Sheep and Goat Production Handbook for Ethiopia

Edited by Alemu Yami & R.C. Merkel

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Ethiopia Sheep and Goat productivity Improvement Program (ESGPIP)

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ETHIOPIA SHEEP AND GOAT PRODUCTIVITY IMPROVEMENT PROGRAM

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Preface

Ethiopia, with over 42 million head, has the third largest number of sheep and goats among African nations and ranks eighth in the world. Traditionally, sheep and goats have served as a means of ready cash and a reserve against economic and agricultural production hardship. However, the proximity of Ethiopia to large Middle Eastern markets demanding export quality sheep and goat carcasses and an increase in the domestic demand for small ruminant meat is leading to a change in the importance and scale of sheep and goat production. No longer are sheep and goats subsistence livestock species only. Economic opportunities exist for small ruminant producers to supply animals to both the export and domestic markets. Taking advantage of these opportunities requires overcoming many barriers to increased productivity, including nutrition, health, reproduction/genetics, marketing, and management. This Sheep and Goat Production Handbook for Ethiopia is designed to assist in overcoming these barriers. Publication of this book is part of the Ethiopia Sheep and Goat Productivity Improvement Program (ESGPIP), a USAID-funded project involving the Ethiopian Ministry of Agriculture and Rural Development (MoARD) and two American universities, Prairie View A&M University and Langston University.

The Sheep and Goat Production Handbook for Ethiopia is the first text devoted to small ruminant production written exclusively for Ethiopian conditions by Ethiopian scientists. The broad scope of the handbook allows it to serve a variety of audiences. Its primary use will be as a training resource and reference handbook for Kebele Development Agents (KDAs) in their quest to transfer knowledge and skills to sheep and goat producers. Other stakeholders, such as non-governmental agencies and development workers will also find the book useful in their efforts to enhance sheep and goat productivity. The depth and coverage of information on all aspects of small ruminant production also renders the book usable in an academic environment as a resource or classroom text.

The outline for the wide array of topics covered in the handbook was prepared by the ESGPIP team with inputs from the MoARD and the American Institute for Goat Research of Langston University. Leading authorities for each topic were sought from universities, research institutes, and the MoARD to develop the handbook's content. Each chapter was then rigorously reviewed by relevant professionals and partner institutions to ensure the content would be applicable and useful to KDAs and farmers. Draft chapters were used in training KDAs in six regions of Ethiopia and comments received from KDAs themselves on ways to improve the handbook's usefulness.

It is the sincere belief of the ESGPIP team that the Sheep and Goat Production Handbook for Ethiopia, along with a companion series of Technical Bulletins on specific issues of small ruminant production, will greatly contribute towards improving the productivity of sheep and goats. Improving small ruminant production will enhance food security and help to bring about meaningful changes in the livelihoods of Ethiopian farmers and the country's economy.

At this juncture, I would like to express my special thanks to Drs. Alemu Yami, Training Officer at the ESGPIP, and Roger Merkel, Langston University, for devoting much effort and time to bring the handbook to its current state.

Desta Hamito (Prof.)
Chief of Party
ESGPIP

Contents

Chapter One

Economic Significance of Sheep and Goats

Adane Hirpa and Girma Abebe

Objectives

1. To explain the importance of sheep and goats in rural production systems.
2. To show the advantages of small ruminants over cattle.
3. To show the trends in export for sheep and goat meat and how that impacts demand and production.
4. To discuss the constraints of sheep and goat production in Ethiopia.

Expected Outputs

1. Improved knowledge of the economic significance and roles of sheep and goats in the livelihoods of producers in Ethiopia.
2. Increased understanding of the constraints of sheep and goat production in Ethiopia.

1.1. Significance (Advantages) of Raising Sheep and Goats

The total number of sheep and goats in Ethiopia is estimated to be nearly 48 million. Sheep and goats are widely adapted to different climates and are found in all production systems. They also have lower feed requirements compared to cattle because of their small body size. This allows easy integration of small ruminants into different farming systems.

Human population growth in Ethiopia is forcing the conversion of many former grazing areas into croplands needed for increased food production. Raising large ruminants is becoming increasingly difficult as a result of the ensuing lack of grazing areas. Land holdings in densely populated areas are below 0.5 ha. In such places, the importance of sheep and goats in fulfilling the role once played by cattle for meat, milk and manure production is being increasingly recognized. The increased demand for sheep and goat meat has also increased their importance in lowland pastoral areas as a source of cash income, food security, etc.

Special features of sheep and goats

Feeding behavior

Sheep and goats have different but complementary feeding habits. Sheep are grazers and amenable to herding, hence a species of choice in mixed cropping areas where cereal production dominates. On the other hand, goats are browsers and highly selective feeders – a strategy that enables them to thrive and produce even when feed resources, except bushes and shrubs, appear to be non-existent. Thus, the presence of goats in mixed species grazing systems can lead to a more efficient use of the natural resource base and add flexibility to the management of livestock. This characteristic is especially desirable in fragile environments.

Size

Being small-sized animals, sheep and goats require a small initial investment. Their small size, together with early maturity, makes them suitable for meeting subsistence needs for meat and milk.

Fat deposition

Sheep and goats vary in fat deposition, presumably due to different adaptation strategies. Compared to goats, sheep lay down more subcutaneous and intramuscular fat from surplus energy. Goats tend to lay down more internal fat, which is not associated with the carcass. Where carcass fat is a delicacy and fetches a higher price, sheep make an important contribution to the household economy.

Survival rate during drought

Sheep and goats have higher survival rates under drought conditions compared to cattle. Moreover, because of their reproductive rates, flock numbers can be restored more rapidly. With regard to goats, water economy is also an important biological feature. It is common for goats to be watered every four days and still provide a reasonable amount of production.

High offtake

Due to their short reproductive cycles (short lambing/kidding interval) and high incidence of multiple births (particularly for some breeds such as the Horro), there is potential for a higher annual offtake of sheep and goats than seen with cattle. This allows farmers/producers a quick interval of selling part of their flock and generating cash income.

1.2. The Role of Sheep and Goats in Food and Economic Security

Sheep and goats are among the major economically important livestock in Ethiopia. There are about 23.62 million sheep and 23.33 million goats (IBC, 2004) in the country, playing an important role in the livelihood of resource-poor farmers. They provide their owners with a vast range of products and services such as meat, milk, skin, hair, horns, bones, manure and urine for cash, security, gifts, religious rituals, medicine, etc.

Sheep and goats are relatively cheap and are often the first asset acquired, through purchase or customary means, by a young family or by a poor family recovering from a disaster such as drought or war. Sheep and goats, once acquired, become a valuable asset providing security to the family as well as milk and dairy products.

In the subsistence sector, farmers and pastoralists depend on small ruminants for much of their livelihood, often to a greater extent than on cattle, because sheep and goats are generally owned by the poorer sectors of the community. Any intervention that improves the productivity of sheep and goats is important in creating wealth and improving the standard of living of resource-poor farmers. The short generation interval of sheep and goats coupled with high frequency of multiple births allow for rapid increases in animal numbers. This builds financial capital and allows the sale of surplus animals for cash that can be used for other agricultural enterprises, school fees, medical bills, etc.

Very often, there are no banking facilities in rural areas and an easy way to store cash for future needs is through the purchase of sheep and goats. In fact, in some areas, small ruminants have been described as the 'village bank'. It has to be noted that this is beyond the cash value of the animal. Small ruminants represent only 7% of the average total capital invested in livestock in the mixed crop-livestock production system, but they account on average for 40% of the cash income and 19% of the total value of subsistence food derived from all livestock production.

Sheep and goats contribute a quarter of the domestic meat consumption; about half of the domestic wool requirements; about 40% of fresh skins and 92% of the value of semi-processed skin and hide export trade. It is estimated that 1,078,000 sheep and 1,128,000 goats are used in Ethiopia for domestic consumption annually. There is also a growing export market for sheep and goat meat in the Middle Eastern Gulf States and some African countries (Figure 1.1). At optimum offtake rates, Ethiopia can export 700,000 sheep and 2 million goats annually, and at the same time supply 1,078,000 sheep and 1,128,000 goats for the domestic market. The current annual offtake rate of sheep and goats is**,** however, only 33 and 35%, respectively. The average carcass weight of Ethiopian sheep and goats is 10 kg, which is the second lowest in sub-Saharan Africa.

The increased domestic and international demand for Ethiopian sheep and goats has established them as important sources of inland revenue as well as foreign currency. This increased demand also creates an opportunity to substantially improve food security of the population and alleviate poverty.

