensive systems involve land where the rainfall is generally higher (500 - 1200 mm annually) and relatively more herbage yield is available. Accordingly, stocking rates are generally higher and around 0.1 - 0.4 RLU/ha.

In both systems, goats and sheep are managed together in which goats lead the herd. A characteristic feature of the village and extensive systems is that a low level of unpaid family income represents the main input. By implication, the use of this unpaid family labour, usually women and children, represents an aspect of effective labour use whereby both cropping and also rearing of ruminants are important components of farm income. Except for the use of this low labour input, the system is principally one of low resource use, and a generally low level of productivity emerges from sub-standard nutritional management whereby very little or no concentrates, salt or mineral licks are provided.

(iii) Semi-intensive Systems

Semi-intensive systems are a compromise between the more extensive and intensive systems. It is a system that typically combines grazing and the utilisation of crop residues and by-products with some form of arable cropping. In this system, there is usually limited grazing and stall feeding, depending on the availability of time, labour and feed. Like the village system, it is essentially a part-time operation. The duration of grazing is variable, but is

usually about 4 - 6 hours a day, generally in the late morning or evening. The animals are then housed and given some forage or crop residues. Very seldom are concentrates offered.

(iv) Intensive Systems

Intensive systems can be divided into two categories : the intensive use of cultivated forages and stall feeding. Although goats prefer to browse rather than graze, they are nevertheless quite capable of making efficient use of cultivated pastures for meat or milk production. Stocking rates of 16 - 60 goats/ha are feasible, depending on the type of grass used, the level of fertilizer application and the presence or absence of legumes. Table 2 summarises the capacity of pasture for adult goats in various parts of the tropics. The carrying capacity of sheep approximate to the data in Table 2 for meat production.

(Table 2 here)

Stall feeding or the cut-and carry system is common where land is a limiting factor and where crop residues or forages are abundant. In this system, a high production of the feed is usually brought from the outside because of the small size of the holding in relation to the number of animals kept. The system is subject to the vagaries of seasonal abundance and shortage of forage that characterise it. Since the animals are housed most of the time, this results in a growing dependence on concentrate feeds especially during periods of feed scarcity. In general, stall feeding of goats is less common than is the case with sheep, but has been practised successfully in Fiji (Hussein *et al.*, 1983), India (Sehgal and Punj, 1983), Nigeria (Ademosum, Jansen and van Houtert, 1984), Cyprus (Hadjipanayiotou, 1984), West Java, Malaysia and elsewhere. By comparison, stall feeding of sheep is very common and has been reported in several studies, for example, in Iraq (Al-Tawesh and Alwash, 1983) and in the Sudan (El Hag, Kurdi and Mahgoub, 1985).

(v) Integration with Tree Crops

Although this system can be described under the intensive arable system, it merits separate treatment especially in view of the area under tree crops (coconuts, oil palm and rubber) in West Africa, South East Asia and the South Pacific. More particularly, this is also justified by the fact that the system has considerable future potential in increasing production from especially small ruminants (Devendra, 1985), in view of the expanding hectareage under these tree crops.

This system is especially common in the humid and sub-humid regions where there is intensive crop production. 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 :

- 1) increased fertility of the land via the return of dung and urine,
- 2) control of waste herbage growth,
- 3) reduced use of weedicides,
- 4) reduced fertiliser wastage,
- 5) easier management of the crop and
- 6) distinct possibilities of increases in crop yields, consistent with greater economic including sale of animals and their products.

The benefits of the integration are seen in the results of a study in Malaysia in which goat and cattle were grazed together in an oil palm plantation. Table 3 shows that the differences in yield in favour of combined cattle and goat grazing 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 related to the total hectareage and sale value of the oil palm yield, the advantage is substantial. Similar opportunities thus exist elsewhere to increase ruminant production from the land. In Malaysia for example, the total hectareage under oil palm and rubber is approximately 4.3 millions. Even if only

half of this crop area is utilised by ruminants, and assuming a stocking rate of 0.3 RLU/ha, the potential stocking capacity is of the order of 1.3×10^6 RLU.

(Table 3 here)

An additional advantage inherent in this system is the presence of abundant shade offered by the trees. This creates an environment which reduces heat stress on the animals.

