CHAPTER 5

Improved nutrition

5.1 Introduction

The basic principles of goat nutrition were described in Chapter 4. The challenge for extension staff and farmers is to put them into practice in the real world. In order to improve the feeding of an individual goat, there are two courses of action:

• improve the balance of nutrients reaching the rumen and small intestine;
• increase the total amount of food eaten.

However, the farmer is seldom feeding just one goat. In a flock of goats of any size, different goats will have different nutritional needs; where feeds are scarce, the farmer may have to target those scarce feed resources to the most needy goats. In addition, farmers have to cope with fluctuations in the feeding supply with the seasons, and so they must also consider how to:

• target goats with special needs;
• reduce the seasonal fluctuation in feed supply.

5.1.1 Checklist of questions on feeding

Before any attempt is made to improve the feeding of goats in any situation, it is important to understand the current feeding practices. Chapter 2 described the feeding problems commonly found in each of the major systems of goat production. Chapter 3 outlined methods to investigate feeding practices: feed calendars (3.2.5) and feed monitoring (3.3.12). Before any action is taken, the following information should, ideally, be known:

• seasonal description of feeds fed to goats, by quantity and quality: grazing, crop residues, supplements, etc;
• seasonal description of method of feeding: free grazing, tethered, housed, etc;
• seasonal pattern of production: breeding season, family's milk requirements, special ceremonies;
• likely periods of feed deficit;
• availability of supplements, minerals, water.
This chapter will describe practical methods of improvement which can be adopted by farmers in different systems of production. It will then use three case studies as examples to show how feeding problems can be analysed and strategies designed to overcome the problems identified.

5.1.2 Common feeding problems of goats in the tropics

A wide range of feeding problems is commonly encountered in tropical goat-keeping, including:

- fibrous feeds causing low intake rates, resulting in low levels of overall production;
- seasonal fluctuations in quantity, digestibility, protein, water availability;
- low levels of protein for growth and milk production;
- specific mineral deficiencies, such as a lack of sodium in feeds with high moisture content or in a specific area;
- poor presentation of feed to confined goats;
- poor access to water;
- poor nutrition of lactating dams, leading to low milk yields and poor rates of growth and survival among kids;
- poor quality of feeds for kids at weaning, causing a sharp drop in weight and possible death.

5.1.3 What practical options are available to farmers?

The main options for improving the quantity and quality of feed available, and the amount of feed consumed by goats in different feeding systems, are shown in Table 5.1.

5.2 Improving feed supply: grazing management

Owners often have to graze their goats on communal grazing areas, either supervised by a full-time herder, or left to roam by themselves. Often children herd goats, but in some systems a herdsman is employed to look after large flocks. Goats are adept at looking after themselves, and in several systems, such as village goat-keeping in humid West Africa, or forest goat-keeping in western Ethiopia, they are allowed to go out by themselves, following a leader goat, and returning home by themselves at night.

The communal ownership of grazing resources leaves few options to an individual goat owner acting alone to improve the amount consumed by his or her goats. There are more options if all livestock owners act together.
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**Table 5.1 Options to improve feed supply, nutrient balance, and quantity of feed consumed**

<table>
<thead>
<tr>
<th>Options</th>
<th>Free grazing</th>
<th>Feeding system</th>
<th>Stall-fed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Feed supply</strong> (Quantity and nutrient balance)</td>
<td>Select grazing area</td>
<td>Select best site</td>
<td>Select quality feeds</td>
</tr>
<tr>
<td></td>
<td>Develop forage crops</td>
<td>Develop forage crops</td>
<td>Mix feeds</td>
</tr>
<tr>
<td></td>
<td>Supplement diet with energy protein minerals</td>
<td>Supplement diet with energy protein minerals</td>
<td>Develop forage crops</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Supplement diet with energy protein minerals</td>
</tr>
<tr>
<td><strong>Treatment of feed</strong></td>
<td>Conserve feed</td>
<td>Chop unpalatable feeds</td>
<td>Chop unpalatable feeds</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wilt wet feeds</td>
<td>Wilt wet feeds</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mix feeds</td>
<td>Mix feeds</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Treat with urea</td>
<td>Treat with urea</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Conserve feeds</td>
<td>Conserve feeds</td>
</tr>
<tr>
<td><strong>Presentation</strong></td>
<td>Increase total grazing time</td>
<td>Ensure comfort and safety of tether</td>
<td>Feed at correct height</td>
</tr>
<tr>
<td></td>
<td>Allow time for ruminating</td>
<td>Move frequently</td>
<td>Present feed in an accessible manner</td>
</tr>
<tr>
<td></td>
<td>Ensure presence of shade</td>
<td>Ensure presence of shade</td>
<td>Ensure adequate space for all goats</td>
</tr>
<tr>
<td></td>
<td>Select best time to graze</td>
<td></td>
<td>Feed little and often</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Clean up waste feed</td>
</tr>
<tr>
<td><strong>Water</strong></td>
<td>Allow frequent access</td>
<td>Allow frequent access</td>
<td>Allow continuous access</td>
</tr>
</tbody>
</table>

In herded systems the herder is likely to have a fairly limited choice of places to graze within walking distance of the house. However, herders quickly learn what their goats like to eat and will normally allow them to linger in places supporting the preferred vegetation. In very hot climates, goats will seek shade in the middle of the day and should be allowed to rest and ruminate there during the hottest period. However, this resting time will cut down the time which goats have for grazing; so, to
compensate, they should be taken out early in the morning and
returned home late in the afternoon, to allow sufficient time to
seek food. This is especially important during drier seasons, when
vegetation is scarce and goats need much time to seek and eat
enough feed, even to satisfy their maintenance requirements.

Goats need water in order to digest fibrous feeds, but valuable
grazing time is lost during watering. In arid and semi-arid
environments, herders have to decide how frequently to water
their goats. Vegetation around watering points is usually over-
grazed, so time must be spent in walking from the water point to
better grazing; thus grazing time is lost. Goats in arid areas may be
watered only every three–four days.

In societies which rely on communal grazing, the community
has usually developed traditional ways of managing the grazing
resource, to allow equal access to it, and to try to prevent its over-
use. It is always important to try to understand the traditional
systems of grazing management and find out if they still exist, or
whether they have died out. In many pastoral societies in Africa
and the Middle East, traditional management systems are under
great pressure from increasing human and livestock populations
using diminishing grazing areas. In many places these traditional
systems have broken down altogether.

Most communal systems of grazing management function to
limit the number of owners using the grazing, and allow the
preservation of grazing for dry periods. Often particular groups,
clans, or relatives may claim traditional rights over a defined
grazing area and will try to exclude others from its use. Traditional
grazing rights may be fiercely protected.

Community agreement controlling when, and where, livestock
may graze can allow the regeneration of vegetation for future use
in more difficult periods such as the dry season. This community
agreement can be used as a basis for establishing a more formal
management plan for the grazing area, which may also include
some forage development such as establishing banks of high-
quality forage for use in the dry season. Up-grading the vegetation
of communal grazing areas is discussed in the section on
oversowing communal grazing areas (5.3.7).

Herding goats requires a great deal of labour. Often this task is
carried out by children, usually boys, which prevents them from
attending school. As governments become more strict about
compulsory school attendance, it will become increasingly difficult
to find the labour needed to herd goats all day. In most societies
the education of male children is given priority over that of their
sisters. As a result, in many parts of the tropics, there is a trend
towards girls taking on more responsibility for herding livestock.
The long-term viability of many goat-herding systems must be in
doubt, because of the shortage of labour, together with the
reduction in grazing lands from encroaching cultivation.
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Traditional grazing organisation of the Maasai of southern Kenya

The Maasai traditionally used to divide their grazing land into residential areas, areas set aside for calves, grazing areas for the early/mid dry season, and distant areas for the end of the dry season. Groups of households, associated with particular reserved grazing areas, do not have exclusive rights to that grazing but do, collectively, decide when livestock may enter an area for grazing. When disputes arise about the time of entry, collective action may be taken against any person who uses the reserved grazing prematurely. Owners of large herds are discouraged from taking up residence in a neighbourhood. This system of controlling the rate at which grazing resources are used existed widely before the 1960s, but has since declined with the introduction of group ranches. The system still exists in pockets, but is under great pressure.

5.3 Improving feed supply: forage development

5.3.1 Forage for what?

The development of forage crops is one way of making affordable improvements to the quantity and quality of feed available to goats. Forage crops can

- improve the total supply of bulk feed available to goats;
- improve the quality (digestibility and protein) of feed;
- compensate for seasonal fluctuations in quantity and quality.

In addition to the advantages for the goat, growing forage crops can have many beneficial side effects for the farmer, his or her family, and the environment. For instance, it may

- reduce soil erosion;
- provide a source of green manure for food crops;
- provide firewood and building materials;
- reduce the labour required to feed goats;
- provide shade.

Before a decision is made on what to grow, and where and when to grow it, the current feeding problems must be considered. Do the goats need more bulk feed? Do they need a source of protein? Do they need better feed in the dry season? Do particular goats, such as weaners and lactating does, need special feeding?

Apart from improving the quality and quantity of feed, developing forage for cut-and-carry feeding systems can ease the burden of the person responsible for collecting feed for the goats.
Improving feed supply: forage development

This task may take several hours each day. Often this job is done by women or children, and it takes time away from their other work on the farm or in the household.

When the needs are clear, a forage strategy can be planned and species to meet those needs can be selected.

Experience of introducing forage growing to farmers in the tropics has shown that it is most successful in systems of production that offer a good monetary return. If farmers are already making money from their goats, there is a great incentive for them to feed them better and make more money. In this case they are much more likely to put effort into developing forage. This issue will be discussed again when the implications of forage development for extension are considered (5.3.10).

5.3.2 When and where can forage be grown?

Growing trees, grasses, and bushes to feed to goats is often a very new technology for farmers, and careful consideration should be given to the question of how the forage species fit into the existing farm. Often too much time is spent testing which species or cultivar best suits a particular environment, but what is much more important to the farmer is not so much the species themselves but the strategy for growing them: where, when, and how.

Forage crops, whether they are perennial trees, bushes, grasses, or annual legumes, need a place to grow and a time to be grown. A few simple questions can quite quickly pinpoint the opportunities — in space and time — for growing forage on the farm. Once the opportunities have been identified, a suitable strategy can be designed, and species found that will best fit into that strategy in that particular environment. Look at the farm and discuss with the
In the foothills of Mount Kilimanjaro in Tanzania, farmers have very small farms. In the 1960s and 1970s they planted a lot of coffee, but when the price fell, some farmers changed to dairy farming of cows or goats. Some farmers have been pulling up their coffee trees and planting forage crops, because they can make more money from forage than coffee.

Consider farmer’s objectives and current feeding practices.
What are the major deficiencies?
Identify nutritional needs.

Seek land and time slot free for forage.
Select forage strategy.

Consider environment (rainfall, temperature, soils, etc.).
Select available species for strategy.

Promote strategy and observe outcome.
Adapt strategy and species as needed.

The areas that might be considered for forage production are:
- the area immediately around the house;
- along the edge of fields, including bunds in rice fields;
- a strip of land in the field area;
- underneath an established annual crop;
- underneath a perennial crop;
- communal grazing areas.
Improving feed supply: forage development

Discuss how long these areas will be available for forage. Can they be permanently allocated for forage production, in which case a perennial species can be planted? Or is it possible to plant a forage crop for a short time only, for example until the next crop has to be planted? Look for these slots of space and time when forage can be planted (Figure 5.2).

Very often the land that is found to be available, which a farmer is prepared to set aside for growing forage, will be some of the worst, most infertile, and otherwise unusable land. It may be a challenge to grow anything on it successfully! If forage growing is being introduced for the first time, the results in such unpromising areas can be disheartening for all concerned. In this case, select good pioneer species: ones that are easy to establish and grow quickly. In this way farmers are encouraged and will allocate more of their better land for forage in the future.

A communal grazing area is more difficult to improve, because it requires the agreement of the whole community to control their livestock and work together in improving the vegetation of the area.

5.3.3 What species to use?

Once the forage strategy has been agreed, the species to use in that strategy must be selected. The major deciding factors in selecting suitable species will be

- desired characteristics: annual/perennial; tree, bush, grass, creeping;
- availability of planting material: seed, cuttings, splits;
- rainfall;
- temperature;
- soils.