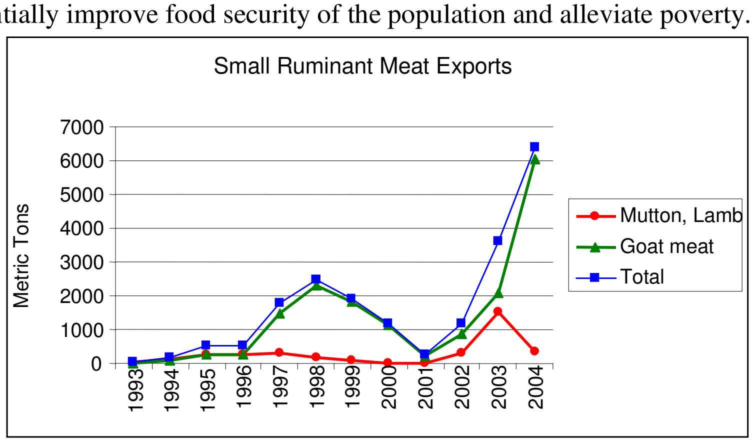


Figure 1.1. Volume (Metric Tons) of small ruminant meat exports from Ethiopia, 1993–2004.
Source: Data for 1993–2003 (FAO statistics); Data for 2004 (Ethiopian LFMD, unpublished statistics).

1.3. Major Constraints of Sheep and Goat Production in Ethiopia

Sheep and goat production and productivity in Ethiopia is constrained by many factors. The major ones are summarized below.

Scarcity of feed: The feed resource base for sheep and goat production in Ethiopia is natural grazing and crop residues. The quality and supply of these resources is seasonally variable. Grazing resources in the highlands are diminishing due to increases in cropping land. Bush encroachment and overgrazing have reduced grazing resources in the pastoral areas.

Lack of infrastructure: Infrastructure necessary to transport livestock or livestock products from remote rural communities, where production is concentrated, to urban markets is lacking. Sheep and goats are generally trekked long distances for marketing, often without adequate water and feed. They are also trekked similarly long distances in search of feed and water. There are very limited market centers and stock routes with the necessary facilities such as feeding and watering points.

High mortality rates: About one-half of all lambs/kids born die due to various causes. This is a very important constraint limiting productivity. Annual mortality in all classes of stock averages 23% for sheep and 25% for goats in the central highlands.

Inadequate veterinary coverage: This results in high mortality and morbidity. Certain disease conditions are also causing Ethiopian animals and products to be banned from export markets.

Long marketing channels and lack of market information: Producers do not have access to market information. The system lacks market orientation, which would have been an important driving force for increased production.

Low product quality: Poor quality of live animals and small ruminant meat and meat products prevents penetration into many export markets.

Absence or inadequate provision of credit services: Livestock owners have difficulty obtaining credit to begin or expand production, purchase inputs, increase stock, etc.

Low average reproductive rates: Typical reproductive rates average as low as 55 lambs and 56 kids born per 100 mature females per year in the central highlands.

References

Ehui, S. 2000**.** A review of the contribution of livestock to food security, poverty alleviation and environmental sustainability in sub-Saharan Africa. ESAP (Ethiopian Society of Animal Production) 2000. **Livestock production and the environment – implication for sustainable livelihoods**. Proceedings of the 7th annual conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, 26–27 May 1999. ESAP (Ethiopian Society of Animal Production), Addis Ababa. pp. 1–13.

FAO. 2004. FAO production yearbook, http://faostat.fao.org

Institute of Biodiversity Conservation. 2004. The state of Ethiopia's farm animal genetic resources: Country Report. A contribution to the first report on the state of the world's animal genetic resources. IBC. May 2004. Addis Ababa, Ethiopia.

Markos Tibbo. 2006. Productivity and health of indigenous sheep breeds and crossbreds in the central Ethiopian highlands. PhD Thesis. Swedish University of Agricultural Sciences.

Peacock, C., Devendra, C., Ahuya, C., Roets, M., Hossain, M., and Osafo, E. 2005. Goats, livestock and wealth creation. E. Owen, A. Kitallyi, N. Jayasuriya and T. Smith eds. Improving the husbandry of animals kept by resource-poor people in developing countries. Nottingham University Press, Manor Farm, Main Street, Thrumpton Nottingham NG11 0AX, United Kingdom.

Zelalem Alemayehu and Fletcher, I. 1991. Small ruminant productivity in the central Ethiopian mixed farming systems. Proceedings of the 4th NLIC, 13–15 November 1991. Addis Ababa, Ethiopia. pp. 141–147.

Chapter Two

Breeds of Sheep and Goats

Kassahun Awgichew and Solomon Abegaz

Objectives

1. To identify some important indigenous breeds of sheep and goats in Ethiopia.
2. To describe the main features of important indigenous breeds of sheep and goats in Ethiopia.
3. To describe some important breeds of sheep and goats that were introduced earlier or have the potential to be introduced into Ethiopia and the advantages and disadvantages of their introduction.
4. To explain important parameters for meat, milk, fiber and skin production.
5. To describe some important breed identification parameters.

Expected outputs

1. Knowledge of the descriptions and types of sheep and goats in Ethiopia.
2. Understanding of some breed identification parameters.
3. Knowledge of the purpose and advantages of breed introduction.
4. Understanding of measures to be taken in breed importation and use.

2.1. Origin, Domestication and Distribution of Sheep and Goats

2.1.1. Sheep

Sheep (*Ovis aries*) are believed to have been among the first animals to be domesticated, preceded by the dog and goat. The domestication of both sheep and goats probably dates back to the pre-settled agricultural period. It is also believed that most domestication took place in western Asia where the majority of the present day small ruminant breeds likely originated. Existence of some ancestral stock of wild sheep extends from western Europe to China. These are:

- the *mouflon* of Europe, the Middle East (Asia Minor), and western Iran,
- the *urial* of western Asia and Afghanistan,
- the *argali* of central Asia, and
- the *bighorn* of northern Asia and North America.

It is assumed that the majority of today's domestic sheep breeds descended from the *urial* which is currently found in central Asian countries and in northern Iran extending up to Tibet and northern China. The hair sheep of Africa and Asia are thought to have descended mainly from the *urial*. The *argali* is believed to have played a significant role in the development of domesticated sheep of India and the Far East.

In Ethiopia, there exists a great variation in climate and topography, harboring diversified livestock species which also have variability among themselves. The sheep found in Ethiopia could fall into different breeds and types whose habitat ranges from tropical to temperate environments. The present fat-tailed sheep of Ethiopia that are believed to have replaced the original African long-thin-tailed sheep came from Asia through the Strait of Bab El Mandeb.

Although sheep were domesticated as dual purpose animals to produce wool and meat, early people would have valued sheep milk as well.

2.1.2. Goats

Goats (*Capra hircus*) are believed to be the second animal domesticated following the dog. It is also believed that the first goats reached Egypt around 5000 B.C. and then spread south and west throughout Africa. African goats could be grouped into three main families: the Dwarf goats of West and Central Africa, the Savannah goats of sub-Saharan Africa and the Nubian type goats of North Africa. The parents of the Nubian goats came from Asia. It is assumed that the first wave of goats entered Ethiopia from the north between 2000 and 3000 B.C. The ancestors of Ethiopian goats are closely associated with goat types which migrated from the Middle East and North Africa. According to earlier characterization work, indigenous Ethiopian goats have been phenotypically classified into 11 types while a recent genetic characterization showed only eight distinctively different types (Tesfaye, 2004).

The indigenous goats of Ethiopia are found in all agro-ecological zones of the country. It is believed that these goats have evolved through a process of natural selection that resulted in goats selected for adaptation and survival rather than production *per se*. Ethiopian goats in the lowlands are highly valued and reared mainly for milk and meat production. In the highlands, goats are mainly kept for meat. Goats are also sources of manure, valuable skins and cash income.

2.2. Ways of Classifying Breeds

Identification, characterization and documentation of sheep and goat breeds is important for any type of development or improvement work. Without such documentation it would be difficult to know the animals and their potential.

A modification of the FAO sheep and goat breed descriptors list (FAO, 1986) could be adopted for use in identifying both species in Ethiopia. In addition to FAO's descriptors, tropical goat breeds could also be classified according to their height at withers (Devendera and Mcleroy, 1982). These methods are useful to list both qualitative and quantitative morphological characteristics and other variables. This serves as a Master Record where physical characteristics of breeds within species are recorded. The main elements of the Master Record are presented in Table 2.1.

Table 2.1. Example of a Master Record showing main elements to be considered in developing a master record for description of sheep and goat breeds.