Associated with integrated tree cropping systems is the alley cropping system developed in Nigeria (Kang, Wilson and Sipkens, 1981) in which crops are grown in alleys between rows of frequently pruned trees. Although the method needs to be more intensively studied, present indications are that its secondary contribution as a source of feed production for small ruminants is promising (Sumberg, 1984) and can be extended to many other parts of the humid tropics.

V BROWSE IN THE DIET OF GOATS AND SHEEP

A feature that is common to all the feeding systems is browse, which is used by both species, but especially by goats, throughout Asia, Africa, Near East and Latin America. In recent years, the importance of browse has been increasingly recognised and was in fact the subject of an international conference (Le Houerou, 1980a).

The importance of browse in the diet of particularly goats and to a lesser extent sheep is reflected in reports from Africa, Latin America and Australia. In northern Africa, browse forms 60 - 70% of rangeland production and 40% of the total availability of animal feeds in the region. The annual production is about 1.5 kg of DM/ha/mm of annual rainfall of which 50% is consumed (Le Houerou, 1980b). Browse is also a component of alley cropping (Sumberg, 1984).

In the arid zones of Mexico, observations of 1728 goat bites in a mixed brush grass forb community revealed that 83% of the bites were

on browse and forbs, and 17% on grass (Carrera, 1971). It appears likely that the higher nutritive value of some browse accounts for a greater net daily intake of nutrients by goats than by cattle or sheep (Short, Blair and Epps, 1973; Cordova and Wallace, 1975; Rector and Huston, 1976). By comparison in Australia, Wilson et al., (1975) used oesophageal fistula to study the food preferences measured of captive feral goats compared with sheep at three grazing pressures (0.5, 0.25 and 0.17 animals per hectare). At low stocking rates, sheep ate 80% herbs and 20% browse, while goats ate the reverse, at medium and high stocking rates, availability of herbs governed intake. Goats tended to select diets with an appreciably higher nitrogen content than did sheep, but in vitro digestibility of the nitrogen was not always as high.

The upper limits of the proportion of browse in the diets of goat and sheep are uncertain presently. Based on the review of the literature however, and the information on hand, it would seem that these proportions were about 30% in sheep and 85% in goats.

FEEDING STRATEGIES FOR GOATS AND SHEEP

It is pertinent to discuss feeding strategies and the more important applied aspects of the nutrition appropriate to goats and sheep. These strategies should be viewed in the context of the particular abilities of goats and sheep and their feeding habits. This is essential for reasons of examining the opportunities for stimulating more application of the knowledge on hand to ensure maximum productivity from both species. The justification for this is seen in the generally low productivity with goats and sheep throughout the tropics. Thus for example, Demiruren (1972) has reported that lamb production per ewe, average carcass weight and wool production per ewe were improved 40, 33 and 69% respectively. Table 4 summarises the results.

(Table 4 here)

A number of real possibilities exist which can be vigorously pursued. These merit brief discussion.

(i) More intensive use of crop residues and agro-industrial by-products

Much more use can be made of crop residues, agro-industrial by-products, including non-conventional feed resources. Often the issue is one of the best means to combine feeds in optimum proportions which while being palatable and attractive to the animals, are also capable of releasing nutrients that are required for both maintenance and production. Initially, it is appropriate to aim for utilisation in situ in close proximity to where these are produced and with no or a minimum of processing.

The second alternative is to process or treat some of these crop residues or agro-industrial by-products with one of several alkalis, such as ammonium hydroxide or calcium hydroxide or even urea. However, the case for processing and/or chemical treatment needs careful consideration of several factors. These include the availability of reliable and proven techniques which are practical, applicable to real farm situations, and more particularly are economically justified. This aspect is illustrated in Table 5. It is obvious that the components of the cost of processing and treatment can only be justified if these costs are significantly lower than the added benefits in terms of animal response.

(Table 5 here)

(ii) Strategic use of Concentrate Supplements

Strategic use of supplements is an important aspect of efficient feeding and management. However, the justification for concentrate supplementation is associated with four factors :

- 1) Scarcity of nutrients for production quantitatively and qualitatively.
- 2) Restriction in energy uptake imposed by bulky roughages.
- 3) Relatively high price of alternative mixed feeds or purchased concentrates.
- 4) Increased yield (meat and milk) of a monetary value greater than the cost of the feed required to produce it.