Figure 5.2 The forage strategies appropriate for different slots of space and time
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*Table 5.2 Key features of the major forage types*

<table>
<thead>
<tr>
<th>Forage type</th>
<th>Quantity</th>
<th>Digestibility</th>
<th>Protein</th>
<th>Other uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tree legumes</td>
<td>Low</td>
<td>High</td>
<td>High</td>
<td>Firewood Timber Green manure Shade</td>
</tr>
<tr>
<td>Herbaceous legumes</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Grasses</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>Thatching Weaving</td>
</tr>
</tbody>
</table>

*Table 5.3 Common forage species suitable for different climates*

<table>
<thead>
<tr>
<th>Type of forage</th>
<th>Humid Rainfall 1000 mm+</th>
<th>Sub-humid Rainfall 700-1000 mm</th>
<th>Semi-arid Rainfall 400-700 mm</th>
<th>Highland Rainfall 500-1000 mm, frost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tree legumes</strong></td>
<td>Leucaena</td>
<td>Leucaena</td>
<td>Sesbania</td>
<td>Tree lucerne</td>
</tr>
<tr>
<td></td>
<td>Glyricidia</td>
<td>Glyricidia</td>
<td>Leucaena</td>
<td>Sesbania</td>
</tr>
<tr>
<td></td>
<td>Calliandra</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sesbania</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Herbaceous legumes</strong></td>
<td>Centrosema</td>
<td>Pigeon pea</td>
<td>Pigeon pea</td>
<td>Clover</td>
</tr>
<tr>
<td></td>
<td>Axillaris</td>
<td>Axillaris</td>
<td>Stylosanthes</td>
<td>Alfalfa</td>
</tr>
<tr>
<td></td>
<td>Desmodium</td>
<td>Desmodium</td>
<td>Axillaris</td>
<td>Vetch</td>
</tr>
<tr>
<td></td>
<td>Stylosanthes</td>
<td>Stylosanthes</td>
<td>Desmanthus</td>
<td>Medics</td>
</tr>
<tr>
<td></td>
<td>Desmanthus</td>
<td>Desmanthus</td>
<td>Glycine</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Calopo</td>
<td>Calopo</td>
<td>Siratro</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lablab</td>
<td>Lablab</td>
<td>Lablab</td>
<td></td>
</tr>
<tr>
<td><strong>Grasses</strong></td>
<td>Elephant grass</td>
<td>Elephant grass</td>
<td>Elephant grass</td>
<td>Rye grass</td>
</tr>
<tr>
<td></td>
<td>Rhodes grass</td>
<td>Rhodes grass</td>
<td>Forage sorghum</td>
<td>Tall fescue</td>
</tr>
<tr>
<td></td>
<td>Green panic</td>
<td>Green panic</td>
<td>Buffel grass</td>
<td>Cocksfoot</td>
</tr>
<tr>
<td></td>
<td>Para grass</td>
<td>Para grass</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Setaria</td>
<td>Setaria</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Phalaris</td>
<td>Phalaris</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Multi-purpose</strong></td>
<td>Sweet potato</td>
<td>Sweet potato</td>
<td>Sweet potato</td>
<td>Fodder beet</td>
</tr>
<tr>
<td></td>
<td>Banana</td>
<td>Banana</td>
<td>Banana</td>
<td>Oats</td>
</tr>
</tbody>
</table>

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Many extension staff assume that exotic forage species are the only species to use. While the well-known forage species have been cultivated for years and selected for high yields, they may not always perform better than local species. Consider the forage species currently eaten by goats and the ones particularly liked by them, and consider whether these species can be more widely grown and promoted in forage strategies. For example, *Erythrina* spp is a family of leguminous trees, indigenous to many parts of the tropics, easy to establish by seed or cuttings, and often used as a living fence. Goats appear to relish the leaves of most species of *Erythrina*, and it could be much more widely used as a forage tree. However, if the indigenous species are difficult to propagate, or they are not very productive, then try exotic species, but do not immediately rush to use exotic species without first considering indigenous ones.

A major problem with exotic species of forage is obtaining the seed in sufficient quantities for an extension programme. Several of the more common species, such as leucaena, sesbania, glyricidia, and calliandra, are now quite widely available; but others, such as axillaris, desmodium, or centrosema, are more difficult to obtain and may even have to be imported. Always be sure you have a good supply of the seed for the farmers with whom you work. In the long term, farmers should produce their own seed, or planting material. Later we will consider how this can be organised in order to make forage-development sustainable.

Once the type of forage desired and the strategy in which it will be grown are agreed, the species that best fit the farmer's particular needs can be selected. Consider the rainfall and temperature pattern of the area. What is the total rainfall? How long is the dry season? Are there ever frosts? What sorts of soil are there? Do they ever get waterlogged, or are they very sandy and free-draining?

The key features of the different types of forage species are shown in Table 5.2. Legumes, being able to trap atmospheric nitrogen in the soil and convert it into vegetative material, produce forage with relatively high levels of protein. Grasses produce lower-quality bulk feed, which needs to be supplemented with legumes to make a balanced diet.

The common exotic improved forage species used in forage development are listed in Table 5.3. The major climatic zones in which they perform best are also shown. Each species will have several cultivars or varieties, each with slightly different characteristics and adaptabilities. The agronomic characteristics of the common forage species are summarised in Table 5.4.
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**Table 5.4 Characteristics of common forage crops**

<table>
<thead>
<tr>
<th>Common name</th>
<th>Scientific name</th>
<th>Minimum rainfall (mm/yr)</th>
<th>Seeding rate (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tree legumes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pigeon pea</td>
<td><em>Cajanus cajan</em></td>
<td>300</td>
<td>20-25</td>
</tr>
<tr>
<td>Calliandra</td>
<td><em>Calliandra calothyrs</em></td>
<td>1,000</td>
<td>20-50 seeds/metre</td>
</tr>
<tr>
<td>Glyricidia</td>
<td><em>Glyricidia maculata</em></td>
<td>900</td>
<td>Cutting/seed</td>
</tr>
<tr>
<td></td>
<td><em>Glyricidia sepium</em></td>
<td>900</td>
<td>Cutting/seed</td>
</tr>
<tr>
<td>Leucaena</td>
<td><em>Leucaena diversfolia</em></td>
<td>500</td>
<td>20-50 seeds/metre</td>
</tr>
<tr>
<td></td>
<td><em>Leucaena leucocephala</em></td>
<td>400</td>
<td>20-50 seeds/metre</td>
</tr>
<tr>
<td>Sesbania</td>
<td><em>Sesbania grandifolia</em></td>
<td>600</td>
<td>20-50 seeds/metre</td>
</tr>
<tr>
<td></td>
<td><em>Sesbania sesban</em></td>
<td>500</td>
<td>20-50 seeds/metre</td>
</tr>
<tr>
<td>Tree lucerne</td>
<td><em>Chamaecytisus prolifer</em></td>
<td>500</td>
<td>20-50 seeds/metre</td>
</tr>
<tr>
<td><strong>Herbaceous legumes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calopo</td>
<td><em>Calopogonium mucunoides</em></td>
<td>700</td>
<td>1-3</td>
</tr>
<tr>
<td>Cassia</td>
<td><em>Cassia rotundifolia</em></td>
<td>400</td>
<td>2-3</td>
</tr>
<tr>
<td>Centro</td>
<td><em>Centrosema pubescens</em></td>
<td>900</td>
<td>3-5</td>
</tr>
<tr>
<td>Desmanthus</td>
<td><em>Desmanthus virgatus</em></td>
<td>500</td>
<td>1-2</td>
</tr>
<tr>
<td>Greenleaf desmodium</td>
<td><em>Desmodium intortum</em></td>
<td>700</td>
<td>1-2</td>
</tr>
<tr>
<td>Silverleaf desmodium</td>
<td><em>Desmodium uncinatum</em></td>
<td>700</td>
<td>1-3</td>
</tr>
<tr>
<td>Glycine</td>
<td><em>Glycine wightii</em></td>
<td>600</td>
<td>2-5</td>
</tr>
<tr>
<td>Lablab</td>
<td><em>Lablab purpureus</em></td>
<td>400</td>
<td>10-30</td>
</tr>
<tr>
<td>Lotononis</td>
<td><em>Lotononis bainesii</em></td>
<td>800</td>
<td>0.5-1</td>
</tr>
<tr>
<td>Siratro</td>
<td><em>Macroptilium atropurpureum</em></td>
<td>500</td>
<td>1-3</td>
</tr>
<tr>
<td>Axillaris</td>
<td><em>Macrostyloma axillare</em></td>
<td>500</td>
<td>3-5</td>
</tr>
<tr>
<td>Alfalfa</td>
<td><em>Medicago sativa</em></td>
<td>600</td>
<td>2-15</td>
</tr>
<tr>
<td>Tepary bean</td>
<td><em>Phaseolus acutifolius</em></td>
<td>300</td>
<td>n/a</td>
</tr>
<tr>
<td>Puero</td>
<td><em>Pueraria phaseoloides</em></td>
<td>1,000</td>
<td>1-5</td>
</tr>
<tr>
<td>Graham stylo</td>
<td><em>Stylosanthes guianensis</em></td>
<td>600</td>
<td>3-6</td>
</tr>
<tr>
<td>Verano stylo</td>
<td><em>Stylosanthes hamata</em></td>
<td>500</td>
<td>3-6</td>
</tr>
<tr>
<td>Seca stylo</td>
<td><em>Stylosanthes scabra</em></td>
<td>500</td>
<td>3-6</td>
</tr>
<tr>
<td>Red clover</td>
<td><em>Trifolium pratense</em></td>
<td>600</td>
<td>2-8</td>
</tr>
<tr>
<td>White clover</td>
<td><em>Trifolium repens</em></td>
<td>600</td>
<td>1-4</td>
</tr>
<tr>
<td>Vetch</td>
<td><em>Vicia dasycapa</em></td>
<td>400</td>
<td>20</td>
</tr>
<tr>
<td>Cowpea</td>
<td><em>Vigna sinensis</em></td>
<td>300</td>
<td>20</td>
</tr>
<tr>
<td>Tolerance to Drought</td>
<td>Tolerance to waterlogging</td>
<td>Tolerance to frost</td>
<td>Establishment method</td>
</tr>
<tr>
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## Improved nutrition

<table>
<thead>
<tr>
<th>Common name</th>
<th>Scientific name</th>
<th>Minimum rainfall (mm/yr)</th>
<th>Seeding rate (kg/ha)</th>
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<tr>
<td><strong>Grasses</strong></td>
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<tr>
<td>Rhodes grass</td>
<td><em>Chloris gayana</em></td>
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<td>1-6</td>
</tr>
<tr>
<td>Cocksfoot</td>
<td><em>Dactylis glomerata</em></td>
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</tr>
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<td>Tall fescue</td>
<td><em>Festuca aruninacea</em></td>
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<tr>
<td>Perennial ryegrass</td>
<td><em>Lolium perenne</em></td>
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<tr>
<td>Molasses grass</td>
<td><em>Melinis minutiflora</em></td>
<td>1000</td>
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</tr>
<tr>
<td>Elephant grass</td>
<td><em>Pennisetum purpureum</em></td>
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<td>Bambatsi panic</td>
<td><em>Panicum coloratum</em></td>
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<tr>
<td>Gatton panic</td>
<td><em>Panicum maximum</em></td>
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<tr>
<td>Green panic</td>
<td><em>Panicum maximum</em></td>
<td>550</td>
<td>1-6</td>
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<tr>
<td>Guinea grass</td>
<td><em>Panicum maximum</em></td>
<td>900</td>
<td>2-6</td>
</tr>
<tr>
<td>Hamil grass</td>
<td><em>Panicum maximum</em></td>
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<td>1-4</td>
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<td><em>Paspalum plicatulum</em></td>
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<td><em>Phalaris aquatica</em></td>
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<td>Setaria</td>
<td><em>Setaria sphacelata</em></td>
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<td>2-5</td>
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<tr>
<td><strong>Fodder crops</strong></td>
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</tr>
<tr>
<td>Oats</td>
<td><em>Avena sativa</em></td>
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<tr>
<td>Fodder beet</td>
<td><em>Beta vulgaris</em></td>
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</table>

*Table 5.4 continued*

### 5.3.4 Back-yard pasture

Back-yard pasture is the growing of forage in the area around the house. It is a relatively simple way of increasing forage production and is often a good one for farmers to start with. It is particularly appropriate for women, because they are normally responsible for looking after the house compound. The fertility of the soil around the house is usually high, so even small forage plots can be very productive.

Back-yard forage may consist of the following:

- hedges of tree legumes;
- mixed plots of perennial grasses and herbaceous legumes;
Improving feed supply: forage development

<table>
<thead>
<tr>
<th>Tolerance to Drought</th>
<th>Tolerance to waterlogging</th>
<th>Tolerance to frost</th>
<th>Establishment method</th>
<th>Nutritive value</th>
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<td>Seed/splits</td>
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- highly productive legumes, such as alfalfa;
- highly productive grasses, such as elephant grass;
- annual fodder crop, such as fodder beet.

Tree legumes are particularly suitable, for several reasons.

- They can be sown around the edges of the plot and so do not compete for space with other crops.
- They can be interplanted with existing back-yard crops.
- They can improve soil fertility.
- They can provide shade for livestock and for the family.
- They can provide a handy source of firewood.

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It is best to start farmers who are new to growing forage trees with a mixture of tree species. For example, sesbania, glyricidia, and pigeon pea grow very fast; farmers are usually impressed by how quickly they grow and are encouraged by this. Trees such as leucaena or tree lucerne grow much more slowly at the start, but may be more productive in the long term. Planting a mixture of tree species ensures that farmers are both encouraged and rewarded by the trees they plant.

Planting a mixture of species is also best for ecological reasons. Forage plants harbour pests, and planting large areas of one species makes the farmer vulnerable to their loss by insect, bacterial, or fungus attack. The most dramatic example of a forage pest has been the psyllid attack on leucaena in Asia and Africa. The psyllid is a tiny insect that sucks sap from the growing tips of leucaena branches. Most varieties of leucaena are susceptible to their attack and quickly die. In parts of the Indonesian archipelago, and notably the island of Timor, large areas of leucaena have been destroyed by this pest. Although some trees recover and some varieties have been found to be relatively resistant to attack, millions of trees have been destroyed. Psyllid-resistant varieties are now widely available, but much damage has already been done. Although planting a mixture of trees would not have prevented the psyllid attack, it would have reduced the increase in the psyllid population, and the other species of trees would have provided an alternative supply of forage. A hard lesson has been learned.