No.	Part of breed master record
1	Breed name *(if listed in Mason's World Dictionary of Livestock Breeds, types and varieties)*
2	Breed name *(local or other synonyms)*
3	Classification *(for goats):*
	a. Short-eared with small or no horns
	b. Short-eared with twisted horns
	c. Long-eared, hornless
	c. Long-eared, horned
	d. Height at withers *(large, >65 cm and weighing 37–50 kg; small, 51–65 cm and weighing 26–36 kg; dwarf, <50 cm and weighing 18–25 kg)*
4	Strains (or within breed types or sub-types)
5	Use: for meat, milk, skins, fiber, manure or other (specify)
6	General information and breed description:
	a. General information and breed description
	b. Region, Wereda, zone and population data (population size, annual population trend: +%; -% or unknown
	c. Flock size (communally owned, smallholders, commercial or government farms)
	d. Origin of breed if known (indigenous, exotic); if exotic, from which country or region was it imported?
7	Coat color (% of surface area for both males and females)
8	Head (Profile: straight, slightly convex, markedly convex-Roman nose for both males and females)
9	Ears (erect, pendulous, semi-pendulous, carried horizontally, vestigial or absent — give % with absent ears)
10	Wattles (sometimes present, always present in both males and females)
11	Horns:
	a. number (males, females: indicate absence by "0")
	b. shape (straight, curved, spiral, corkscrew)
	c. orientation (lateral, obliquely upward, backwards)
	d. size (small, <15cm; medium, 15–25 cm; large, >25 cm)
12	Hair/Wool:
	a. Type (hair or wool)
	b. Length (12 months-old fleece: short, <5cm; medium, 5–10cm; long, >10 cm)
	c. Crimp/curl (straight, low crimp frequency: <4/cm, high crimp frequency: > 4/cm)
	d. Wool cover (give % of sheep in each category):
	Head (covered, bare)
	Face (covered, partly covered, bare)
	Belly (covered, bare)
	Legs (covered to hocks, covered to below hocks, bare)
13	Bearded (males and females): Present or absent (give % in each)
14	Tail (Sheep: males and females)
	a. Type (Thin, Fat rump, Fat)
	b. Shape of fat tail (cylindrical and straight, cylindrical twisted up at end, broad)
	c. Length (undocked): short: well above hocks, medium: at or near hocks, long: well below hocks
15	Ruff on brisket and shoulder *(males and females)*
	a. Present or absent *(give % in each)*
16	Basic temperament *(males and females)*
	a. Docile
	b. Moderately tractable
	c. Wild

17 Conservation status
a. Endangered
b. Vulnerable
c. Rare
d. Indeterminate
e. Out of danger
f. Insufficiently known
g. Not at risk
18 Drought tolerance *(give grades 1–5, 1 = high)*
19 Heat tolerance *(give grades 1–5, 1 = high)*
20 Free format breed description field *(description of breed characters may be entered here instead of information under fields 6–15)*
21 Record prepared by:
a. Name:
b. Title:
c. Address:
d. Institutional Affiliation
e. Date of amendment
22 Record updated or edited by:
a. Name:
b. Title:
c. Address:
d. Institutional affiliation
e. Date of amendment

2.3. Ethiopian Sheep Breeds and Their Characteristics

Attempts have been made since 1975 to identify and characterize Ethiopia's sheep breeds or types (IAR, 1975). Unsuccessful attempts have been made to establish elite flocks of identified sheep such as Afar, Blackhead Ogaden (Blackhead Somali), Horro and Menz in research centers and government farms. Other additional breeds/types such as the Washera sheep in the Amhara Region and Arsi-Bale sheep in the Oromia Region have been described to a limited extent. The map in Figure 2.1 shows distribution of some Ethiopian sheep breeds (Solomon Gizaw, 2007) and a sketch of the Red Sea area showing the Bab El Mandeb route of fat-tailed sheep introduction into Africa. .

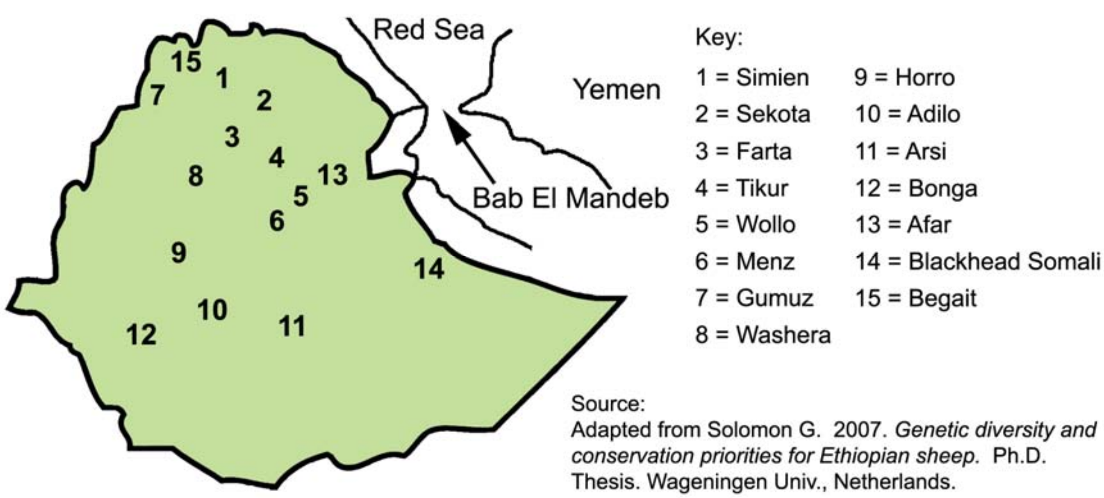


Figure 2.1. Geographic distribution of some of the major Ethiopian sheep breeds

2.3.1. Afar sheep

The Afar sheep formerly referred to as Adal sheep in literature, is a fat-tailed sheep. It is a small-sized breed with mature weight ranging 30–35 kilograms (kg). The natural habitat of the breed is the Middle Awash Valley in eastern Ethiopia, extending as far as Dire Dawa in the east and the town of Bati in the north. The habitat has an altitude ranging 300–1100 meters above sea level (m.a.s.l.), and is between 40 and 42 ºE longitudes and 9 and 11 ºN latitudes. Rainfall in the area is erratic and annual precipitation ranges from 300 to 700 millimeters (mm). The vegetation is mainly of sub-desert range types consisting of a sparse cover of low shrubs and bush cover, which is currently being invaded by *Prosopis* (an invasive tree species). The Afar sheep are hardy and tolerate periods of drought relatively well as the breed evolved under harsh environmental conditions.

The Afar sheep have small ears and usually have a dewlap and thick layers of fat on the brisket. The fat tail has a wide base and reaches below the hocks. Hair is short and coarse, the predominant color being solid blond with other colors ranging from shaded white to light brown. There are a few exceptions of animals with spotted color patterns and/or dark brown hair. The average observed wither height for adult rams is 66 centimeters (cm) while that for adult ewes is 61 cm. Afar sheep weigh about 2.5 kg, 13 kg and 25.8 kg at birth, weaning (90 days), and one year of age, respectively. Ewe mature weight is about 31.6 kg. Twin births are not common.

Figure 2.2. Afar sheep at Melka Werer Research Center.

2.3.2. Arsi-Bale sheep

Arsi-Bale sheep are fat-tailed and covered with coarse wool (wavy wool). They are widely distributed in the highlands of eastern and south-central Ethiopia, in Arsi, Bale, Hararghe and East Shoa zones of Oromia Region and in many parts of the southern region. The climate in these areas varies from semi-arid to sub-humid with annual rainfall above 1500 mm. The production systems range from agro-pastoral to agricultural and urban. Arsi-Bale lambs weigh 2.7 kg and 14.2 kg at birth and at 120 days (weaning), respectively.

Figure 2.3. Arsi-Bale sheep (in background).

Figure 2.4. Arsi-Bale sheep, Arsi Negele Market.

2.3.3. Blackhead Somali sheep

The Blackhead Somali is indigenous to the Ogaden area of the Somali Region. The breed is also known by various names in eastern Africa and other countries including Blackhead Persian and sometimes as Blackhead Ogaden sheep. It is widely distributed within 42–48 ºE longitudes and 3–9 ºN latitudes.

Figure 2.5. Blackhead Somali sheep at Jijiga.

The Blackhead Somali is distinguished by the black color of the head. The body is predominantly white but other colors may be observed. The hair is short, stiff and shiny. Both rams and ewes are hornless, though males can sometimes have rudimentary horns. The forehead is convex and the nose tends to be of the Roman type. The ears are short and pointed with an outward-forward inclination. Most animals have a well-developed dewlap which sometimes extends from the chin to the chest with considerable fat deposits. The tail is a fat rump type with a very distinct fat depot having a thin tip sticking straight backward and sometimes hanging down.

Figure 2.6. Blackhead Somali ewe flock at Haramaya University.

There is some undocumented evidence which indicates that there are some Somali clans in the Ogaden who specialize in stud breeding. These clans apply some sort of selection, favoring larger body size and fatter tail and rump. The adult weight of Blackhead Somali ewes is between 30 and 35 kg. The Blackhead Somali sheep are also hardy and well adapted to the dry, drought-prone environments of the Somali and southern tip of Oromia regions. The altitude in the Somali region is below 1000 m and mostly below 500 m. The climate is dry and arid with erratic rainfall and a mean annual precipitation ranging between 200 and 400 mm. The vegetation is similar to that found in the Afar Region.