Where grass production is limited, the need for alternative supplies of nutrients is necessary. It is equally important to stress that the intake of grass would be largely dependent on its quality. This quality affects the total yield of milk produced and also the milk composition of lactating goats and sheep.

One additional justification for feeding concentrates is concerned with draught animals or for animals in adverse conditions where there are extreme shortages of feed supplies. Under these circumstances the physiological justification to meet the immediate nutrient requirements of ruminants to preserve its life, is far greater than other considerations, including the cost of the feed. While these circumstances are rare, the value of concentrate supplements are enormous under these conditions.

Concentrate supplementation is in any case a must for high levels of milk production in order that lactating animals can accommodate in its digestive tract the need for a large quantity of dry matter. Differences in milk composition in the goat are caused by variations in the quantity and quality of the feed ingredients, especially physical form of the diet and the level of nutrients in the feed (Devendra, 1982).

(iii) Use of proteinaceous forages

In many situations, dietary protein rather than energy is the main limiting factor. Thus, supplementary protein goes a long way towards meeting requirements, as well as promoting high animal performance. Good quality protein sources such as groundnut cake and soybean meal are generally expensive and in short supply, which means that the bulk of them ought to be retained for non-ruminant feeding. With regard to goats and sheep, a realistic alternative approach is the use of good quality leguminous forages as sources of supplementary protein.

There are several excellent examples of good quality proteinaceous fodders that are used for feeding small ruminants, often as supplements (Devendra, 1984). Table 6 presents a list of the more important examples.

(Table 6 here)

Among these however, the most widely used forage, and one that is increasingly becoming particularly important is leucaena (Leucaena leucocephala). There are several examples of studies that have demonstrated the value of dietary leucaena in terms of increased digestibility, energy uptake, nitrogen retention and therefore performance. These include studies with goats and sheep in Indonesia (Somali and Mathius, 1984; Utomo et al., 1984), Malaysia (Devendra, 1982; 1983), Thailand (Veerasilp, 1981), Mexico (Jodoy and Elliott, 1981) and Nigeria (Ademosum, Jansen and van Houtert, 1984). The value of this forage in the ASEAN region has recently been reviewed (Devendra, 1986).

(Table 7 here)

(iv) The Significance of Dietary Urea

The value of NPN sources like urea is associated with dietary molasses. Not enough use is being made of the value of dietary urea, mainly because of inadequate understanding of the principles of NPN used by the ruminant. Possibly the greatest value of urea is associated with the advantage that firstly, preformed or true proteins are spared from inefficient breakdown and utilization by rumen micro-organisms and secondly, these can be conserved for more efficient use in non-ruminant pig and poultry feeding and also for human use. NPN use generally reduces the cost of feeding. Other good examples of NPN are biuret and poultry litter.

Much greater use can be made of urea especially for feeding goats and sheep. It is essential to use good sources of soluble carbohydrates, in order to ensure that there will be maximum microbial protein synthesis.

Improving the use of NPN sources like urea or biuret can be achieved by employing one of several methods appropriate to a particular situation. Some of the methods applicable are as follows :

- (1) Spraying to pasture
- (2) Spraying or addition to hay
- (3) As a liquid in a trough in association with molasses
- (4) As a block lick
- (5) Inclusion in drinking water
- (6) Additive in cereals or concentrates

Recently, molasses-urea block licks are being increasingly considered because it is an attractive and practical means of making NPN such as urea (15%) continuously available. The advantageous effects include means of providing a slow and continuous intake of NPN, increased intake of crop residues, decrease in the requirements of concentrates, stimulated

growth and milk production, reduced requirement for green fodder, and reduced cost of feeding (Kunju, 1985). The method is also an important and practical means to make available macro and micro minerals and even medications to correct multinutritional deficiencies. Recently, the innovation has been extended to goats and sheep with successful results in Indonesia (Soetanto, 1986).