Establishment

It is normally best to establish tree legumes by planting seedlings, but some species such as glyricidia can be easily established by using cuttings. Sesbania can be directly seeded into the soil and
can grow very quickly after planting in this way. Whichever way the trees are established, it is vital that they are planted as early in the growing season as possible. This may not be so important in the humid tropics, which may have higher rainfall, more evenly distributed, but it is vital in the sub-humid and semi-arid tropics, which have marked wet and dry seasons. Young seedlings will have trouble surviving a dry season unless they are well established at the start of it, or are watered through the dry period, which may be difficult.

Young trees are very vulnerable to weeds and to being damaged by livestock — particularly by the goats for whom they are planted! Young trees should be protected by, for example, thorn branches, and the family’s and neighbour’s livestock should be controlled.

Management and use
It is best to allow trees to become well established before starting to cut them. Exactly when to start cutting will depend on their growth, which in turn will depend on rainfall and temperature and will be different in each area and for each farm. Cutting too early can damage the tree and may even kill it, while cutting too late will encourage the development of a large trunk but few branches. The frequency of cutting will depend on the growth-rate of the tree. Farmers will quickly learn what is best for the trees around their house.

Cutting heights can be varied according to the farmer’s preference. Cutting low at one metre is easier for the person cutting, but means that the new growth is within easy reach of goats and other livestock. Cutting at a height of 1.75–2.0 metres is higher than normally recommended, but has the advantage of being too high even for cattle to reach (Figure 5.4).

Tree legumes can provide a valuable source of high-quality protein. When they are planted around the house, there is unlikely to be a sufficient quantity for them to be anything other than a protein supplement. When in very short supply, legumes should be fed to the goats most in need of a high-quality protein supplement: lactating does, weaners, and fattening males.
Improved nutrition

When and where to promote back-yard forage
Back-yard forage production can be promoted in the following situations:

- where livestock numbers are high and there is little grazing;
- where it is possible to control livestock;
- where there is enough space in the back yard;
- where a protein supplement is needed;
- where women are closely involved in goat-keeping.

5.3.5 Forage strips and alley farming

Forage strips are narrow lines of forage planted between arable crops. The forage strips can have several purposes:

- to provide both bulk and quality feed for a cut-and-carry feeding system;
- to prevent soil erosion;
- to provide fuel-wood;
- to provide shelter and green manure for crops;
- to improve soil fertility.

Forage strips are particularly useful in erosion-prone areas — sloping land, light soils, etc. — and, if planted on contours, can serve as a cheap and effective method of soil-erosion control. Contour forage strips are cheap to establish and can, over a number of years, result in the formation of effective terraces. They require much less maintenance than the more conventional stone or soil terraces normally promoted in soil-conservation programmes.

Forage strips may include the following:

- grass/legume mixtures planted in a dense strip;
- tree legumes closely planted in parallel rows, forming alleys ('alley farming');
- trees planted as shelter belts around crop land;
- forage species planted on existing terraces or bunds.

A wide range of forage species is suitable for use in forage strips. On or around arable land, creeping grasses should never be used, because they can quickly become a weed in the crop and will be difficult to eradicate. Likewise if erect grasses or creeping legumes...
are included, they should be cut regularly to prevent them seeding near the crop-land.

Forage species suitable for use in forage strips depend on the physical context.

- **Bunds, terrace walls, and contour strips**
  - Erect grasses: setaria, phalaris, panics, buffel grass
  - Herbaceous legumes: axillaris, desmodium, vetch
  - Tree legumes: glyricidia, leucaena, sesbania

- **Alley farming, hedges and shelter belts**
  - Tree legumes: leucaena, glyricidia, sesbania, tree lucerne, calliandra

**Establishment**

Tree legumes may be established from seedlings, cuttings, or seeds, depending on the species. Grasses should be established from seed or splits, as appropriate. Forage strips should be established early in the growing season, to ensure their survival through the first dry season.

Tree legumes for alley farming can be planted close together, 25–35 cm apart, in areas of high rainfall (more than 1,000 mm), but should be farther apart (50 cm) in areas with lower rainfall. Likewise the spacing between the rows should vary according to rainfall, availability of arable land, type of crop grown between rows, the slope of the land, and the preference of the farmer. They could be quite close together, at 4 metres apart, if arable land is not in short supply, the rainfall is high, and the farmer wants a high proportion of forage. In areas of lower rainfall, a less intensive system should be practised, with rows farther apart, 8 or more metres. On sloping land, rows should be closer together as the slope gets steeper.
Improved nutrition

Management and use

Ideally forage strips should be cut to get the best production. If goats are tethered beside strips, they should be supervised to make sure they do not over-graze the strip or trample it excessively. Regular cutting of all species is essential during crop growth, to ensure that there is no interference with the arable crop. Regular cutting results in higher-quality feed, because there will be a higher proportion of young leaves, which are easily digestible and have high levels of protein. Cutting frequency can be increased during the wet season, but must be reduced during dry periods, or the tree will suffer and might even die if it is not given time to recover.

In alley farming, trees may be cut at a height of about one metre. The farmer may prefer low cutting during the time of crop establishment, to avoid shading the emerging crop. Alley farming is often promoted as a way of supplying a cheap source of nitrogen to the crop, through cutting leaves for use as a green

Alley farming in Nigeria

Much research on alley farming in Africa has been carried out in southern Nigeria by the International Livestock Research Institute (ILRI) and the International Institute for Tropical Agriculture (IITA). In this region typical farms consist of an area of cultivated land (2 hectares) and an area of fallow land (6 ha). The main crops grown are maize, cassava, and yam. The family may consist of 6–8 people, who look after 3–6 goats. Alley farming offers the possibility of reducing the need for a fallow period, through fertilising arable land with a green mulch of tree-legume leaves. The main tree species used have been Glyricidia sepium and Leucaena leucocephala. As population pressure mounts, goats, which currently roam freely through the village, scavenging for food, will have to be confined. Alley farming offers a means of supplying high-quality feed to confined goats.

ILRI’s research has shown that, in order to maintain crop yields, the trees should be cut just before the planting of the crop and the cuttings should be used as a mulch and green manure. Thereafter most (75 per cent) of the cuttings can be fed to goats without any harmful effect on crop yield.

Goats were allowed into the plots during the fallow period. Some trouble occurred when the understorey vegetation was poor and unpalatable, and the goats took to eating the bark of the trees. This can kill the trees. It is best to allow the goats into the plots only for short periods, if at all, to ensure that they never resort to debarking trees.

Source: AFNETA (1992)
In the uplands of the Philippines, the Mindanao Baptist Rural Life Centre has been working for a number of years on the problems of soil conservation. They have been promoting a strategy widely known as SALT (Sloping Agricultural Land Technology), which encourages farmers to plant double rows of leguminous trees and shrubs along contours on sloping land. In the original SALT scheme, cuttings from the trees were used exclusively for manuring crops and providing vegetative cover, conserving soil and water. SALT 2 is a similar strategy, developed specifically for goats, which incorporates a higher proportion of tree legumes and sets aside blocks of land for pure forage production.

The double hedgerows consist of closely planted Flamengia congesta, Glyricidia sepium, Desmodium rensonii and Leucaena diversifolia. Napier grass is also planted between the trees. It is reported that a farm of 0.5 ha, with half of the land producing food crops and the other half producing forage for 12 Anglo-Nubian milking does, can produce an income for the family far above the income from a traditional farm in the same area.

Source: HRR (1990)

manure, as well as building up soil fertility through the decay of roots and root nodules; livestock feeding is a secondary objective. Green manure from alley farming can completely replace any previous use of chemical fertilisers and plays a part in a long-term sustainable system of crop production. However, increases in crop
Improved nutrition

yields take several years to develop, while farmers can get more immediate benefit from the improved feeding of livestock. As a result, it is necessary to develop a balance between using the legume leaves for manure and using them for feed. In most cases, if goats are kept, farmers tend to direct more cuttings towards feeding their animals than manuring their land. However, for the system to be sustainable and crop yields to be maintained, care needs to be exercised in ensuring that sufficient nutrients are directed to the crop, and not exclusively to the goats.

In well-developed alley-farming systems, a large quantity of high-quality livestock feed can be produced and a highly productive goat system can develop as a result.

When and where to promote forage strips
Forage strips should be used

• on sloping land where soil erosion is a problem;
• where good control of livestock is possible;
• where both bulk and quality feeds are scarce.

5.3.6 Undersowing

Undersowing is the planting of forage, normally forage legumes, underneath an existing crop. The crop may be an annual food crop such as maize or sorghum, or a perennial crop such as rubber, coffee, citrus trees, oil palm or coconuts. Undersowing has a number of functions.

• It improves the feeding value of crop residues.
• It provides ground cover and protects against soil erosion.
• It improves soil fertility of the existing and/or following crop.
• If grain legumes are used, it can provide extra food for the family.
• It is one method of establishing long-term pastures.

Undersowing allows farmers to grow both food and cash crops, together with forage. It is therefore very useful in areas where land is scarce. It also serves to control erosion, because it maintains ground cover when the soil would otherwise be exposed, and helps the farmer by suppressing weeds underneath the crop and replacing them with more useful species.

Undersowing in annual crops
Forage species planted underneath an annual crop should be sown soon after the last weeding of the crop, when the maize or sorghum is well established. Planting then will not interfere with the farmer’s normal cultural practices. Low seeding rates should be used in areas where soil moisture is likely to be low after the growing season. It is not the aim to have a dense sward. The
Improving feed supply: forage development

A forage crop will start by growing slowly, because it will be shaded by the main crop, and will not interfere with it. It will grow more rapidly after the main crop has been harvested, and go on growing well into the dry season. After harvesting the crop, the forage can either be rotationally grazed by tethering goats in a different area each day, or it can be cut, carried, and fed to stalled goats.

Undersowing can very quickly increase feed supply with little labour or management, and will leave nitrogen and organic matter in the soil for the crop in the next cropping season. This can be particularly valuable for infertile, sandy soils.

Farmers are likely to be anxious about undersowing a crop of additional ‘weeds’, underneath their valuable food crop. To start with it is best to plant a small area of the field, so the farmer can see if there is any detrimental effect on the main crop. Once the farmer is convinced that it does no harm, the area can be expanded the next year.

A range of legume species is suitable for undersowing beneath annual crops. The species should have the following characteristics.

- It should be deep-rooting, to allow the plants to continue growing when the rains have stopped and the main crop has been harvested.
- It should retain its green leaves, to increase the feeding value of the stubble or crop residue.
- It should be easy to establish.
- If it is a grain legume, it should need only a short period to mature.

Species such as lablab, vetch, or cowpea are ideal annuals. Species such as desmodium, axillaris, siratro, or a species of stylosanthes are perennials that might be established by undersowing.

**Undersowing perennial crops**

Shade-tolerant forage crops can be planted underneath perennial crops in plantations or on small farms. It is best to plant them at the same time as the perennial crop, so they can grow quickly before the crop’s canopy reduces the sunlight reaching the understorey; the forage crop will protect the soil while the canopy develops. If forage is being introduced into perennial systems, shade-tolerant species, such as centrosema, should be selected. High production from forage crops planted underneath perennial trees should not be expected. Goats can graze underneath trees, or forage can be cut and carried to them. If goats are grazing under trees, they must have enough to eat, or they may resort to eating the bark of the trees. Some difficulty has been found in grazing goats under rubber, because their inquisitive nature leads them to disturb the latex-collection cups.

The key characteristic for species under perennial tree crops is that they should be able to tolerate the shade underneath the tree.
Improved nutrition

canopy. Legumes such as centrosema, siratro, and glycine are particularly well adapted to shady conditions. Creeping grasses such as signal grass, para grass, and rhodes grass are most suitable for planting with legumes.

5.3.7 Oversowing and improvement of communal grazing areas

Communal grazing areas in places of high livestock populations are generally over-grazed and may also be severely eroded. As the human population increases and arable land becomes scarce, farmers are forced to cultivate increasingly marginal land — which is usually the community’s grazing land. As the livestock population builds up and exerts increasing pressure on the dwindling grazing areas, unpalatable species will become more dominant, because the palatable species will be over-grazed and eventually eliminated. Under severe grazing pressure, little edible vegetation is left and the community’s livestock will suffer. This is a common situation in many parts of Africa and Asia.

Improving the quantity and quality of feed from communal grazing areas is not easy. It requires the coordinated effort of the whole community — which can be difficult, but not impossible, to organise. The approach adopted depends on whether or not it is possible to control the livestock currently using the land. Control can be achieved on a voluntary basis through community agreement — which is often done traditionally anyway; or it can be achieved through legislation. If livestock are excluded from the area, regeneration of the existing vegetation can take place

In the Tigray region of northern Ethiopia, the Hezati system of communal grazing management is under great pressure. Traditionally farmers set aside grazing areas — hillsides or swamps — which cannot otherwise be used for crop production. The grazing is guarded and used by the community only at the end of the dry season. This is a particularly important source of feed to strengthen oxen before the ploughing season. It may also be used by sick cattle, sheep, and goats throughout the year. The Hezati areas are managed by a committee. Tigray suffered from famine and civil war during the 1970s and 1980s. In areas where the Hezati system broke down but has been reinstated, the indigenous vegetation has made a spectacular recovery. If livestock can be successfully controlled, it would be relatively easy to oversow these areas with improved forage legumes such as Stylosanthes spp, which would substantially improve the quality and quantity of forage available, as well as reducing soil erosion.