2.3.4. Horro sheep

The natural habitats of Horro sheep are the western and southwestern parts of the country. The Horro sheep is widely distributed in areas covering western Shoa to East and West Wollega, Illubabor and Jimma zones of Oromia Region. These areas lie between 35 and 38 ºE longitudes and 6 and 10 ºN latitudes. Altitude of the area ranges 1400–2000 m.a.s.l.. Mean annual precipitation is between 1000 and 1400 mm. The vegetation of the habitat ranges from broadleaf savannas to woodland and open wooded grassland to forest types.

The predominant color of Horro sheep is a solid tan (light brown). Other colors observed are creamy white, dark brown, and sometimes black and spotted. The body is covered with short, shiny hair. The face profile is straight with a somewhat convex appearance in males. Both rams and ewes are hornless.

Figure 2.7. Horro sheep at Bako Agricultural Research Center.

Horro sheep have a relatively long neck without a dewlap but most have fat deposits below the lower jaw and in the brisket. Wattles are rarely present. The fat tail is triangular with a relatively narrow base and pointed end which hangs downward sometimes with a slight twist, mostly reaching just below the hocks. The rams usually have a mane between the head and brisket and above the neck and shoulder.

Horro sheep are larger than most other indigenous sheep having a mean height of 73 cm and 68 cm at the shoulders for adult rams and ewes, respectively. Horro sheep weigh 2.8–2.9 kg, 13–15 kg and 25–33.5 kg at birth, weaning (90 days), and one year of age, respectively. Ewe mature weight is about 38.2 kg. Twin births are common, sometimes reaching 60% in older (multiparous) ewes. Horro sheep are not only larger in size compared with other indigenous breeds but also seem to be more prolific.

2.3.5. Menz sheep

The natural habitat of Menz sheep is North Shoa and parts of Wollo Zone of the Amhara Region. These areas lie within 39–40 ºE longitudes and 10–11 ºN latitudes. Altitude in most cases is above 2500 m.a.s.l. with a cold, harsh climate that occasionally has frost, particularly between November and January. The mean annual precipitation is between 900 and 1360 mm and the rainfall pattern is bimodal.

DAGRIS , 2004

Figure 2.8. Menz sheep in Debre Birhan area.

Menz sheep are the most prominent coarse wool bearing sheep in Ethiopia. The body is compact and mostly covered with coarse hair with a wooly undercoat. The people in the area use the coarse wool to make a cloak, locally called "*Bernos*," and rugs. The coat color is black or dark brown, perhaps with white spots on the head, neck and legs. Other colors such as light brown, roan and white also exist.

Figure 2.9. Menz ewes — Mehal Meda area, North Shoa.

The head has a straight profile and is free of any wool cover. Rams mostly have twisted horns while ewes are usually hornless. Menz sheep have small ears with a downward-forward inclination. This breed has no dewlap and wattles are very rare. The tail is short and fat and has a broad base, ending halfway to the hocks with a slight twist at the end. Menz sheep are not known to be a docile breed.

The mean height at the shoulders is 64 cm and 58 cm for adult rams and ewes, respectively. Menz sheep weigh about 2.3, 11 and 26–30 kg at birth, weaning (90 days) and one year of age, respectively. Ewe mature weight is estimated to be about 35 kg. Twin births are common, sometimes up to 60%.

2.3.6. Washera (Dangla) sheep

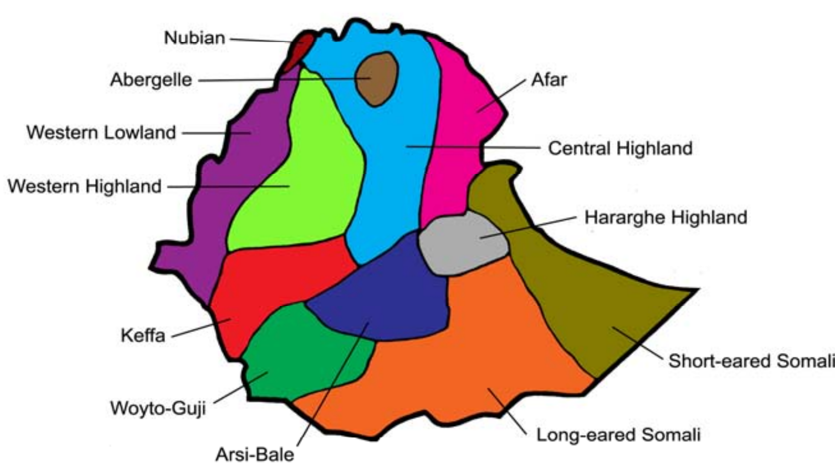
The Washera (Dangla) sheep is found predominantly in West and East Gojam zones of the Amhara Region extending to the south of Lake Tana. Washera sheep weigh about 2.8, 13.8 and 22.7 kg at birth, weaning and six months of age, respectively. The growth rate after weaning is comparable and even better than some other indigenous breeds. This indicates the potential of this breed for commercial mutton production for the local and export markets. Washera sheep have high twinning rates.

Figure 2.10. Washera (Dangla) sheep.

2.4. Ethiopian Goat Breeds and Their Characteristics

According to recent estimates, the goat population in Ethiopia is about 23.3 million. A large proportion is found in the lowlands of the country, raised in large flocks by pastoralists. Nearly 10 million goats (42% of the total) are found in the highlands.

Figure 2.11 shows the distribution of goat types in Ethiopia. Some of the most important goat breeds and their characteristics are presented in the discussion that follows.



Source: Adapted from FARM Africa et al. 1996

Figure 2.11. Geographic distribution of Ethiopian goats.

2.4.1. Abergelle goats

The Abergelle goat is believed to be a relative of the Afar and Worre goats. It is found along the Tekeze River and some parts of Alamata of the Tigray Region, and Wag Hamra (Sekota) and East Gondar zones of the Amhara Region. Abergelle goats are stocky, compact and well-built. The goats have a straight to concave facial profile. Both males and females have horns and in most cases the horns in males are much bigger and spiral shaped. The coat of most goats is plain and patchy. Spotted coat colors are common. The hair is short and smooth in both sexes and males have beards and ruffs. Mean height at the shoulders is 71.4 cm and 65 cm for adult bucks and does, respectively. Abergelle goats are milked for domestic consumption. Their skin is also used to make aprons, containers, etc.

ARM-Africa, 1996.

Figure 2.12. Abergelle male (left) and female goats.

2.4.2. Afar goats

The Afar goat is also referred to as the Adal and Danakil goat. Its natural habitat is the Afar Region but it can also be found in northern and western Hararghe zones of the Oromia Region. Its distribution extends to the Afar area of Eritrea and northern Djibouti. Afar goats are well adapted to arid environments where they are watered every three or four days. These goats are hardy and used to long distance trekking in search of feed and water.

The Afar goat has a concave facial profile, narrow face and forward-pointed ears. The breed is also characterized as being leggy. Both males and females are horned, though females have smaller horns. The coat color is variable with a fine, short appearance. Most males have beards while wattles could appear in both males and females. Mean height at the shoulders is 64.5 and 60 cm for adult bucks and does, respectively. Afar goats are milked for domestic use or sale. The goats are maintained for meat, milk and skin production and for social affairs as they are commonly given away as dowry.

FARM-Africa , 1996.

Figure 2.13. Afar female goats.

2.4.3. Arsi-Bale goats

The Arsi-Bale goats are widely distributed covering the whole of Arsi, Bale and western Hararghe zones of the Oromia Region, and the high altitude areas of Sidama Zone of the Southern Region. Arsi-Bale goats are also found in most areas of the Rift Valley from Lake Abaya to south Shoa Zone. They are mostly kept in small flocks in mixed farming areas.

FARM-Africa, 1996.

Figure 2.14. Arsi-Bale male goat.

Figure 2.15. Arsi-Bale female goats; Adami Tulu Research Center, Oromia.

The Arsi-Bale goat has a straight facial profile. Males have curved and backward-pointed horns. Females mostly have shorter horns. Some males have ruffs while most have beards. Wattles are also present in some males and females. The coat color varies considerably with white as the most common color in males, and brown in females. Goats at higher altitudes have longer hair. Arsi-Bale goats have fairly long ears, and some of them have pendulous ears. Mean height at the shoulders is 73.2 cm and 66.1 cm for adult bucks and does, respectively. Arsi-Bale goats are reared for meat, milk and skin production. Manure is also a valuable product used to fertilize backyard farms.