(v) Water

For the very extensive and extensive systems, drinking water is often a limiting factor in the semi-arid and arid regions. It is essential therefore that adequate drinking water be provided as well as watering places such as pipes, wells and dams. Water in these areas is important for improved productivity and also for survival. The requirement for water is affected by such environmental factors as the amount of DMI, nature of the food, physiological condition, temperate of drinking water, ambient temperature, frequency of drinking and also by species and breed within species.

(vi) Mineral and Vitamin Supplements

In many parts of the tropics mineral deficiencies of both macro and micro minerals are common. These deficiencies seriously impair production and the problem is exacerbated in situations where inadequacy of feeds and a consequent insufficiency of energy and protein result in under nutrition.

The deficiencies include mainly phosphorus which is widespread in many parts of Africa and also in Latin America, Asia and Australia. Other mineral deficiencies relate to magnesium, sodium, cobalt, copper and selenium. Often common salt is provided but this is inadequate to meet the requirements. Since goats and sheep, depend mainly on housing and grazing to satisfy their mineral requirements, which in any case is inadequate, the justification for providing mineral and vitamin supplements in feeding systems is obvious.

(vii) Feeding Standards

In the quest to ensure that both goats and sheep are adequately fed and therefore will achieve high performance, it is imperative that use be made of published feeding standards. These feeding standards are no more than a guide to requirements, but their use provides for adequacy of dietary nutrients that is consistent with good performance and profitability. The feeding standards that are commonly used refer to that for goats (N.R.C., 1981) and sheep (N.R.C., 1975; A.R.C., 1980).

(viii) Improved Husbandry Practices

The overriding factor that ensures the successful application of specific strategies, and the development of component technologies is improved husbandry practices. Africa, more than any other continent, has fragile ecologies for which sound management practices are absolutely essential. In particular, these practices can ensure that the seasonal shortages in feed supplies are accommodated, and carrying capacities can be controlled and regulated in a manner that is consistent with no environmental degradation. The overall strategy is to combine sound management practices with pasture improvement and rangeland development.

TABLE 1

COMPARATIVE DIFFERENCES IN THE NUTRITION
BETWEEN GOATS AND SHEEP

Characteristic	Goats	Sheep
1. Activity	Bipedal stance and walk longer distances	Walk shorter distances
2. Feeding pattern	Brower, more selective	Grazer, less selective
3. Browse and tree leaves	Relished	Less relished
4. Variety in feeds	Preference greater	Preference less
5. Taste sensation	More discerning	Less discerning
6. Salivary secretion rate	Greater	Moderate
7. Recycling of urea in saliva	Greater	Less
8. Dry matter intake:		
- For Meat	3% of B.W.	3% of B.W.
- For Lactation	4-6% B.W.	3% of B.W.
9. Digestive efficiency	With coarse roughages higher	Less efficient
10. Retention time	Longer	Shorter
11. Water intake/unit DMI	Lower	Higer
12. Rumen NH ₃ concentration	Higher	Lower
13. Water economy	- More efficient	- Less efficient
- Turnover rate	- Lower	- Higher
14. Fat mobilisaton	Increased during periods of feed shortages	Less evident
15. Dehydration		
- Faeces	Less water loss	Relatively higher water loss
- Urine	More concentrated	Less concentrated