Hezati grazing areas, Ethiopia
In parts of Tanzania, over-grazing of community grazing areas is so severe that many local councils pass laws banning the free grazing of livestock species in communal grazing areas. In several areas, livestock are not only banned but have to be confined, with feed cut and carried to them. Heavy fines are imposed on farmers who allow their animals out to graze. In the Dareda area of Babati district, several village committees have banned the grazing of livestock on the steeply sloping forested escarpment spanning the district.

Legislation banning livestock in Tanzania

and it is possible to oversow the area with improved forages. In the absence of stock control, it is much harder to establish new species, because the soil is compacted and the existing vegetation is continuously grazed. Vigorous species must be used to oversow the area lightly, or sow in strips. Heavily-used roadside grazing can also be improved in this way.

Tropical environments are remarkably resilient and have an extraordinary ability to recover from over-use. Excluding livestock from a grazing area permanently, or temporarily, will allow the (sometimes spectacular) regeneration of indigenous vegetation.

If the community do agree to control their livestock, forage species can be planted and will help to improve the regenerating indigenous species. Which species to plant will depend on whether stock can be excluded permanently, and feed cut from the area — in which case they should be highly productive species — or whether there is only a temporary exclusion of livestock — in which case hardy, resilient species should be planted.

If stock control is not possible, oversowing vigorous-growing forage species can still improve forage production and soil fertility at very low cost. It requires little labour, and little or no management. The seed should be broadcast before the start of the rainy season, to give the forage plants the best chance of establishment and survival. Encourage farmers to sow on loose soils, because it is very hard for seeds to germinate on compacted soils. Seeding rates should be low. If the species do survive, they will seed and spread by themselves. Sowing may cover the whole area, or be done in strips, or in small patches where soil has been lightly disturbed, to aid germination and establishment.

Suitable species are stylosanthes, siratro, axillaris, and calopo.

In north-east Thailand, there is such a shortage of grazing for livestock that the only grazing available is along the side of the roads. The quality and quantity of this roadside grazing has been improved by oversowing it with *Stylosanthes* species. The seed was broadcast out of the window of a moving vehicle.

Roadside seeding in Thailand
5.3.8 Fodder crops

Growing a high-yielding, normally annual, crop specifically to feed to goats is not common, but it can be done to supply feed in intensive systems of goat production where land can be set aside for it. Species used might be forage sorghum, maize, oats, and vetch, or fodder beet. Their advantage is that they produce a large quantity of high-quality feed in a short time, but they do require good cultivation and management. Fodder crops might usefully be grown at institutional breeding stations, research stations, or commercial dairy or fattening goat farms.

5.3.9 Permanent grass/legume pasture for goats

Permanent pastures are normally mixtures of grasses and legumes. They can be extremely productive over a long period, with little management, once established. However, they do require land to be permanently set aside, which may not be possible for small farmers, but might be suitable for commercial farms or institutions. Grass/legume pastures produce high-quality forage, improve soil fertility, and can support a large number of highly productive goats.

Pastures can be grazed, but goats should be obliged to graze closely by tethering or fencing them, in order to reduce wastage from trampling and selection. Pastures can also be used in cut-
Improving feed supply: forage development

There has been little experience of pastures specifically designed for goats which take into account their particular feeding habits and needs. In any area there is much scope to select species and adapt management systems specifically for goats. If the pasture is to be grazed, planting tree legumes, up which creeping legumes may climb, would allow goats to browse. A multi-layered pasture made up of herbaceous legume, tree legumes, and some grasses, resulting in a high proportion of forage in the browsing zone, would suit goats extremely well (Figure 5.8).

Establishing permanent pastures can be expensive, because high seeding rates need to be used, and because during the first year weeding should be carried out to ensure good establishment. Pastures cannot be used in the first year, unless in areas of high rainfall, which is an additional cost. A well-prepared seedbed is also essential for good germination and survival. Fertiliser may be recommended, but should not be needed if there is a high proportion of legumes in the mixture.

Management of the pasture should be guided by observation of the performance of the pasture itself and the behaviour of the goats. There are no fixed rules. The aim should be to maintain high-quality (i.e. young) forage, maintaining a high proportion of legumes, little stemmy material, and few weeds. Grazing/cutting pressure should be adjusted in order to preserve the most desired species.

Suitable species in a mixture for goats might be:

- **tree legumes**: sesbania, leucaena, pigeon pea and glyricidia;
- **herbaceous legumes**: desmodium, siratro, calopo, axillaris, clover;
- **grasses**: rhodes grass, panic grasses, rye-grass, setaria.

5.3.10 Planning and implementing successful forage development

In order to achieve successful long-term forage development, there are certain conditions which have to be met, including:

- well-motivated farmers;
- initial extension support;
- selection of appropriate forage strategy;
- stock control (total or partial);
- availability of planting material.

First and foremost, farmers must be convinced of the value of forage development for their goat enterprise. Unless farmers make money from the forage, or at least derive some tangible benefit from it for their families, they are unlikely to want to expend effort on developing forage on their farms. Forage
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Forage extension package for highland farmers in Ethiopia

development is often a new technology, and farmers may have to gain some direct personal experience of forage growing before they are convinced of its value. Forage development nearly always requires good extension support initially. Farmers should be encouraged to start small and gain experience before expanding the area covered.

A forage extension package, consisting of a set of flip charts and guidelines for extension staff, was developed as part of a World Bank-funded livestock project implemented by the Ministry of Agriculture in Ethiopia. The package is designed to be used during a course of eight meetings involving groups of 15–30 farmers. The extension agent is given training in how to use the package as the framework of a course introducing farmers to forage development. The extension agent encourages the group to discuss their present and future needs for forage for their draught cattle, milking cows, young oxen, and small ruminants. Different ways of integrating forage on the farm as well as improving community grazing areas are described and discussed in a series of meetings.

The package has been found to be an effective way of introducing farmers to different means of forage development, and stimulating discussion about how improvement could be made on their own farms. For the package to be used effectively, the extension agent needs good communication skills and a high level of commitment to its use.

Often farmers cite lack of feed as one of their biggest problems, but may be unwilling to set aside land and labour for forage production. There may be good reason for this: perhaps they have to plant forage at the same time as the main crop, and they simply do not have the labour available to do so. Or they accord greater priority to having fruit trees around the house than tree legumes, and no other spare land is available. It is important to be sure that farmers need the forage and that the strategy selected is that one that best fits into their existing system of production.

The control of livestock for some period of time is necessary for nearly every strategy. In up-grading communal grazing areas it may be crucial; for other strategies it may be desirable for a short period only — for example, when tree seedlings have just been planted. Make sure it is possible to control all livestock, not just goats, during the relevant period, or that the new growth is effectively protected in some other way, such as fencing. Many tree seedlings are carefully grown in tree nurseries, only to be destroyed soon after planting out in the field site.
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Sufficient quantities of planting materials — seed, cuttings, seedlings — should be available at the correct time. All too often, tree seedlings planted in a large nursery are ready too late, or cannot be delivered to the farmer on time because of lack of transport. This leads to disappointment for all concerned. It is preferable if farmers themselves can be closely involved in nursery management or even have their own individual nurseries. Ultimately farmers should also be responsible for growing their own seeds. This may be at the community or individual level for their own use, or on contract to a purchaser such as a project or government department.

5.3.11 Planting trees, herbaceous legumes, and grasses

There are three ways to plant forage species: by direct seeding; by seedlings; and by cuttings and splits. The choice of method will depend on the species (see Table 5.4), the planting material available, and the situation in which it is to be planted.

**Direct seeding**

Direct seeding is used for all herbaceous legumes and most grasses, and can be used for some tree legumes. Seeds can be broadcast, sown in rows, or sown in patches. Early sowing is usually the key to successful establishment. Sowing can even take place before the rains start, because the seed can survive in the dry soil and be ready to germinate as soon as the rains arrive. This is important in strategies, like oversowing, where plants are likely to have difficulty in becoming established. Dry planting also helps the farmer who is likely to be busy with other cropping activities at the start of the rains.

In strategies such as oversowing that require only low seeding rates, or when sowing species with very small seeds, such as desmodium, it is helpful to mix the seed with sand to ensure an even distribution. When tree legumes are sowed directly into the soil, it is best to sow 2–3 seeds per hole.

When planting trees in soils of low fertility, it has been found to be helpful to roll the seed in a small ball of manure, to give it a small source of nutrients just after germination.

When using strategies such as permanent grass/legume pastures, where much seed has to be sown for the success of the strategy, it is advisable to carry out a simple test of the germination capacity of the seed. Germination declines with age, especially if the seed is stored in damp conditions. Try to keep seed dry and use it when fresh. If germination is found to be low, seeding rates should be increased to compensate.
A germination test is conducted as follows.

1. Cover the bottom of a shallow tray with blotting paper or layers of tissue paper. Moisten the paper. Do not make it too wet, or the seeds will rot.
2. Count 100 seeds of the species or mixture to be tested, and scatter them evenly on the tray.
3. Leave the tray to stand.
4. Keep the paper moist all the time.
5. Count the seeds that germinate every day.
6. After one week, most of the seeds will have germinated. Calculate how many seeds have germinated and divide by 100. This is the germination percentage.

Some legumes require a treatment in order to break dormancy and ensure more even germination. This is particularly important for tree legumes being raised in tree nurseries, where a batch of trees are sown and raised at the same time. However, for direct seeding, if rainfall is very uneven and likely to start and then stop for a long period, it is best to sow a mixture of treated and untreated seeds, to ensure that at least some seeds germinate and get established.

The following method of seed treatment is suitable for most species.

1. Boil a container of water.
2. Remove from the heat and immerse the seed in a porous bag such as a jute sack for 5–10 minutes. The length of time for soaking varies according to species. Species such as leucaena or tree lucerne need to be boiled for 3–5 minutes. Alternative treatments, such as scalding and soaking the seed for 24 hours, or manually scarifying the seed, require much labour.

Another form of treatment is called seed inoculation. Legumes are able to trap atmospheric nitrogen in the soil by establishing a relationship with a bacterium called rhizobium which lives in the soil. The bacterium establishes itself by developing small nodules on the roots. There are several strains of the bacterium and, although different strains can trap nitrogen to some degree, there are certain strains that are able to do this more efficiently than others. Some legumes require to be inoculated with a specific strain of rhizobium before sowing, to ensure good growth and nitrogen fixation. This is particularly important if the legume is new to the area. Inoculation simply means sticking some of the bacteria on to the surface of the seed when it is planted. In this way nodules will quickly develop on the young plant’s roots and it will quickly start trapping nitrogen for the benefit of its host plant. Inoculating legumes with the correct rhizobium is the ideal method of planting them. But not all legumes require inoculation, and the rhizobium is often hard to
obtain and requires cold storage when it has been procured. For all these reasons most legumes in the tropics are not inoculated before planting. In some cases this may result in a complete failure to grow (this is often the reason why leucaena does not grow well), and so either the inoculant must be obtained or use of the species should be avoided. To check if a legume is nodulating properly, simply dig it up and look at the roots and see if the root nodules exist and are full and hard. Nodules will reduce in size during the dry season, when nitrogen fixation is limited by the lack of moisture. An alternative means of obtaining an inoculant is to find a growing, healthy specimen of the species to be planted and to dig up some soil from around the tree. This soil is likely to contain the right strain of rhizobium. Mix this soil with the legume seed before planting.

If inoculation is carried out, a sticking agent is required. Common sticking agents are 40 per cent gum arabic in water or 4 per cent methyl cellulose in water. A simpler agent is to make a very concentrated sugar solution in water. Mix the inoculant and sticking agent together and then add the seeds. This mixing can be done in a strong plastic bag. Continue mixing until all the seeds are coated. Take them out and dry them in a cool place. Sow as soon as possible. Do not store the seed for more than three days; after that, the inoculation process should be repeated.

**Seedlings**

Tree legumes can be planted as potted seedlings or bare-root seedlings, by direct seeding, or cuttings. Seedlings grown in plastic pots or polythene bags have very high survival rates when planted out, but producing them is expensive. The plastic containers have to be obtained, much labour is involved, and it may be difficult to transport them to their planting sites. Ideally the nursery would be close to the final planting sites, so that farmers can transport their own seedlings. Unfortunately large government nurseries are often far from the community.

Bare-root seedlings are grown in a large bed. Before planting out, the leaves should be stripped off and the seedlings carefully lifted out of the bed. They are planted in the same way as potted seedlings, but they are much cheaper to produce and easier to manage and transport. Unfortunately their survival rates are lower than potted seedlings. Once lifted out of the bed, they should be planted out quickly.

The major advantage of planting tree legumes as seedlings is that it gives the trees an early start in the growing season. Trees may be two-three months old at planting time, which should be at the start of the wet season. This gives them a good chance of surviving the first year and getting well established.