2.4.4. Begayit (Barka) goats

It is believed that the Begayit, also known as Barka in Eritrea, was derived from Nubian type goats. These goats are mainly found in western Tigray. Begayit goats have a predominantly Roman type facial profile. They are tall with mean height at the shoulders being 74.3 cm for adult bucks and 67.9 cm for does.

The coat color of Begayit goats is mainly white with brown patches. Their hair is particularly long around the thighs. Both sexes have horns that are straight or curved and oriented backwards. Males have beards and ruffs. Begayit goats have relatively large udders and are milked.

FARM-Africa, 1996.

Figure 2.16. Begayit (Barka) male (top) and female goats

2.4.5. Central Highland goats

Central Highland goats are related to Western Highland and Keffa goats. These goats are mainly found in the Central highlands, west of the Rift Valley, Wollo, Gondar and Shoa.

The Central Highland goats have a predominantly straight facial profile. All male goats have curved or straight horns which are oriented backwards. The coat color varies, the predominant color being red-brown, and the hair is smooth. Males have beards and ruffs. In some cases, wattles are also present.

The mean height at the shoulders is 76.3 cm for adult bucks and 67.9 cm for does. Skin is an exportable commodity while manure is used to fertilize backyard farms.

2.4.6. Hararghe Highland goats

Hararghe Highland goats are believed to have been derived from Short-eared Somali goats. These goats are small in size. The coat color is white, brown or black and the hair is short and shiny.

Photos: DAGRIS, 2004.

Figure 2.17. Central Highland goats

The goats have a straight-to-concave facial profile. Both males and females are horned but there could also be a high proportion of polled goats among the flock. Horns could be straight or curved. Most male goats have beards but no ruffs. Some goats have wattles. Mean height at the shoulders is 71.5 cm and 62.5 cm for adult bucks and does, respectively. Hararghe Highland goats are kept for meat, milk, skin production and for social functions.

Photo: FARM-Africa (1996)

Figure 2.18. Hararghe Highland goats.

2.4.7. Keffa goats

The Keffa goat is related to the Western Highland goat. They are widely distributed in the highlands and lowlands of Keffa and South Shoa zones of the southern region. Keffa goats are relatively short and have a straight facial profile. Mean height at the shoulders is 75.6 cm and 66.7 cm for adult bucks and does, respectively. Most males have straight and backward-oriented horns. Keffa goats have a coarse, hairy coat, the dominant colors being black or brown. Males have beards and ruffs. Wattles are also observed in some goats. Goat meat is frequently eaten in areas where these goats are kept. They are also used for some social functions.

FARM-Africa, 1996.

Figure 2.19. Keffa male (left) and female goats.

2.4.8. Somali goats

The Short- and Long-eared Somali goats are related. The Short-eared Somali goats are widely distributed in northern and eastern Ogaden, Dire Dawa. The Long-eared Somali goats are found in all parts of the Ogaden, lowlands of Bale and Borana zones of Oromia and in some parts of Sidama zone of the Southern Region.

Figure 2.20. Somali bucks at Haramaya University.

The Short-eared Somali goats are smaller than the Long-eared ones. Mean height at shoulders for adult Short-eared Somali bucks and does is 64.9 cm and 61.8 cm, respectively. The corresponding figures for Long-eared Somali adult male and female goats are 75.8 cm and 69.4 cm, respectively.

Figure 2.21. Somali does at Hawassa University.

Both types have a straight facial profile and a short, smooth coat which is mainly white. Horns are present in both males and females and the horns are curved and oriented backwards. Males also have beards but only the Long-eared Somali bucks have ruffs. Short-eared Somali goats have shorter and slightly forward pointed ears while the Long-eared Somali goats have horizontally oriented and semi-pendulous ears.

Both the Short- and Long-eared Somali goats are milked extensively. Goat meat is also favored in these areas compared to mutton. Both types are reared for meat, milk, various social affairs and skin production.

2.4.9. Western Highland goats

Western Highland goats are known to be related to the Central Highland and Keffa goats. These types of goats are widely found in the Highlands of South Gondar, Gojam, Wollega and West Shoa.

The western Highland goat is relatively tall and has a concave facial profile. The body is mostly covered with coarse hair, forming a long coat. Mean height at the shoulders is 80.7 cm and 70.8 cm for adult bucks and does, respectively.

The most observed color is plain followed by patchy and spotted color patterns. Although both males and females have horns, there are also some polled animals. Horns are mostly straight and backward-oriented. Males also have beards and ruffs. Polledness and presence of wattles is also observed among some goats. Goat milk is not consumed in these areas.

Photos: FARM-Africa (1996)

Figure 2.22. Western Highland male (left) and female goats.

2.4.10. Western Lowland goats

The Western Lowland goats are also called Gumuz. These are thought to be closely related to the Central and Western Highland goats. The Western Lowland goats are widely distributed along the areas bordering the Sudan (Metekel, Assosa and Gambela).

Identifying features of Western Lowland goats are their relatively short stature and straight facial profile. The dominant color is white followed by fawn, black and grey. White patchy colors are also commonly observed. Mean height at the shoulders is 67.2 cm and 63.5 cm for adult bucks and does, respectively.

Both males and females have straight and backward-oriented horns. Most males also have beards and ruffs. Polledness and presence of wattles is also observed in some goats. Goats are milked in the pastoral and agro-pastoral areas.

FARM-Africa, 1996

Figure 2.23. Western Lowland male (left) and female goats.

2.4.11. Woyto-Guji goats

Woyto-Guji goats are known to be related to the Arsi-Bale types. These goats inhabit a wide area extending from South Omo to southern Sidama and Wolayita. Woyto-Guji goats are also found in trypanosomiasis affected areas in and along the Gelo valley to the south of Lake Abaya and other adjacent areas.

The body is covered with shiny and smooth hair of various colors. The predominant coat colors are reddish-brown appearing in a patchy pattern with black or brown stripes running along the back, on the underside or on the front of the legs.

Photo: FARM-Africa, 1996

Figure 2.24. Male (left) and female Woyto-Guji goats.

The Woyto-Guji goat is a medium-sized goat. The head is small with a mostly straight-to-concave facial profile. Most males and females are horned and there are some polled animals. Horns are mostly oriented backward or upward and sometimes laterally. Males have beards and ruffs, and some goats have wattles.

Goats in these areas are kept for milk, meat, skins and manure production. They are also important for some social functions.

2.5. Important Exotic Sheep Breeds

There are many types of sheep in the world kept for a variety of purposes. Only some of the important breeds that can play a role in the development of Ethiopian breed productivity are selectively described.

Some of these breeds have been imported into Ethiopia at some time in the past in an attempt to improve meat and fiber production of the indigenous breeds, particularly the Menz sheep.

Figure 2.25. Awassi Ewes at Amedguya Sheep Breeding Center, Amhara Region.

2.5.1. Awassi sheep

Awassi sheep are widely distributed in the Middle East with a range covering Israel, southwest Iran, southern Iraq, Syria and northeast Arabia. These are fat-tailed sheep known mainly for their meat and coarse wool along with dairy potential.

The average, traditionally maintained mature ewe weight is between 40 and 50 kg. Rams have

large horns and ewes are polled.
Awassi rams and ewes were imported in 1980, 1984 and 1994 from Israel to be crossed with the Menz sheep at Amedguya and Debre Birhan sheep breeding and multiplication centers. Reports show that 87.5, 75 and 50% crosses were distributed to farmers through the extension program of the then Ministry of Agriculture.

Farmers seemed to prefer Awassi crosses over crosses with fine wool-bearing exotic sheep like the Hampshire and Corriedale. The reason for farmers' preference is presumed to be the phenotypic similarity of Awassi crosses to the local sheep along with their larger size and ability to produce substantial amounts of carpet type wool which was very useful for local cottage industries.

Figure 2.26. Awassi Rams at Amedguya Sheep Breeding Center, Amhara Region.

2.5.2. Corriedale sheep

The Corriedale breed originated in New Zealand and is a cross between Lincoln and Merino with a later addition of the Leicester breed into the crossing. The intent was to develop a dual purpose breed that could produce medium wool as well as a good quality carcass.

Corriedale sheep were used in Debre Birhan and Amedguya sheep breeding ranches for many years from the 1970's through the early 1990's to produce crossbred Corriedale/Menz animals for distribution. The crosses, particularly the 75 and 87.5% Corriedale rams, were distributed to many parts of the country.

Photos: Courtesy – Graham Meadows Photography; 1999-2000 Hoseasons Web Designs & New Zealand Sheep Breeders' Association

Figure 2.27. Corriedale ram (left) and ewe with twin lambs.

2.5.3. Dorper sheep

The Dorper is a meat breed developed in South Africa. It is a crossbred between the Dorset Horn and Blackhead Persian breeds. Dorper sheep are also widely distributed in some African countries such as Botswana, Zimbabwe, Zambia and Kenya.