FIGURE 1

THE EFFECTIVE CONVERSION OF AVAILABLE ENERGY IN HERBAGE

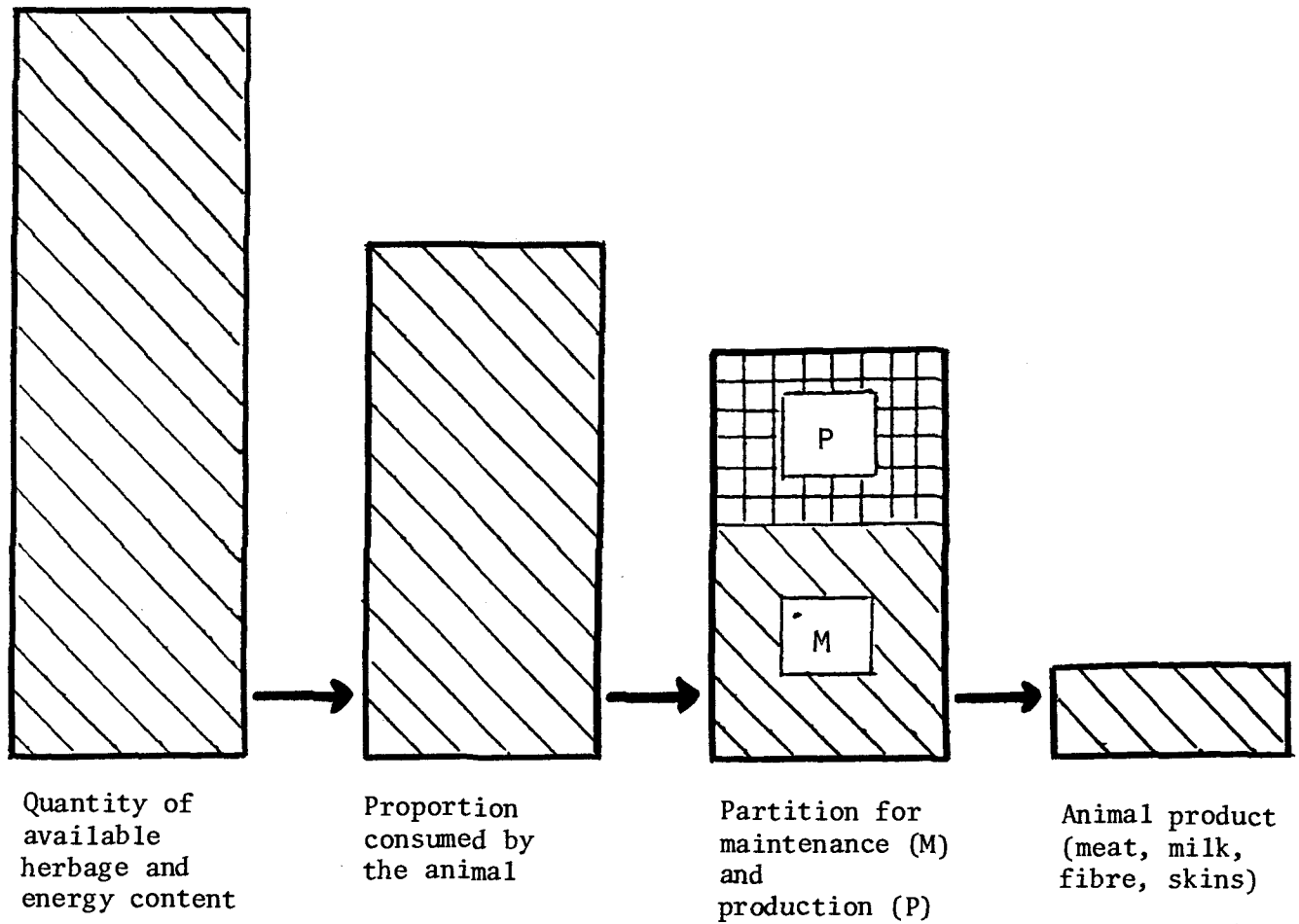


TABLE 2

CARRYING CAPACITY OF PASTURE FOR ADULT GOATS IN VARIOUS PARTS OF THE TROPICS

Type of grass	Location	Breed	Carrying capacity	Production	Reference
Pangola grass (Digitaria decumbens)	Jamaica	Criollo	37-45	463-563 dressed carcass	Devendra (1971a)
Pangola grass -30 days regrowth			(62)	14150)	
-50 days regrowth			(75)	11500)	
-30 days regrowth + concentrates	Guadeloupe	French Alpine	(102)	21200) milk	Chenost and Bousquest (1974)
-50 days regrowth + concentrates			(126)	14500)	
Annual ryegrass (Lolium perenne)	Mexico	Criollo	(40)	2054)	
Italian ryegrass (Lolium multiflorum)	Mexico	Criollo	(50)	2054) milk	Loza, Gonzalez and Claveren (1978)
Annual ryegrass			(60)	2667)	Martinez and Salinas (1978)
Annual ryegrass			52	7445 milk	
Annual ryegrass+ concentrates	Mexico	Criollo	(52)	7020)	
Bermuda grass (Cynodon dactylon)			(60)	3696)	Juarez and Peraza (1981)
			(95)	3149) milk	
			(45)	6408)	
			(48)	2419)	