Tree seedlings can be grown in government/NGO nurseries; community nurseries; and individual nurseries. The management
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of a large government or NGO nursery is beyond the scope of this book. However, nurseries managed by communities or by individual farmers in their own house compounds should be encouraged in goat-development programmes. If farmers become involved in preparing their own tree seedlings, they will feel responsible for the trees' future care.

Konso, Ethiopia: a tree nursery run by women

Women involved in a goat project in Konso, south-west Ethiopia, were encouraged by local extension staff to plant leucaena trees around their houses and in their fields. The local NGO had a tree nursery near one village and ran the nursery, giving tree seedlings free to any farmer who wanted them. One year the NGO supplied tree seedlings late, towards the end of the rains. Most of the seedlings died. Some seedlings survived, because the women carried water to them throughout the dry season. Frustrated, the women asked if they could take over one of the nursery beds and raise their own trees. The NGO agreed and supplied them with seed and polythene tubes. The next year the trees were ready in time for the start of the rains, and the NGO found the women to be so efficient that some of them were employed full-time in the nursery.

Community tree nurseries

Members of the community involved in goat development may decide to get together and run their own tree nursery. This may be on a voluntary basis, or they might be paid in food, or cash, for the work they do. All that is needed is a small level area, close to a water source and protected from livestock. A source of good soil for the beds is also important and protection against wind may also be necessary. Bed-width should be about one metre (about one pace) wide, with 0.5 metre walk-ways in between. Lengths can vary according to the size of the site. A bed one pace wide and three paces long is big enough for about 100 seedlings. If plastic containers are not used, sink the beds below the surface of the soil, so that they hold the water given to the seedlings. If the sun is very strong, a simple shade should be constructed over the beds so that the seedlings do not wither (Figure 5.11).

Seedlings may be distributed free to those who worked in the nursery and sold to those who did not. Either way a value has been placed on the tree, which is important in order for people to appreciate them fully.

It may also be beneficial to get schools involved in raising trees. Helping a school establish a small tree nursery can have a long-term impact on tree planting in a community. Children can work in the nursery and take home forage and fruit trees. Perhaps
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prizes can be given for the pupil, or class, achieving the best tree-survival rates. Children can quickly learn the value of trees for their family and can even help to educate the other members of their family.

**Individual nurseries**

A farmer and his or her family can develop their own small tree nursery close to the house (Figure 5.12). This is often a good project for children to take part in. A small plot, even as small as 1 m x 1 m, is enough to start. The soil should be well cultivated and seeds directly sown into the plot. It is more convenient if the bed can be raised slightly and water seepage prevented by wooden barriers around the edge of the plot, but this is not essential. In this way it is easier to lift out the seedlings for planting. If wooden battens are not available, the plot should be level with the soil surface, so that water is retained. This is very important, because in most back-yard nurseries water has to be carried to the seedlings, and so it must be used efficiently.

**Figure 5.11 The key features of a community tree nursery**
It is a good idea in individual nurseries to start by using tree species which are very easy to grow. This encourages those involved.

**Cuttings**

Cuttings are an easy and cheap way of propagating some forage species, particularly glyricidia and some grasses, such as elephant grass.

**Tree legumes:** Cuttings from tree legumes should be taken from mature branches. Cut woody sections 30–50 cm long, about the length of an arm and about the thickness of a thumb. The sections should be cut at a 45-degree angle. Do not allow the cuttings to dry out: plant them quickly into a moist site. Trees planted from cuttings tend to develop a very superficial root system, which may make them vulnerable to periods of drought. Trees planted from seedlings develop a deeper root system and can better withstand dry periods.

**Grass cuttings and splits:** Elephant grass is propagated by cutting the mature stem and planting sections 20–30 cm long at an angle in the soil. If the soil is moist, survival rates can be excellent. Elephant grass cuttings should not be planted straight down during the rainy season, or the rain may rot the cutting before the nodules have sprouted. At least half the cutting must be below the surface at an angle, with a nodule just visible. Planting too high may cause the cutting to dry out (Figure 5.13).

*Figure 5.12* A woman weeding sesbania in her own tree nursery, Hararghe, Ethiopia

*Figure 5.13* Planting elephant grass with the cut face angled towards the ground, to prevent it from trapping rainwater and rotting
Many erect grasses, such as guinea grass and phalaris, can be propagated by splits. Cut the grass low, then dig it up carefully and separate it into splits and plant. Creeping grasses can be planted using runners. Cut a section with at least three nodes and bury it so that only a very small part is exposed.

**Seed supply**

Once forage growing becomes a firmly established practice, the supply of planting material must be ensured. Plants may age and die and need to be replanted; farmers may want to expand their forage area; new farmers are likely to become interested in forage growing and will need a source of seeds, seedlings, and cuttings. In some countries there is a well-developed structure for supplying seeds through extension staff or commercial retailers. These countries have their own seed farms and may even export forage seeds. In most countries in the tropics, forage crops are not widely grown and it is hard for farmers to obtain planting material. But once they are introduced to forage species and convinced of their value, provision must be made to maintain a supply of seeds and other planting material. How can this be done?

A government or NGO project promoting forage development should be able to organise the contract production of seed, seedlings, cuttings, and splits, either for sale to the project for subsequent delivery to farmers, or for sale directly to farmers. If a good price is offered, farmers will become interested in growing forage for seed and it can become a valuable cash crop. Guidance should be given on how to grow the species for seed, and a price should be guaranteed for production of seed of a clearly specified quality.

On individual farms, the farmers should be able to multiply their own forage species without external help. A farmer might set aside two or three trees for tree-legume seed-production, for use in his or her own tree nursery. Elephant grass can be allowed to grow and cuttings can be taken from it to expand the area on the farm. Community nurseries may leave a few trees around the edge of the nursery and allow them to flower and set seed for collection and use in the nursery. In this way whole communities can become independent of outside seed suppliers.

Some of the herbaceous legumes and grasses may be difficult for farmers to grow for seed, and the seed may have to be obtained from outside the community; but farmers should be encouraged to become as self-sufficient as possible in the forage species they need.

### 5.4 Feed conservation

In most parts of the tropics, the supply of feeds fluctuates through the seasons. Preserving surplus feed in the wet season for use in the dry season is one method of making the supply of feed to goats...
Improved nutrition

more evenly distributed through the year. There are two main methods of preserving feed: drying and making silage.

5.4.1 Drying

For use in the dry season, crop residues are commonly preserved, either in the field or in the farmer’s house for storage. But natural and improved grass, herbaceous legumes, and tree legumes can also be dried and stored for later use.

Grass can be cut, wilted, dried, and stored in a stack or tied in a bundle or bale of hay. In order to make high-quality hay, the grass should be cut quite young. If it is left to grow past the flowering stage, a greater quantity of hay will be harvested, but it will be of lower quality. In order to balance quality and quantity, a compromise is to cut the hay when about half the grass has just flowered. It should be cut on a dry day and left in the field. It should be turned over at least once to ensure even drying. It will probably take about two days to dry sufficiently for storage.

Unfortunately, in the tropics, the time of year when grass is growing is also the time of year when it is raining, so the cut hay is quite likely to get wet. This reduces the quality slightly, but efforts to dry it should continue. If the rain is very heavy, it is not worth trying to make hay. Hay-making should not be attempted until the end of the wet season, when the rain is stopping. Once made, the hay must be stored in a dry place. If the hay cannot be kept under a waterproof roof, a tightly packed stack will keep most of it dry. Ideally the stack would be raised off the ground, but this might not be possible. In some places farmers use a hay box to make a tightly packed bale, tied with string (Figure 5.14).

In places with a long severe dry season, tree legumes may lose their leaves during the driest period. Rather than being wasted, the leaves can be collected, dried, and used as a protein supplement. Herbaceous legumes such as desmodium can also be dried and stored. High-quality hay, relished by goats, can be made from desmodium. It should be cut and carried to the place of storage when green, to avoid losses from the shattering of leaves. Once dry, leaves tend to fall off the stems and can be lost completely if left in the field — although goats can be put into the field to eat fallen leaves off the ground. Once collected and dried, legume hay can be stored in a stack. Tree-legume branches should be cut and the leaves allowed to dry on the branch. They can then be easily

![Figure 5.14 Hay-box construction](image-url)
Feed conservation

stripped off the branch and stored in a sack as a protein supplement for later feeding.

Cutting, turning, transporting, and storing hay requires much labour and should not be attempted except in the absence of any alternative feed source in the dry season.

Grass can also be left standing in a field or grazing area to dry. If livestock are excluded, this standing hay can be a useful dry-season feed. It has a much lower digestibility and lower protein content than cut hay, because the stem becomes increasingly lignified as it dries out. Standing hay can be a useful feed and it takes no labour to preserve. Leaving standing hay in grazing areas is a common method used by pastoralists for preserving feed for the dry season.

5.4.2 Silage

If green feed is allowed to ferment in the absence of air, it can be preserved in a good state for later feeding. The product made is called silage. This technique is much used in temperate countries. The process of making silage requires bacteria to produce lactic acid, increasing the acid content of the feed and preserving it. If the acid content is high enough, unwelcome micro-organisms cannot grow and the feed is preserved. In order for this to happen, the bacteria need a source of energy. Some crops such as whole maize plants, which have developing grain in their immature cobs, can supply energy, and can be ensiled by themselves. Other tropical forages will need the addition of a source of energy, such as molasses, in order to ferment successfully.

The green feed should be packed very tightly into a pit, or in bags in a pit, and sealed so that no air can enter. Ideally a plastic sheet and stones, or banana leaves and stones, should be placed on top of the pit to seal it, and then people should jump up and down on the contents.

Very little high-quality silage is made in the tropics. Silage making requires the quick cutting of all the forage to be ensiled, and so demands much labour or machinery. The silage pit requires good sealing and possibly the addition of molasses. Rather than risk wasting the feed altogether and making unpalatable silage, rejected by selective goats, it is probably best to make lower-quality hay with any excess feed. Large farms and institutions might be able to make good-quality silage, but it is a difficult, labour-intensive, technology for small farmers.

5.5 Improving the quality of feed and the quantity eaten

In nearly every goat-production system in the tropics, goats will have to eat, at some time of the year, feeds that contain a lot of fibre
Table 5.5 Typical nutritional values of some fibrous residues

<table>
<thead>
<tr>
<th>Feed</th>
<th>Dry matter (%)</th>
<th>Crude protein (%)</th>
<th>Crude fibre (%)</th>
<th>Digestibility of crude fibre (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereal crop residues</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maize stover</td>
<td>85</td>
<td>7.0</td>
<td>34</td>
<td>65</td>
</tr>
<tr>
<td>Wheat straw</td>
<td>90</td>
<td>3.6</td>
<td>42</td>
<td>61</td>
</tr>
<tr>
<td>Sorghum straw</td>
<td>85</td>
<td>6.0</td>
<td>33</td>
<td>74</td>
</tr>
<tr>
<td>Barley straw</td>
<td>92</td>
<td>4.2</td>
<td>35</td>
<td>55</td>
</tr>
<tr>
<td>Rice straw</td>
<td>91</td>
<td>4.6</td>
<td>36</td>
<td>60</td>
</tr>
</tbody>
</table>

(Table 5.5). These feeds may be coarse grass, crop residues such as maize stover or rice straw, or legume crop residues such as peanut stover. All these feeds have a lot of indigestible fibre in them, making it difficult for the goat to digest them and release the nutrients they contain. Goats will struggle to eat these feeds and, once inside them, the feed has to remain in the rumen for a long time before it is digested sufficiently to move out of the rumen and allow more feed in. These feeds thus create double trouble for the goat, supplying it with few nutrients and also reducing the amount it is able to eat. It is common, when fed only these low-quality feeds, for goats to lose weight and condition, produce little milk, and even have difficulty breeding.

There are two methods of increasing the quality of these fibrous feeds and so increasing the amount which the goat eats:

- to treat the residues physically or chemically, to make degradation by rumen micro-organisms easier;
- to supplement the residues with energy and protein to enable the rumen micro-organisms to be very active in breaking down the fibrous feeds.

5.5.1 Treatment of fibrous feeds

Three main treatments can be applied to residues such as straws: chopping; treatment with sodium hydroxide; treatment with urea.

Chopping

When goats are stall-fed, chopping residues, such as rice straw or maize stovers, can improve the amount they are able to eat. The
Improving the quality of feed and the quantity eaten

goat, being a small animal, has a small mouth, and prefers to pick its own feed from a tree or bush using its agile jaws, rather than having to chew its way through large quantities of coarse, unpalatable, feed. When faced with a feed like maize stover, they can commonly be seen struggling to bite an edible mouthful off a stalk, sometimes even resorting to standing on one end of the stalk in order to have something to pull against, and biting off part of the stalk. If residues have to be fed, it will help the goat if they can be chopped into small, mouth-sized, pieces which can be easily eaten. Chopping some of the coarser green feeds such as elephant grass will also increase the amount eaten. This chopping can simply be done by a machete knife. There are also special manual or motor-driven choppers which are very efficient (Figure 5.15).

Treatment with sodium hydroxide
In some parts of the world, the finer straws from rice, wheat, or barley are treated with an alkali such as sodium hydroxide (NaOH) or caustic soda. Alkalis attack the cellulose in the straw, making it easier for the micro-organisms to attack them in the rumen. Unfortunately, strong solutions of sodium hydroxide can be dangerous when spilt on the skin or eye, so special clothes and gloves have to be worn and great care taken. Because of this it is a technology that is appropriate only for farmers who are used to handling chemicals.