Dorper sheep can also be found in North America and other countries around the world. The body of Dorper sheep, except the belly and the face, is covered with a mixture of hair and some coarse wool. Dorpers have a black head and neck with a white body, but there are also solid white Dorper sheep.

Both rams and ewes are polled. Dorper sheep are relatively big and ewes under a favorable environment weigh about 60 kg. Dorper sheep are fast-growing with good conformation for meat production. The breed is well adapted to dry environments and is well-suited to a wide range of production systems.

Photos: Henry du Plooy, Select Genes Ltd, Republic of South Africa

Figure 2.28. Dorper ram (left) and ewe with lamb.

Photos: P J Cilliers (Jnr), Select Genes Ltd, Republic of South Africa (1999)

Figure 2.29. Whte Dorpers.

2.5.4. Hampshire sheep

The Hampshire breed was established in 1815 in the United Kingdom. Hampshire sheep are famous for early maturity and carcass quality. A fully grown ram weighs about 90 kg and a ewe, 63 kg. Under good management, lambs will gain 0.45 kg daily from birth to four months, reaching a weight of about 40 kg at four months. They are also known to produce good wool with an average staple length of 9 cm. The breed is widely used for crossbreeding throughout the world to produce top quality lambs for meat production.

Photo: From- Ponting, K. (1980)

Figure 2.30. Hampshire Down ram.

This breed was crossed with Menz sheep at Debre Birhan and Amedguya Sheep Breeding and Multiplication Centers in the 1970's, 1980's and early 1990's. Crossbred animals appeared to have no adaptability problems. However, in all cases, farmers complained that the Hampshire crosses produced poor quality skins. This has not been substantiated through studies. Hampshire crosses are reported to still exist in some parts of Wollo, and the north-central highlands. All pure and crossbred Hampshire sheep were sold out from both sheep breeding centers in the late 1990's.

2.6. Important Exotic Goat Breeds

There are also many types of meat and dairy goat breeds in the world. Only some of the important breeds that have been introduced to Ethiopia earlier or with merits of high value for future use are described. Most of the breeds introduced to date have been dairy goats with the main purpose of crossing with local goats to improve milk production in areas where goat milk is known to be consumed.

2.6.1. Anglo-Nubian goats

The Anglo-Nubian is a dual purpose breed known for both meat and milk production. The breed was developed through the crossing of Jamnapari (Indian) and Zaraiby (Egypt) breeds with Nubian and Damascus ancestry. Anglo-Nubians are polled, have a convex facial profile and lopped ears. The breed is well-adapted to tropical environments and was introduced to Ethiopia through FARM-Africa for upgrading Hararghe Highland goats for milk production.

Figure 2.31. Anglo-Nubian bucks at Haramaya University.

There has also been a crossbreeding study of Anglo-Nubian with Somali goats at the Awassa College of Agriculture. Crossbred kids weighed about 3.2 kg and 14.8 kg at birth and nine months of age, respectively. The breed performs well both as a purebred and a crossbred for meat and milk production.

2.6.2. Beetal goats

Beetal goats were developed from the Jamnapari breed and are found in the states of Punjab, Haryana and other Indian states. The temperature of the areas where this breed is found ranges from 17 to 32ºC (degree Celsius) with an average annual rainfall of 700 mm.

Beetal goats have a convex facial profile with a typical Roman nose. Ears are long, curled and drooping. The length of the ears is about 25 cm. Horns are thick and medium sized and carried horizontally with backward and upward orientation. The breed has a short, lustrous coat cover with variable colors dominated by brown or black. White spots of differing sizes are also common.

Photo: Acharya. R.M.,1982

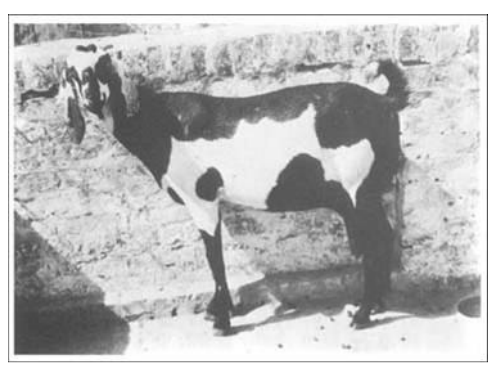


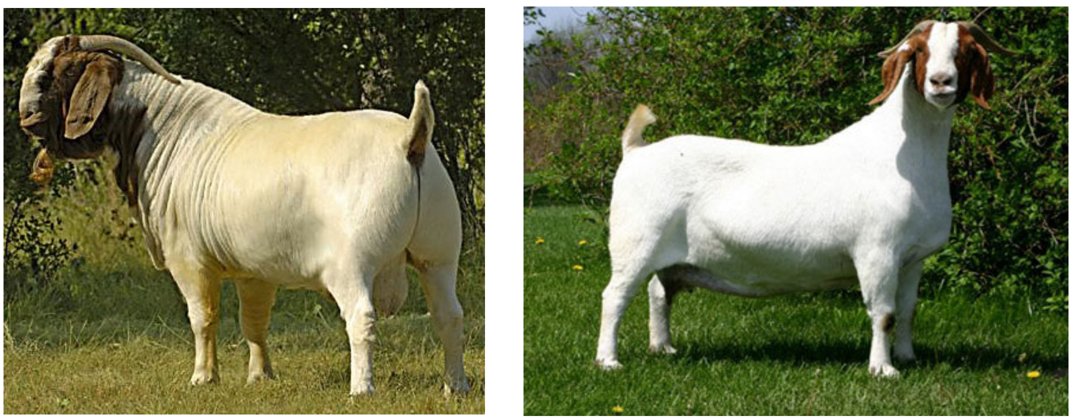
Figure 2.32. Beetal buck (left) and doe.

Beetal goats weigh 2.8, 12.2 and 21.8 kg at birth, 6 and 12 months of age, respectively. Mature weights of male and female goats are about 59 and 35 kg, respectively. Wither height for mature males is about 92 cm while that for mature females is about 77 cm. Age at first kidding is about 560 days at the farm level. Multiple births typically occur at a rate of 60%. Beetal goats give about 195 liters of milk in about 6 months of lactation.

2.6.3. Boer goats

The Boer goat was developed in South Africa through crossing Africander, South African Common, indigenous Bantus, European, Angora, and Indian blood. Boer goats are medium to large, 75–80 cm in height at the shoulders. Male and female Boer goats weigh up to 130 and 80 kg, respectively, with most animals weighing between 75 and 90 kg and 50 and 60 kg for males and females, respectively. The coat color is white with red or brown on the head and neck. The hair is short and shiny. Boer goats have horns and large drooping ears.

Lewis Creek Boer Goats, Greg & Thecla Patterson



Courtesy; T4 Ranch, W.E. and Carolyn Whitehead, 2004

Figure 2.33. Boer buck (left) and doe.

The Boer goat is a meat breed but milk and skin are also important products. The breed has good meat conformation, possessing superior rib, body length and muscling. Carcass yield ranges 48–60%. Boer goats are also known to be fertile with up to 50% of births being twins. Kids weigh 3–5 kg at birth and can reach 40–50 kg at six months of age.

Some preliminary work has been done in Ethiopia to improve local goats through the use of Boer goat semen. Arsi-Bale goats were inseminated with Boer goat semen at Hawassa University to produce F1 crosses. Somali goats were also inseminated with Boer goat semen at Haramaya University to produce crossbreds. Although results have not yet been analyzed, the crossbreds seem to perform well provided that appropriate management and health care is provided.

2.6.4. Damascus or Shami goats

Damascus goats are among the known dairy goat breeds of eastern Mediterranean countries and Iraq. This breed belongs to the Nubian group. It is believed that Nubian and Jamnapari goats of India might have the same ancestry. The dairy characteristic of this breed has been particularly developed through breed improvement programs in Syria and Cyprus.

Damascus goats are tall with a pronounced Roman-type nose. Ears are pendulous reaching 25–30 cm in length. The breed is normally polled. Horns, if present, are moderate in length and diameter with a back and downward orientation and have a homonymous twist in males while they are sickle-shaped in females.

Luis Iniguez, ICARDA, 2006.

Figure 2.34. Damascus goats (buck and doe).

Mature body weight ranges 50–90 kg and 35–65 kg for males and females, respectively. Damascus goats weigh 3–4.2 kg at birth and 19 kg at weaning. Height at the withers for mature males ranges 75–89 cm, and for mature females 60–76 cm. Age at first kidding ranges 15–24 months. Multiple births occur in about 70% of the births. Milk production ranges 250–558 kg in lactation periods ranging from 155 to 300 days.

2.6.5. Jamnapari goats

Jamnapari is an Indian breed indigenous to the State of Uttar Pradesh. It is widely distributed within Uttar Pradesh and adjacent areas of Madhya Pradesh State. The area where this breed is found is climatically characterized by temperatures ranging between 19 and 32ºC with a mean annual precipitation of 765 mm.