TABLE 3

THE EFFECT OF MIXED CATTLE AND GOAT GRAZING
ON THE YIELD OF FRESH FRUITS IN OIL PALM CULTIVATION IN MALAYSIA
 (Devendra, 1985)

Year	Grazed area (Yield of fresh fruit/ ha/yr, mt)	Non-grazed area (Yield of fresh fruit/ ha/yr, mt)	Difference (Fresh fruit/ha/ yr,mt)
1980	30.55 (C)+	25.61	4.94
1981	17.69 (C)+	15.87	1.82
1982	25.12 (C + G)++	22.97	2.15
1983	23.45 (C + G)	18.29	5.16
Mean	24.20	20.69	3.51

+ C - Cattle

++ C + G - Cattle + Goats

TABLE 4

COMPARATIVE PRODUCTION PERFORMANCE OF IRANIAN SHEEP
UNDER EXTENSIVE AND IMPROVED SEMI-INTENSIVE SYSTEMS
OF HUSBANDRY IN THE EASTERN MEDITERRANEAN
(Demiruren, 1972)

Production	Extensive System (Unimproved)	Semi-intensive System (improved)	Possible Increase in Production (%)
Lamb production/ewe	0.8	1.12	40
Avg. carcass weight (kg)	21.0	28.0 ^a 34.0 ^b	33
Milk production/ewe/ lactation (kg)	45.0	59.5	32
Wool production/ewe (kg)	1.3	2.2	69
Flock offtake (%)	33	42	27

^aEwe carcass.

^bRam carcass.

TABLE 5

ECONOMIC BENEFITS OF PROCESSING AND/OR
TREATMENT OF RESIDUES AND BY-PRODUCTS

(Devendra, 1984)

Benefits	Attendant Costs
(A) Added Benefits e.g. - increased ME intake - increased digestibility - increased animal response	(C) Associated Costs e.g. - cost of processing - cost of treatment - cost of transportation
(B) Reduced Costs e.g. - reduced wastage - less dependence on supplements	

PROCESSING and/or TREATMENT is profitable if $(A) + (B) > (C)$

TABLE 6

SOME IMPORTANT EXAMPLES OF PROTEINACEOUS FORAGES

<u>Common Name</u>	<u>Botanical Name</u>
Babul	<u>Acacia arabica</u>
Banana	<u>Musa spp.</u>
Cassava	<u>Manihot esculenta</u> Crantz
Gliricidia	<u>Gliricidia maculata</u>
Gular	<u>Ficus glomerata</u>
Imli	<u>Tamarindus indica</u>
Ipil-ipil	<u>Leucaena leucocephala</u>
Jackfruit	<u>Artocarpus heterophyllus</u>
Kheiri	<u>Prosopis cineraria</u>
Khair	<u>Acacia catechu</u>
Khanthal	<u>Artocarpus integrifolia</u>
Mulberry	<u>Morus indica</u>
Pigeon pea	<u>Cajanus cajan</u>
Pipal leaves	<u>Ficus religiosa</u>

TABLE 7

THE EFFECT OF SUPPLEMENTATION WITH LEUCAENA FORAGE
ON INTAKE AND UTILIZATION OF RICE STRAW

(Devendra, 1983)

Treatment	DMI as % of body weight	OM digestibility	ME intake (MJ/kg)	N retention as % intake
100% Rice straw (RS, chopped)	2.7a*	50.9a	3.63a	0.1a
90 : 10, RS : Leucaena ⁺¹	2.6a	51.3a	4.22b	20.2b
80 : 20, RS : Leucaena ⁺	2.6a	49.5a	4.39b	16.4b
70 : 30, RS : Leucaena ⁺	2.7a	52.5b	5.17c	23.6b
60 : 40, RS : Leucaena ⁺	3.1a	53.3b	6.04d	31.5c
50 : 50, RS : Leucaena ⁺	2.7a	55.5b	6.76e	27.5c
40 : 60, RS : Leucaena ⁺	2.6a	52.4b	4.74b	30.8c

* In terms of total dry matter intake. Each value is the mean of three sheep

1 Leucaena forage : 22.0% crude protein and 22,18 MJ/kg gross energy content

* Means on the same line with different italicized letters differ significantly (P/0.05)

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