Treatment with urea
A much safer chemical treatment of straws is to use urea. Urea has many advantages over sodium hydroxide. It is easier to obtain, it is not toxic, and it also supplies some nitrogen for use by the rumen micro-organisms. The effect of urea treatment on rice straw is shown in Table 5.6. It is clear that the effect is quite small and is the result of a combination of increased digestibility and increased intake. The effect may be significant in some systems. If there are no tree leaves or grass available, urea treatment may be an option for some goat keepers. It might be suitable in intensively cultivated irrigated rice systems, where there is little room for forage growing, but where there is a copious supply of rice straw which is normally burned and wasted. In some parts of the Sahel, millet

Figure 5.15 Using a manually operated chopping machine. Chopping by hand would be cheaper and more appropriate for a small flock.
stover is even collected from fields and sold in town for dry-
season feed. For the effect to be best appreciated, the goat should
be offered as much treated straw as it can eat. Ideally if any
production above a maintenance level is desired, a protein and/or
energy supplement should also be fed.

Urea treatment procedure
Straws can be treated either in a stack or in a pit in the ground.

1 The straw is stacked or put into a pit. The bottom of the stack
should be on waterproof plastic sacks, or plastic sheeting. The
pit should be lined with plastic sheeting.

2 The urea solution should be poured over the straw at 40 g urea
in 900 ml water per kg straw (i.e. 200 g/4.5 litres/5 kg) to make
a feed of 50 per cent moisture. Using a watering can or
knapsack sprayer to apply the urea solution ensures an even
distribution throughout the straw.

3 The stack or pit is then sealed with plastic and left for three
weeks.

4 After three weeks it should be opened and allowed to ventilate.
A strong smell of ammonia will be released; this smell must
fade before feeding the treated straw.

Farmers should always use the best-quality straw available and
store it in a stack before treatment. It is best to treat small batches
of straw, because it will not keep for long, once treated and
opened to the air.

5.5.2 Supplementation
The physiological principles behind supplementation have been
described in Section 4.6. It is important first to identify the
deficiency in the current diet. Most tropical feeds have a high
fibre-content. When thinking about supplementing any fibrous
feed, think about how to feed the rumen micro-organisms with
the nutrients they need to be active, and then think about directly
feeding the goat. Fibrous feeds contain low levels of protein.
Table 5.7 Ranking of common supplements

<table>
<thead>
<tr>
<th></th>
<th>Energy</th>
<th>Protein</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Legume leaves</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leucaena</td>
<td>•</td>
<td>••</td>
<td>•</td>
</tr>
<tr>
<td>Glyricidia</td>
<td>•</td>
<td>••</td>
<td>•</td>
</tr>
<tr>
<td>Sesbania</td>
<td>•</td>
<td>••</td>
<td>•</td>
</tr>
<tr>
<td>Desmodium</td>
<td>•</td>
<td>••</td>
<td>•</td>
</tr>
<tr>
<td><strong>Cereal by-products</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rice bran</td>
<td>••</td>
<td>••</td>
<td>••</td>
</tr>
<tr>
<td>Wheat bran</td>
<td>••</td>
<td>••</td>
<td>••</td>
</tr>
<tr>
<td>Brewers’ grain</td>
<td>••</td>
<td>••</td>
<td>••</td>
</tr>
<tr>
<td><strong>Oil by-products</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peanut cake</td>
<td>•••</td>
<td>•••</td>
<td>•••</td>
</tr>
<tr>
<td>Linseed cake</td>
<td>••</td>
<td>•••</td>
<td>•••</td>
</tr>
<tr>
<td>Cotton seed meal</td>
<td>•••</td>
<td>•••</td>
<td>•••</td>
</tr>
<tr>
<td>Coconut cake</td>
<td>••</td>
<td>••</td>
<td>••</td>
</tr>
<tr>
<td><strong>Fruit and vegetables</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cassava whole</td>
<td>•••</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Cassava leaves</td>
<td>••</td>
<td>••</td>
<td>•</td>
</tr>
<tr>
<td>Sweet potato (whole)</td>
<td>••</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Sweet-potato vines</td>
<td>••</td>
<td>••</td>
<td>•</td>
</tr>
<tr>
<td>Banana peelings</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Sugar-cane tops</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Molasses</td>
<td>•••</td>
<td>•</td>
<td>•••</td>
</tr>
<tr>
<td><strong>Animal origin</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fish meal</td>
<td>••</td>
<td>•••</td>
<td>•••</td>
</tr>
<tr>
<td>Poultry manure</td>
<td>•</td>
<td>•••</td>
<td>•</td>
</tr>
</tbody>
</table>
Improved nutrition

Micro-organisms require both energy and protein to multiply and enable them to attack the fibrous feed and break it down.

There are many feeds in the tropics that can be used as supplements. Table 5.7 lists some of the common supplements and rates them as sources of energy and protein. There are very few energy supplements that are not consumed directly by people as well as by goats. Whole grains or roots or sweet fruit are the best sources of energy that can easily be used by micro-organisms. Obviously they should be used only where there is an unwanted surplus of these foods which humans also consume. Otherwise there are few energy-rich supplements, apart from the by-products of ‘human’ foods such as oil cakes or by-products from milling. Obtaining these will cost the farmer money and they should not be used unless it is clearly profitable to do so.

Purchasing protein supplements is expensive. Avoiding expenditure on supplements is an important reason for growing forage legumes whenever possible.

Mineral supplements

Mineral deficiencies are often hard to detect, because their only effect may be to lower production — which can be caused by several different factors, such as poor nutrition or poor general health. Once mineral deficiencies become pronounced, they are easier to identify, because the symptoms are obvious (see Table 6.15). Kids may be born with bone deformities or muscle stiffness, or hair starts to fall out. In almost every goat system there is likely to be a deficiency of one or more mineral, and goats would benefit from supplementation. In some areas there are well-known deficiencies, such as copper deficiency in the Rift Valley in East Africa.

Ideally goats would receive a specially-formulated mineral supplement in the form of a mineral lick, but in practice this can seldom be achieved. Supplements are not manufactured in every country in the tropics; even if they are, they are seldom widely distributed, except to high-yielding dairy cows near urban centres. In practice, farmers have to rely on locally available minerals, which are likely to be just as deficient as the vegetation. Locally-mined minerals are sometimes traded and find their way to more remote markets. It might be useful to try them, to see if there is any response. Plain cooking salt should be fed where possible: in hot climates, goats will be losing salts all the time and would undoubtedly like, and benefit from, a salt supplement. The mineral nutrition of lactating goats requires special attention. Legumes of all sorts are richer in minerals, particularly calcium and phosphorus, than grasses or stovers.

Internal parasites

All goats in the tropics carry a burden of internal parasites, which rely on their host for nutrients, either (like *Haemonchus contortus*
and *Bunostomum spp*) by sucking blood directly, or (like *Moniezia spp*) by actually consuming partially digested food in the intestinal tract. They place a burden on the goat, which has to support these parasites as well as itself. If farmers decide to put resources, whether labour or money, into supplying food supplements, they should also be encouraged to relieve the goat's parasite burden and spend extra money on anthelmintic drugs (see section 6.4.1). Otherwise the goat will not benefit from the extra nutrients, and farmers will be wasting money.

5.5.3 Improving feed intake: methods of feeding goats

The method of physically presenting food to goats is crucial, yet it has received little attention from researchers. It is important, because it can affect the amount a goat eats, as well as the amount it wastes. If feed has been specially grown, or collected, it is a great waste not to feed it as carefully as possible.

When designing a feeding method, take account of the following factors.

• Goats like to browse, so raise the feed high off the ground.
• Goats are very selective feeders and can waste much of what is offered to them. Ways must be found either to reduce waste feed or to keep fallen feed from being trampled and contaminated.
• There must be enough space at the feeder for all goats to be fed easily without fighting. Young goats should be fed separately from older goats, to avoid competition and trampling.
• If the place where the goats are to be fed is hot and exposed to the sun, the animals' appetite will be depressed. Goats will eat more in a cool and shady place than in a place exposed to direct sunlight.
• The floor must be clean and dry. If goats have to stand for hours on wet and dirty ground, they are likely to develop foot problems. If the ground is clean under the rack or net, then any feed that drops down is more likely to be acceptable if offered again than if it is immediately made dirty by mud and faeces on the ground.
• Think about what materials are available for constructing the feeder. Is there timber, metal or rope?

Bundle and net

The simplest way to feed a small amount of forage is to tie it in a bundle and suspend it from a tree, or from the roof of the farmer's house. The bundle needs to be tied as tight as possible, because goats will pull quite hard. A better method is to make a simple rope net, pack the feed into it, and then suspend the net. The net reduces wastage considerably and is easy to make.
Feed rack
Feed racks can be made from wood or metal. The wood does not have to be cut timber: tree branches will do nearly as well, provided that they are smooth. The height of the rack will depend on the height of the goats. It should be high enough for them to have to reach up and pull the feed down, but not so high that they decide it is less tiring to climb into the rack to eat! Young goats, especially, finding it tiring to eat from an adult-height rack, are prone to jump on top of the rack, and may trap and even break a leg in the gaps between the bars.

Take a goat of average size and extend its head and neck upwards until it is at full stretch. This height should be half-way up the feeding section of the rack. The width between the bars will vary according to the size of the goats and the sort of feed being fed. Fine grass will quickly fall through gaps designed to trap desmodium. Experiment until the gap is the right width for the goats and the feed in question.

The rack may be free-standing or attached to a wall for support. Ideally a tray or second rack would be placed underneath, to catch smaller bits of feed that fall through and prevent them from being soiled on the ground. This feed can be collected and mixed in with fresh batches.

Feeding supplements
Goats can be given feed supplements in various ways: wet or dry, with or without salt, rolled or ground. Farmers should experiment, to find the best method of feeding different supplements, to ensure that they are eaten and not wasted. Goats, like most ruminants, seem to like eating supplements as a gruel rather than as a dry feed. A wooden or clay bowl can be used. Ideally it should be raised and supported, to stop it being knocked over.

Feeding chopped feeds such as elephant grass is difficult with a rack. They should be fed on a tray or in a bowl.

Introduction of new feeds
It is a common misunderstanding that goats will eat anything! This is not true. If goats are allowed to graze freely, they will select a wide-ranging diet, but they can be very fussy when confined and presented with new feeds. Although goats can be persuaded
to eat most feeds, they can remain resolute in their rejection of some. It is a common complaint that when glyricidia is introduced for the first time, goats initially reject it, and may take several weeks to get used to it. Some oil cakes have a strong smell, which goats may take time to get used to. If it smells or tastes disgusting to you, it will not be acceptable to the goat.

Provided that the feed is clean and uncontaminated, goats can learn to eat most feeds. There are various stratagems that can be used. Always present the new feed to them when they are hungry. Mixing the new feed into a favourite feed will normally oblige them to eat a little of the new feed inadvertently. Mixing the new feed with something much liked, such as molasses or salt, will also encourage them to eat it. If all else fails, simply force them to eat it or go hungry. If they have not eaten at least part of it after one or two days, they never will!

5.6 Feeding special goats

In situations of scarce feed resources, or when spending money on feed supplements, it is sensible for the farmer to target scarce or expensive resources on goats that will bring the most reward. The engine of the flock is the breeding female. If she is expected to produce healthy kids regularly, she must be fed enough to do so. If she is also expected to supply milk for human consumption, she will need special feeding to do so. Likewise kids, once produced, deserve special care, because they are vulnerable to poor nutrition and may quickly die because of it.

Fattening young males for sale is an income-generating option for many goat farmers in the tropics. If supplements are purchased, they should be used to their best economic benefit.

5.6.1 Feeding the doe

The doe needs food for maintenance, activity, gestation, lactation for kid(s), lactation for humans, and recuperation.

In addition to looking after herself, the doe needs extra energy and protein to produce young ones, and then to produce milk to feed them. This is a huge nutritional demand. If, in addition to feeding her kid(s), she is expected to produce excess milk for human use, then this is a large extra burden. During lactation,
unless very well fed, the doe will have to use her own body reserves and so will lose weight. After lactation she will need a period of recuperation before producing more offspring. In extreme conditions, if the doe is under-nourished she may not show signs of oestrus and so cannot be mated until she has regained weight. For an efficient goat system, does should kid regularly if possible, but in order to do so they need good feeding.

Figure 5.18 shows the energy and protein requirements of a 30 kg doe that is mated in month 1, becomes pregnant, kids in month 6, and starts her lactation by yielding 1.5 kg milk, which declines to zero in month 12. This figure is presented to indicate how much more energy and protein a doe requires for a successful pregnancy and productive lactation. It also indicates how much she will have to take out of herself if the extra feed is not provided. By the end of the pregnancy the doe has doubled her protein and energy requirements. Lactation starting at 1.5 kg trebles the goat's requirement for protein and doubles its requirement for energy.