This breed was used in the development of Boer and Anglo-Nubian goat breeds. Jamnapari goats have a convex nose line with a tuft of hair. The ears are long and drooping, with a mean ear length of about 27 cm. Horns are short and flat. The breed has a short coat with a relatively thick growth of hair around the rump. Typical coat color is white with small tan patches on the head and neck.

http://www.fao.org/dadis/

Photo: by Dr. Pramod Kumar Rout

Figure 2.35a. Jamnapari buck.

Photo: Dr Abdul Wahab Qureshi

Figure 2.35b. Jamnapari does and kids.

Body weight is about 45 and 38 kg for mature bucks and does, respectively, while the corresponding height at withers is 78 and 75 cm.

Jamnapari goats weigh about 4 kg, 15.6 kg and 29.7 kg at birth, 6 months and 12 months of age, respectively. They also have about 30% multiple births under farmers' conditions. Jamnapari goats produce about 200 liters of milk in about 190 days of lactation.

2.6.6. Saanen goats

Saanen goats are one of the most prominent dairy breeds developed in Switzerland. Saanen goats have been used for crossbreeding to develop other dairy subtypes and as a result German, British, Dutch, Israel, Australian and American Saanen breeds have been developed. In Ethiopia, there were attempts in the early 1970's to cross Saanen with Afar and Highland goat types. However, the program was not sustainable since the effort was not supported by appropriate extension packages including health, feed and management.

Figure 2.36. Saanen Does.

Oklahoma State University: Handbook of Australian Livestock, Australian Meat & Livestock Corporation,1989, 3rd Edition, USA

Saanen goats are characterized by their white, short coat hair. The face is straight; Saanens have short and pointed ears. Mature body weight for pure Saanen males and females is 75 and 50 kg, respectively, while milk production ranges 500–900 kg in 250–300 milking days.

2.6.7. Toggenburg goats

The Toggenburg breed is also a Swiss dairy goat breed originating in the Toggenburg valley. The breed has mostly long hair. The Toggenburg breed was developed through the crossing of Appenzel goats with Chamoisee. The identifying characteristics of this breed are its fawn-to-light grey-base color, the white stripes on the head running from the muzzle to the eyes and polls, and its white ears and legs. Mature body weight is 65 and 45 kg for males and females, respectively. Height at withers is 75–85 cm for males and 70–80 cm for females.

This breed has also been introduced to Ethiopia for crossing to produce grade dairy goats by crossbreeding with Somali goats.

Oklahoma State University: Handbook of Australian Livestock, Australian Meat & Livestock Corporation,1989, 3rd Edition, USA)

Figure 2.37. Toggenburg does.

Transferable Messages

1. Origin and migration routes of today's sheep and goats are known.
2. Ethiopia's sheep and goats are not yet fully characterized. However, there are many types/breeds of sheep and goats in the country that could be used for the production of meat, milk and fiber.
3. Some of the major sheep and goat types/breeds of Ethiopia and their geographical distribution within the country are roughly known.
4. Some of the most important exotic sheep and goat breeds in tropical countries, known for their meat, milk and fiber, and which could be used for crossbreeding with the indigenous, are known.
5. Important parameters to be considered in any sheep or goat production enterprises are known.

Exercises

1. Where is the origin of sheep and goats?
2. Name at least five important or major sheep and goat breeds of Ethiopia:

Sheep: ______________________ Goats: ______________________

3. Name sheep and goat breeds/types found in your area:

Sheep: ______________________ Goats: ______________________

4. List the three most important products of sheep and goats:

Sheep: ______________________ Goats: ______________________

5. For a species of your choice (sheep or goat), list at least five important traits of economic importance:

   Species:

   a.

   b.

   c.

   d.

   e.

6. Why do we need to crossbreed indigenous animals with exotics?

   ____

References

Banerjee, A.K., Getachew Animut, Ewnetu Ermias. 2000. Selection and breeding strategies for increased productivity of goats in Ethiopia. In: Merkel, R.C, Girma Abebe and Goetsch, A.L. (eds) The Opportunities and Challenges of Enhancing Goat Production in East Africa. Proceedings of a conference held at Debub University, Awassa, Ethiopia, from 10–12 November 2000.

Chiman, J. 2003. Observations on the potential of Dangila sheep for improved food security around Quarit and Adet, West Gojam, Northwestern Ethiopia. A field study hosted by the International Livestock Research Institute (ILRI), Addis Ababa, Ethiopia. July 2003.

DAGRIS 2004. Domestic animal genetic resources information system (DAGRIS). (*eds. Rege, J.E.O., Workneh Ayalew and Ephraim Getahun*). International Livestock Research Institute, Addis Ababa, Ethiopia. http://dagris.ilri.cgiar.org

Devendra, C. and Burns, M. 1983. Goat Production in the Tropics. Commonwealth Agricultural Bureau, Farnham House, Slough, UK 1983. 183pp.

Devendra, C. and Mcleroy, G.B. 1982. Goat and Sheep Production in the Tropics. Longman, London, New York.

FARM-Africa. 1996. Goat types of Ethiopia and Eritrea. Physical description and management systems. Published jointly by FARM-Africa, London, UK, and ILRI (international Livestock Research Institute), Nairobi, Kenya. 76pp.

Gall, C. 1999. Goat Breeds of the World. CTA. – Weikersheim, Germany: Margraf Verlag. 1996. 186pp.

Galal, E.S.E. 1983. Sheep germplasm in Ethiopia. Animal Genetic Resources Information. Food and Agricultural Organization of the United Nations (FAO). 1/83, pp.4 –12.

Gatenby, R. 2002. The Tropical Agriculturist–Sheep. Revised Edition. Coste, R. (ed.). Published by Macmillan Publishers Ltd. in cooperation with CTA, Postbus 380, 6700 A.J. Wageningen, The Netherlands. 2002. 178pp.

Girma Abebe, 1996. Studies on performance potential of Somali goats and their crosses with Anglo-Nubian: A contribution to breed documentation and evaluation. Humboldt University of Berlin. Verlag: Dr. Hans-Joachim Koester. 1996. 151pp.

Institute of Agricultural Research (IAR).1975. Technical Committee on "National Sheep Research and Development Policy". IAR.1975.pp.39.

Institute of Biodiversity Conservation. 2004. The state of Ethiopia's farm animal genetic resources: Country Report. A contribution to the first report on the state of the world's animal genetic resources. IBC. May 2004. Addis Ababa, Ethiopia.

Kassahun Awgichew. 2000. Comparative performance evaluation of Horro and Menz sheep of Ethiopia under grazing and intensive feeding conditions. PhD Thesis. Humboldt University of Berlin. 2000. 130pp.

National Sheep Association (NSA). 1979. British Sheep. Revised Edition. Printed by Geerings of Ashford Ltd. Cobbs WoodHouse, Chart Road, Ashford, Kent, TN23 1EP. 195pp.

Niftalem Dibissa. 2000. Sheep production on smallholder farms in the Ethiopian highlands – A farming system approach. PhD Thesis. Humboldt University of Berlin. Verlag: Dr. Hans-Joachim Koester. 2000. 130pp.

Ponting, K. 1980. Sheep of the World in Color. Blandford Press Ltd. Sackville Press, Billericay, Essex. Great Britain. 155pp.

Solomon Gizaw. 2007**.** Genetic diversity and conservation priorities for Ethiopian sheep. Study underway. PhD Thesis draft. Wageningen University.

Steele, M. 1996. The tropical Agriculturist–Goats. Coste, R. and Smith, A.J. (eds.). Published by Macmillan Publishers Ltd. in cooperation with CTA, Postbus 380, 6700 A.J. Wageningen, The Netherlands. 2002. 178pp.

Teferawork Beyene. 1989. Performance of Arsi and crossbred sheep in the highland of Arsi region, Ethiopia. Master of Science Thesis. Swedish University of Agricultural Sciences – Department of Animal Breeding and Genetics. Report 86. Uppsala 1989. 68pp.

CHAPTER THREE

Sheep and Goat Production Systems in Ethiopia

Solomon Abegaz, Girma Abebe and Kassahun Awgichew

Objectives

1. To describe the characteristics of different production systems in the context of sheep and goat production.
2. To describe important activities which characterize different systems of sheep and goat production.

Expected Outputs

1. Knowledge of how to describe a production system and its different components.
2. Ability to visualize areas where appropriate interventions can improve productivity of sheep and goats.

3.1. Basis for Classification of Sheep and Goat Production Systems in Ethiopia

There are a number of ways to classify production systems. In this handbook, sheep and goat production systems were classified using criteria that included degree of integration with crop production and contribution to livelihood, level of input and intensity of production, agro-ecology, length of growing period and relation to land and type of commodity to be produced. Three major and two minor production systems are described.