Based on the data in Tables 4.4, 4.5, 4.6 and 4.7, Table 5.8 shows the quantities of different feeds needed by a 30 kg doe in order to meet her requirements for maintenance, pregnancy, and lactation. It is considered unrealistic to expect the doe to eat more than 4.0 per cent of her liveweight.
Table 5.8 Quantity of different feeds required by a 30 kg pregnant and then lactating doe yielding 1.5 kg milk/day

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Maintenance</th>
<th>Pregnancy</th>
<th>Lactation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Energy</td>
<td>Protein</td>
<td>Energy</td>
</tr>
<tr>
<td></td>
<td>5.3 MJ</td>
<td>35 g DCP/day</td>
<td>11.5 MJ</td>
</tr>
<tr>
<td></td>
<td>ME/day</td>
<td></td>
<td>ME/day</td>
</tr>
<tr>
<td>Young grass</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry matter</td>
<td>0.7</td>
<td>0.5</td>
<td>1.4</td>
</tr>
<tr>
<td>Fresh weight</td>
<td>4.4</td>
<td>3.1</td>
<td>9.6</td>
</tr>
<tr>
<td>Intake</td>
<td>2.3</td>
<td>1.7</td>
<td>4.6!</td>
</tr>
<tr>
<td>(% liveweight)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Legume leaves</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry matter</td>
<td>0.5</td>
<td>0.3</td>
<td>1.2</td>
</tr>
<tr>
<td>Fresh weight</td>
<td>2.6</td>
<td>1.5</td>
<td>5.7</td>
</tr>
<tr>
<td>Intake</td>
<td>1.7</td>
<td>1.0</td>
<td>4.0</td>
</tr>
<tr>
<td>(% liveweight)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roots</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry matter</td>
<td>0.5</td>
<td>1.4</td>
<td>1.1</td>
</tr>
<tr>
<td>Fresh weight</td>
<td>1.5</td>
<td>4.2</td>
<td>3.2</td>
</tr>
<tr>
<td>Intake</td>
<td>1.7</td>
<td>4.6!</td>
<td>3.6</td>
</tr>
<tr>
<td>(% liveweight)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In order to calculate the balance of feeds required for a specific requirement, Pearson's square can be used. The box on the next page shows how to calculate the protein requirement estimated at 103 g/day, from a combination of young grass and legume leaves.

It is a good idea to practise using the tables given in Chapter 4, to calculate the energy and protein requirements of a doe at different times of her life and to consider how these might be met from the feeds available. Think how long she will have to suckle her kid; and, if she is going to be milked, how long she can be milked. Once the lactation length is decided, a simple seasonal calendar of feed demand can be estimated. Is there a deficit? How can this be overcome?

An alternative to altering the feed supply to meet the demands of the goat is to manipulate the feed demand of the doe to match the available feed supply (Figure 5.19). Breeding can be controlled
Improved nutrition

Balance of young grass and legume leaves needed to supply 103 g protein for lactation

On the left side, write the protein content of the two feeds, obtained from Table 4.7 (lower values); in the middle, write the target protein requirement. For each feed, calculate the difference between its protein content and the target, e.g. 120 — 103 = 17. Write the difference on the opposite side of the target figure. The ratio of these differences indicates the balance of these two feeds that must be eaten to supply the needed protein.

Young grass 75 g  
Legume leaves 120 g

In this case, 17 parts young grass should be fed to 28 parts legume leaves; in other words, for every 1 part of young grass fed, 1.6 parts of legume leaves should also be fed.

in most systems of production, and many goat farmers in different parts of the world do control the time of mating so that kids are born when the feed supply is at its best (see section 7.2.2). For example, the Maasai in Kenya use a leather apron to control mating, and there are other devices that can be used. But remember that, although the kid may be born at the best time of year, it may be weaned, three to four months later, at a very difficult time of year.

--- Feed supply
----- Feed demand (year-round breeding)
------ Feed demand (seasonal breeding)

Figure 5.19 Breeding season matched with feed supply
In addition to feed, the dam has a high requirement for water during lactation. If she does not receive enough water, her milk production will be restricted and the kid may suffer and even die.

A dam should receive 4 litres of water for every kilo of dry matter that she eats, and 1.3 litres for every litre of milk she produces.

| A 30 kg doe eats 3 per cent of her body weight in dry matter = 0.9 kg DM per day. |
| She requires 4 litres of water per kg DM eaten = 4 x 0.9 = 3.6 litres |
| and 1.3 litres of water per litre of milk produced. |
| If she produces 1.5 litres of milk per day, she needs 1.95 litres of water. |
| Rounding up these figures, we can say that the TOTAL water required = 3.6 + 2.0 = 5.6 litres of water per day. |

5.6.2 Feeding the kid

The kid is born with a partially developed rumen and needs milk or a milk substitute for the first few weeks of its life, while its rumen develops to digest fibrous food. If the kid and dam were in their natural state, the kid would be following its mother as she grazed, suckling on demand. The dam is producing milk all the time, and the kid is able to suckle only a small amount of milk at one time. Its natural rhythm is to suckle a little, sleep a little, follow its mother and suckle again. When goats are domesticated, this natural rhythm is disturbed. The goat keeper may want some of the milk for the family and may have to restrict the amount taken by the kid. Dairy-goat farms in developed countries will rear female kids on a purchased milk-replacer diet, and may slaughter unwanted male kids at birth, to ensure that all milk produced is sold.

If the doe is milked, then the kid should be allowed to suckle at least twice a day. The presence of the kid at milking encourages the doe to let down all the milk in her udder. The kid may be allowed to suckle one teat, while the other is milked (see 10.1.1). The teat milked and the teat suckled should be changed from morning to evening milking. The kid should be allowed to suckle out both teats at the end of milking, to avoid mastitis (see 6.4.9).

If the doe is not milked, the kid may be allowed to suckle regularly. If the doe is housed all day, the kid could be with the dam continuously, unless the doe is feeding with other goats which may knock over the kid. A way around this is to have a kid box which only kids can get into, or a second pen for kids, separated by
a wall with a gap at the bottom through which kids may creep and suckle and then return to the other pen. If these arrangements do not work, the kids should be kept separately in a draught-free place, out of excessive heat or cold, and put with their mothers three or four times per day.

If the dam is out grazing all day, the kid should be allowed to suckle on its mother’s return and be allowed to stay with its mother all night. Ideally the dam would return in the middle of grazing to allow the kid to suckle, but if the dam is far away, this may be difficult to arrange. Suckling only twice a day will reduce kid growth and make the kid susceptible to malnutrition and disease.

The kids will start nibbling on bits of vegetation one week after birth. They should be encouraged to do so, because this is how the rumen micro-organisms are acquired. However, kids are very susceptible to infections and to picking up parasites when they are very young; so they should be provided with high-quality clean feed, such as sweet-potato vines or tree legume leaves or natural tree leaves (Figure 5.20).

If kids’ suckling time is restricted, they may also need additional water, particularly in very hot climates. If they are allowed to wander freely, they will search for water and may pick up infections from drinking in dirty puddles. Provide a source of clean water for the kid.

Figure 5.20  Sweet-potato vines hung to feed recently weaned kids
CHRISTIE PEACOCK
Kids may be able to go out grazing with their dams when about six weeks old, provided that they do not have to walk too far. Weaning should take place when the kid has reached about three times its birth weight. In most tropical breeds, weaning takes place naturally, because milk supply declines abruptly after two–three months of lactation, and the kid is able to feed on vegetative material.

5.6.3 Feeding for fattening

In most developing countries there is a steady rise in the demand for meat in towns and cities, as population increases and people move into urban areas. As people become richer, they are able to afford more animal protein in their diet. Farmers who have access to urban markets may be able to take advantage of these markets and fatten goats for sale. Goats can also be fattened for specific religious holidays, when prices rise. Farmers may fatten stock which they have reared themselves or buy young males for fattening and sale.

There are very few reports of commercial goat-fattening enterprises in the developing world; some reports indicate that it is probably not economic to spend money on concentrate feeds for indigenous tropical breeds of goats unable to respond to the high level of feeding. It is doubtful whether a large-scale feedlot system, with intensive feeding of batches of goats for slaughter, would be profitable with indigenous breeds of goats. However, the less intensive fattening of goats on low-value feeds is an option for small-scale farmers who have access to cheap agricultural by-products or high-quality forages.

In intensive dairy-goat systems using temperate breeds of goats such as Saanen, Toggenburg or Anglo-Nubian, large numbers of male kids will be produced which would be more responsive to intensive feeding than indigenous goats. A more intensive fattening system might be appropriate, using crosses (or pure) temperate breeds.

The age of fastest growth is between weaning (3–4 months) and acquiring the first pair of permanent incisors at 14–15 months. It is probably not economic in most circumstances to feed a goat very intensively for one year after weaning. The semi-intensive fattening of goats for 12–18 months after weaning, using high-quality forages or crop by-products, might be profitable.

Chapter 4 showed how to calculate the nutrient requirements of different goats, and showed how different feeds were able to supply different nutrients. When fattening a goat, it is likely that several different feeds will be used, some of which may be purchased. If the farmer is going to spend money on purchased feed supplements, it is important to know if the supplementation really does result in a cash profit. This can be calculated by using a partial budget.
Improved nutrition

How to prepare a partial budget in order to calculate the profit/loss of a small change

The following information is needed:

<table>
<thead>
<tr>
<th>Costs</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extra costs</td>
<td>Extra returns</td>
</tr>
<tr>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Reduced returns</td>
<td>Reduced costs</td>
</tr>
<tr>
<td>= Total costs</td>
<td>= Total gain</td>
</tr>
</tbody>
</table>

Total gain - Total costs = Profit/Loss

It is useful to calculate a partial budget in the following circumstances.

- Small changes are made to one enterprise.
- The change made is not linked to an input or output of another enterprise.
- The inputs are easy to measure and value.
- The farmer is interested in a cash profit.
- The fixed costs on the farm do not change.

Simple calculations can help to clarify whether the farmer is receiving real benefits from the change made in the management of the goats.

How to calculate the benefit of supplementation

It is assumed that supplementation increases the growth rate of the goat, resulting in a larger goat sold, in a shorter period, which will reduce the other costs associated with keeping goats.

<table>
<thead>
<tr>
<th>Costs</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of supplement</td>
<td>Higher price because larger goat at sale</td>
</tr>
<tr>
<td>Cost of transporting supplement</td>
<td>Reduced labour because of shorter period</td>
</tr>
<tr>
<td>Cost of feeder construction</td>
<td></td>
</tr>
</tbody>
</table>

Total costs                                Total gain

Total gain - Total costs = Profit/loss

The total cash costs of buying, transporting, and feeding the supplement should be easy to compute. It may be harder to estimate the additional benefits, unless records were kept of performance before the change was made.
Partial budgets are suitable only in situations where farmers have a clear objective to make money from their goats. Once farmers start spending money on inputs (feed supplements, drugs, etc.) for goats, then closer scrutiny of the real benefits of the inputs should begin. There are, of course, many intangible benefits from keeping goats, which cannot easily be costed.

5.7 Case studies

In order to show how to apply nutritional principles to improve the feeding of goats in real systems, three case studies from widely different systems will be described.

5.7.1 Housed goats in Java, Indonesia (mixed farming: humid tropics)

Java is a very densely populated island in Indonesia, where land is very intensively cultivated. The staple crop is rice, which may be irrigated or grown on upland slopes. A multitude of fruit, vegetable, spice, and cash crops are also grown. Around their houses farmers plant several layers of crops, ranging from tall timber trees, to coffee trees and fruit trees, down to spices and herbs and root crops under the ground. Rainfall in the west is as high as 4,000 mm per year, but may fall to 1,000 mm in some parts of the east; humidity is high all the year round. There is no room for any livestock to graze freely, so they are all restrained in some way. Buffaloes and cattle may be tethered in rice-stubble fields when not working, or kept in a small pen close to the farmer’s house. Sheep and goats may also be tethered, but are often kept in specially constructed houses. The houses are made of bamboo, with thatched or tiled roofs, and are normally raised off the ground. Feed has to be cut from roadsides and rice bunds and carried to the goats in the house. They are normally fed from a small trough attached to the outside of the house (Figure 5.21).

Goats are kept for the family’s security and to generate some cash when needed. They are rarely milked. Farmers are trying to keep as many goats as they can on the very limited land available. They like goats to twin and for mortality to be as low as possible. Most people in Java are Muslims, so the price of goats rises sharply at the time of Muslim holidays; good money can be made if goats are sold at this time. Generally the price of meat is increasing, as
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demand rises from the expanding urban population. There is a need to intensify goat production, to make the most efficient use of the limited feed resources, and there is scope for some farmers to engage in the profitable fattening of goats.

A rapid survey of goat production was carried out in two villages in west Java. The rainfall pattern, cropping pattern, and seasonal feeding practices are shown in Figure 5.22.

Farmers rely heavily on crop residues such as rice straw, cassava leaves, sweet-potato vines, legume straws, and rice bran in feeding their livestock, as well as cutting grass (*Axonopus compressus* and *Ischaemum timorense*) from roadsides, rice bunds, and under the many clove trees grown in the area. A few tree legumes such as leucaena and calliandra are cut as feed, and there are several other tree leaves such as jackfruit and banana. The samples of the mixture of feeds were collected and analysed, first

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**Figure 5.22 Rainfall, cropping, and feed calendar, west Java**

- **Rainfall**
  - 500 (mm per month)
  - 0

- **Cropping pattern**
  - Rice • Rice • Rice • Rice • Rice (Irrigated)
  - Rice • Rice • Sweet potatoes • Rice (Semi-irrigated)
  - Rice • Sweet potatoes or maize • Rice (Rain-fed)

- **Goat feeding**
  - Housed/cut-and-carry
  - Mixture of grass, tree leaves and cassava leaves

- Jan June Dec
for simple dry-matter content. The fodder cut to feed goats contained 15–30 per cent DM, herbs 13–20 per cent DM, and tree leaves 20–40 per cent DM. Grasses made up 40–60 per cent of the diet, herbs 20–30 per cent, and tree leaves about 10 per cent. This indicates that not only are farmers carrying a lot of water in this cut-and-carry system, but they are feeding forage with a high water content. This was thought to be reducing the amount the goats were eating.

When proximate analysis was carried out, the crude protein content of grass was found to be 8–20 per cent, for herbs it was 15–30 per cent, and for tree leaves it was 15–25 per cent. The fibre content was quite low, so it would be anticipated that digestibility would be quite high. In addition the feeds were analysed for sodium.

The following conclusions on the quality of the diet were drawn.

- Dry-matter intake-rates were low, because the feed had a high moisture content.
- Protein levels were adequate.
- Levels of energy were not adequate to make use of the protein.
- Levels of sodium were low.

Apart from looking at what feeds were cut and carried to the goats at different seasons, the method of presenting the feed was observed. The feed was collected once a day and given only once a day, in a big load placed on top of the old feed. By the time the new feed was given, the old feed was starting to rot in the high temperature and humidity, and it smelt bad. As the old feed had already been rejected by the goat, it was pointless to keep it in the trough. However, it was not very easy for the farmer to clean the trough, because it was high up and rigid. Cleaning it out would have been easier if it was hinged, so that it could swing down and allow the rejected feed to fall to the ground. Once on the ground, it could be put under the house and mixed with the urine and faeces which fall through the slatted floor. This is a good method of trapping valuable urine to enrich the composted waste feed and faeces. Compost in Java rots very quickly and can be used to fertilise crop-land or forage.

It was obvious that herbs and tree leaves were particularly liked by goats, while the grasses were avoided.

The following conclusions on the method of feeding were drawn.

- Some species were obviously particularly liked by goats and could be fed in greater quantities.
- Most of the feed was liked, but it was fed in one lump, allowing goats to be wastefully selective. More would be eaten if the goats were fed little and often.
- The left-over feed quickly rotted and became unpalatable. It
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would be better if the trough was cleaned every day and the waste feed composted.

The following nutritional improvements were suggested to goat farmers in the village.

1 Construct a hinged feed trough to help cleaning. Cleaning should be carried out every day and the waste feed should be put under the house to trap urine, and mixed with the manure to make high-quality compost.

2 As most of the feed is liked by goats, feed it in small amounts regularly through the day (three–four times a day), to increase in-take.

3 Feed more of the forage species particularly liked by the goats.

4 If possible, feed a source of energy that rumen micro-organisms can use, to make good use of the crude protein already in the diet.

5 Supply salt to the goats in a simple bamboo container.

Near the village are several sources of by-products suitable to feed as a supplement. There is a rice mill where rice bran can be purchased, a cassava-processing factory producing a waste called ‘onggkok’, and a soyabean-processing factory supplying waste from ‘tahu’ processing. Most of these products contain some amount of starch and are quite cheap to buy. They could be fed as energy supplements to selected goats, for example young bucks being fattened for a particular Muslim holiday, or does suckling twins.

Figure 5.23 Improved house design
The supplements should be fed every day in a form which the goat finds easy to eat. For example ‘onggkok’ is very hard and should be soaked in water to soften it before feeding. Adding salt to supplements makes them more palatable. When starting to encourage farmers to purchase supplements, the health of the goats, particularly their intestinal parasite burden, must be considered. Although goats in this area of west Java were housed, because of the humidity they were still picking up parasites’ larvae from their cut feed. Research found that parasite larvae can even live for some time attached to the bamboo poles of the house. Goats were often observed licking the poles of the house, in order to acquire salt, and might pick up parasites in the process. When encouraging farmers to spend money on supplements, they should also be encouraged to spend money on drenching their goats, in order to get the full benefit of the supplement.

5.7.2 Tethered dairy goats in the highlands of Ethiopia (mixed farming: highland)

Goats are kept throughout the highlands of Ethiopia on small mixed farms. Some parts of the highlands are very densely populated, and farms are as small as 0.5–0.25 ha per family. The main crops are sorghum, maize, sweet potatoes, and the narcotic bush and cash crop, ‘chat’ (*Catha edulis*). Rainfall is low, 500–800 mm, and fluctuates from year to year. There are occasional severe droughts. Soil erosion is a serious problem. There is an increasing shortage of livestock feed for the cattle, goats, sheep, and donkeys kept. Communal grazing areas are under pressure from their increasing cultivation, from erosion, and from increasing numbers of livestock.

Poverty and malnutrition are major problems in most areas. With the rainfall available and the small size of the farms, it is very difficult for farmers to feed their families, let alone produce excess for sale. A few cash crops such as coffee or chat may be grown by some farmers. Livestock are an important source of income.

One or two cattle are kept by some farmers for ploughing and milk, and in some areas for fattening. Goats are kept in small flocks of 2–5 animals. The main reasons for owning goats are for family security, for sale, and in some places for the small amount of milk they produce. They are normally housed or tethered during the crop-growing season and may be released to graze in stubble fields or hillsides during the dry season. The price of meat is continuously rising, due to the increasing demand from urban centres, especially before the many religious holidays. Some farmers specialise in fattening cattle, sheep, and goats for sale during these holidays, when high prices can be obtained.
There is an increasingly important role for both goats and sheep in the highlands of Ethiopia, as farms become too small to need, or support, cattle for cultivation or milk. A small intensive goat system fits in well. The question is: how to intensify the feeding of goats when food for humans is so scarce?

A non-governmental agency started a dairy-goat project in the south and east of Ethiopia with the intention of developing a more intensive dairy-goat system. A group of students from the local college carried out a rapid survey of current goat-feeding practices, by interviewing some of the women involved in the project. The seasonal feed calendar they produced is shown in Figure 3.1.

From the descriptions of the feeds available, there are some obvious problems in both quantity and quality of feed. During the growing season, farmers are able to provide a diet of reasonable quality, by feeding weeds from their farm-land, and maize and sorghum-leaf pickings from growing crops. In the dry season the situation changes and quality deteriorates rapidly, unless the goats are able to graze bushy hillsides freely, in which case they can probably select a reasonable diet for themselves. But in some areas goats may have only fibrous maize or sorghum stover, and their condition rapidly deteriorates. There is some scope for using sweet-potato vines in places where they are grown.

The project realised that feed supply was going to be critical to the success of the project, as the aim was eventually to introduce a cross-bred, high-yielding goat on each farm. This goat would need a lot of high-quality feed for it to perform well. The supply of feed had to be ensured.

It was obvious that there were virtually no by-product supplements available, either on or off the farm, to improve the diet, and that any improvement would have to come from improvements on the farm itself. There was, however, potential for integrating forage crops into the cropping system, without affecting the main crop. Growing forage was a new technology for the farmers, so the project started by insisting that they planted a small area of forage around their houses, before they received goats on credit.

The women and their husbands were trained in appropriate forage strategies, in this case backyard pasture, undersowing, and forage strips for forage and erosion control. Farmers started
to plant grass strips on contours in their fields. They also planted tree lucerne, sesbania, and leucaena around their houses and in contour strips, and along paths and as fences. A few farmers sowed vetch under their sorghum crop. Some even planted forage under their valuable chat bushes.

Most farmers developed their own back-yard tree nurseries, growing sesbania and leucaena. As soon as the cross-bred goats were distributed, there was an upsurge in interest in growing forage crops in order to feed the goats well.

The cross-bred goats are kept tethered throughout the year. Women try hard to feed them as well as they possibly can, because they know that the next day they will be rewarded with extra milk. In the dry season, sweet-potato vines and small, poorly formed potatoes are fed. Small quantities of left-overs from maize grinding may also be fed. Leucaena and sesbania are regularly cut, and dry-season bulk feed comes from elephant-grass strips.

The cross-bred goats are performing better than expected. As farmers get more benefit from their goats, they are planting more forage to feed them.

5.7.3 Goat herding by the Maasai in Kenya (semi-arid pastoral)

The Maasai are pastoralists who inhabit the semi-arid grazing lands of southern Kenya and northern Tanzania. Rain falls in two seasons, leaving a long and a short dry season. The long dry period may last for five months. The Maasai are renowned for keeping large herds of cattle and milking them for most of their staple food. In fact the area inhabited by the Maasai is diminishing in size, so it is difficult for the expanding Maasai population to live exclusively off their cattle. They have kept sheep and goats in mixed flocks for centuries, but are increasingly relying on them, as over-grazing and recurrent droughts reduce cattle numbers more than sheep and goat numbers. The ability of sheep and goats to survive droughts has led the Maasai to increase their dependence on them, although cattle are still important. Livestock are regularly traded for grain and other commodities.

The Maasai are nomadic to varying degrees. Some are now settled, but most still move their cattle and sheep and goats, even though they may maintain a house (boma) near schools or shops. The grazing land has always been communal, but is now being broken up into areas owned by groups. Goats are kept in flocks with sheep. Total flock numbers may be as small as 5 or as large as 400. The mean flock size is about 120, usually half goats and half sheep. Goats are mainly kept for family security, and for sale in times of need. They are also used as currency in social transactions such as marriages, or to cement a friendship. They may be slaughtered at ceremonies and are highly prized for their
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medicinal properties. It is thought that, because goats eat so many different species of vegetation, they must possess the ability to cure illness. They may be milked in the dry season, if the cattle have dried up.

Goats are herded the whole day (8–10 hours) by young children or women. In the dry season they walk 8–15 km per day while out grazing. The Maasai try to keep their goats in more favourable bushy areas, rather than grassland areas, which are reserved for cattle. In the dry season they lose weight, as much as 25 g per day, quickly regaining it in the wet season. Goats are able to take advantage of the green flush of new growth immediately before the start of the rains. There are areas known as *enkusero*, specially reserved for sheep and goat grazing. These *enkusero* are...
normally areas of poorly drained black-cotton soils where bush vegetation, such as *Acacia mellifera* and *Acacia nubica*, tends to grow. In some parts of the Maasai territory there are large areas of *Acacia tortilis*. These trees, once mature, produce large quantities of protein-rich seed pods during the long dry season. If the labour is available, flock owners will move their sheep and goats to the *A. tortilis* areas during the dry season and feed their flocks on the pods. Herders use long poles to shake the pods down from the trees, and the flock follows on to pick up the pods.

The environment in which the Maasai live is harsh, and they have to cope with a great deal of variability in the supply of grazing. Rain falls in marked seasons; the amount that falls varies from year to year and from place to place. There is no doubt that being able to move cattle, sheep, and goats to areas of good rainfall is of fundamental importance in ensuring healthy and productive livestock. In this situation of low rainfall and communal ownership, it is very hard for a Maasai goat owner to increase the quantity of feed available through, for example, planting forage crops. All that can be done is to move to good vegetation when possible and make the best of the grazing that is there.

In order to feed their goats well, Maasai goat-keepers have to manipulate the following factors.

- **Movement**
  - The location of the flock
- **The grazing day**
  - The frequency of watering
  - The direction of movement
  - The speed of movement
  - The total time spent grazing

A family's ability to move their livestock is mainly determined by the supply of suitable labour available for herding cattle, sheep, and goats as well as for looking after school-children, old people, and other dependants. In the dry season, households may split into three units: a school-children's boma with some milk cows, a far-away cattle boma, and possibly a sheep and goat boma, perhaps in an area of *A. tortilis* or some other area suited to sheep and goats.

Once in a particular place, the herder has to decide how often to water the goats. In the wet season this will be easy, because there are surface water ponds. But in the dry season, although the herder knows that the goats will be able to eat more if they have water, the watering place is likely to be well used by other flocks, and will be over-grazed in the area immediately surrounding it. Watering takes time away from grazing time, and for that day may result in the flock eating little from the over-used vegetation. On non-watering days the herder is better able to pick the bushy places most suitable for goats, and allow the flock to linger there.
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It is clear that there is little a goat owner can do to improve the total supply of feed available, but he or she could manipulate the seasonal demands of the flock by controlling breeding so that kids are born during the most favourable seasons. This, in fact, is what the Maasai do. Mating is controlled, so that most kids are born during the short wet season, which is followed by a short dry season before the long wet season. This is the best time of year for them to be born; but if the short rains fail, the kids are born at the end of a very long dry season. There are risks associated with this practice.

The results of a monitoring study showed that kids are very vulnerable at the time of weaning, particularly if this takes place in the long dry season. There might be scope for storing some of the *A. tortilis* or other pods, and using them as a supplement for weaners, or for goats suckling twins. Suckling kids also need special care.

Much of the Maasai grazing lands are in or near the Rift Valley, which is known to be deficient in copper and other minerals. The Maasai use natural salt licks, but investigation is needed into whether these natural licks offer an adequate supply of supplementary minerals.

At an aggregate level the Maasai, in any particular area, can coordinate their grazing, so that some is left as standing hay for the dry season, rather than large herd owners moving ahead of smaller families and monopolising the grazing. There is evidence that this coordination was a traditional practice which is now dying.

Further reading