The major production systems are:

- Highland sheep–barley system
- Mixed crop–livestock system
- Pastoral and agro-pastoral production systems

The other production systems that are not currently practiced widely but have a future are:

- Ranching
- Urban and peri-urban (landless) sheep and goat production system

3.2. Description of Production Systems

3.2.1. Highland sheep–barley system

This system is found in the highlands above 3000 m.a.s.l. where the major crops grown are barley and pulses such as faba beans, lentils, etc. Temperature is the main factor determining productivity in the highland sheep–barley production system. At times, night temperatures fall below 0ºC and frosty nights are common, particularly between October and January. Cropping intensity in these areas is generally low. Sheep are the dominant livestock species. The main feed resource-base includes wasteland grazing, stubble and sometimes straw. Sheep flock sizes range from 30 to several hundred head.

Although sheep are reared mainly for meat, skins and coarse wool production for the cottage industry of the central highlands are subsidiary products. There is, therefore, a clear possibility of establishing more formal sheep production enterprises using appropriate technology packages. Large sheep production ranches could be established where mainly meat or dual-purpose breeds could be maintained either by individual farmers or cooperatives. These highland areas are generally unsuitable for sustainable crop production.

3.2.2. Mixed crop–livestock systems

Both sheep and goats are raised in mixed crop–livestock systems. These systems are based on cropping associated with livestock husbandry.

This system is generally found in areas where the altitude ranges between 1500 and 3000 m.a.s.l. The area has adequate rainfall and moderate temperature and is thus suitable for grain production. The integration of crops and livestock is high in most areas. The integration is lower in the perennial crop–livestock system (coffee growing areas) in southern Ethiopia where animals are of minor importance.

Livestock in general and small ruminants in particular play an important role in food security and food self-sufficiency in this production system. In the grain-based mixed production system, livestock are the main cash source for the purchase of agricultural inputs. Livestock are used as a savings and insurance mechanism. Cattle are the dominant livestock species and are kept mainly for draft power. Sheep and goats are kept to meet small and immediate cash needs.

Sheep are more dominant than goats in this production system. The major commodity is meat, while milk is a subsidiary product in some areas. Skin of hair (‘*Gishe*’) goats in the extreme highland areas has a local niche market for making saddles. Coarse wool is also produced from Menz sheep and other sheep in the central and north central highlands. The wool is usually used for the local carpet-making industry.

Land-holding per household is 2–3 hectares with some areas having much smaller holdings of less than 2 ha. The major feed resources are natural pasture and crop residues. In some areas, one-fifth to one-third of the holding is used for grazing. In most of the areas, however, livestock generally depend on grazing communal land that is dwindling in size and productivity. Sheep and goats in this system experience year-round nutritional stress due to increases in cultivated land area. This results in very high grazing pressure and subsequent shortage of feed. This area is also characterized by excessive soil erosion and soil nutrient depletion because of intensive cropping and overgrazing.

The system of sheep and goat production for the most part is a low input / low output system except in some cases of concentrate supplementation and use of anthelmintics for fattening sheep and goats. There is a need to intensify production because of the high population density in these areas. Potential for intensive small ruminant production through finishing activities and stratification of production exists.

3.2.3. Pastoral and agro-pastoral production systems

Pastoral system

In general, pastoral systems are associated with agro-ecological zones (AEZ) that are too dry to sustain crop production. These are characterized by little or no crop agriculture and high mobility in search of grazing and water.

Under Ethiopian conditions, pastoral systems of production are found at altitudes below 1500 m.a.s.l. and where the annual precipitation is less than 500 mm. The following characterize pastoral systems:

- Livestock are maintained as a principal activity. Fifty percent of household revenue comes from livestock or more than 20% of household food energy is derived directly from livestock or livestock-related activities.
- Rangeland is the main land resource.

Livestock species consist of camels, cattle, sheep, goats and donkeys. In recent years, pastoralists have shown an increasing interest in keeping larger numbers of sheep and goats. There are more goats than sheep in this system. Milk and meat are the two outputs. In drought years, goats gain more importance as suppliers of milk to the household. Goats also help to control bush encroachment.

Pastoralists depend on their livestock not only for their income but also for their survival. Consequently, risk avoidance is very important to the pastoralist. Livestock management is, therefore, directed towards risk minimization, which tends to reduce productivity. Pastoralism is ecologically, economically and socially important for sustainable development in dry lands.

Agro-pastoral system

This system is characterized by less integration with crop production as compared to the crop–livestock production systems. Producers under this system have a permanent residence and their movement is limited in terms of both distance and duration. The system is characterized by a high degree of dependence on milk and meat production. Some crop agriculture is practiced around the permanent homestead. This is also a low input / low output system. The system is usually practiced below 1500 m.a.s.l. but with higher rainfall to support short season crops compared to the pastoral system.

3.2.4. Ranching

Ranching is a range-based system of livestock production similar to the pastoral systems but with different production parameters, livestock functions and management. Ranching can be considered as a modern land-use system. It is a labor-extensive system focusing on the production of marketable commodities from one or two selected species. This is mainly in the form of producing live slaughter animals for meat. The main function of the system is to generate cash income.

Management of livestock is characterized by grazing within defined borders and an individual tenure system with possibilities of intensified feeding and watering of animals. The form of ownership in ranching could be parastatal, cooperative or private (companies or individuals). Ranches can be differentiated by the following characteristics:

- *Targeted livestock species and product:* Although the most common system is cattle ranching, sheep and goat ranching for the production of skins (Karakul), wool (Merino), and meat (Dorper sheep and Boer goats) exist in various parts of the world.
- *Intensity and level of development:* This system of ranching works with a minimum of fixed investments and extensive management practices. This system requires heavy investment and improvement practices and well-planned and executed livestock management and grazing systems.
- *Stratified system:* In this case, ranches could be specialized to produce weaner lambs or kids for fattening or finishing by other production systems.

The ranch system of production is important in arid and semi-arid zones of Africa, particularly in eastern and southern Africa (Kenya, Tanzania, Zambia, Zimbabwe, Botswana, Namibia and South Africa). Ranches are also found in some highland areas.

Both highland and arid/semi-arid ranching can be undertaken in Ethiopia. Sheep ranching can be established in the highland sheep–barley system, where there is very little crop cultivation, with targeted production objectives of either meat, coarse wool or both. Extensive ranching can also be established in the arid/semi-arid areas of the lowlands or pastoralist areas for market-oriented sheep or goat meat production using specialized breeds such as the Dorper sheep or Boer goat and their crosses with local stock.

It is possible to produce sheep and goats that are more uniform and targeted to satisfy the increasing export and domestic market if such systems could be introduced into the pastoral, agro-pastoral and the highland sheep–barley production systems.

3.2.5. Urban and peri-urban (landless) sheep and goat production system

This system involves the production of sheep and goats within and at the periphery of cities. Quantitative data is not available on the importance of urban and peri-urban production systems but it is not uncommon to observe sheep and goats in urban areas including the capital Addis Ababa. Feed resources are usually household wastes, market area wastes, mill leftovers, by-products and roadside grazing (particularly in the peri-urban system).

In addition, small-scale sheep fattening is emerging as an economic activity in many growing cities. The viability of this activity depends on its acceptance into the formal extension services. It could either be a high input / high output or low input / low output system.

Figure 3.1. Sheep in the heart of Awassa city, southern Ethiopia.

In most cases, the type of sheep and goats available from this system are meant for local consumption, being well-finished, fatty animals demanded by the local Ethiopian market.

3.3. Integrating Sheep and Goats in Commercial Crop Production

Sheep and goats can be beneficial in many commercial cropping ventures, including fruits, vegetables, and tree crops. As an example, in Southeast Asia, sheep and goats are raised in plantations producing rubber, oil palm, coconut, coffee, and various fruits.

In many of these systems, herbicide was traditionally used to control weeds and grass that compete with the main crop for soil nutrients. Sheep and goat grazing is an alternative weed and grass control method. By using sheep and goats, herbicide use and labor costs for application are decreased, leading to reduced production costs and fewer harmful chemicals released into the environment. The animal manure assists in recycling soil nutrients and improves soil fertility. The animals also become a source of income for the enterprise when sold.

Contrary to popular opinion, sheep and goats do not ruin the crops. Proper management and grazing techniques can prevent damage to trees and other crops by small ruminants. Integrating sheep and goats into commercial crop production systems diversifies production and allows for two income streams, those from crops and livestock, to be realized from the same plot of land. In Ethiopia, such integration could occur in coffee plantations, rubber plantations in the southwest and other tree and fruit crop farms.

3.4. Sheep and Goats in Vegetation Management

Sheep and goats are important animal species in controlling unwanted and invasive vegetation. There are many plant species that cattle do not prefer that are consumed by sheep and goats. As cropland increases and animals are forced to graze increasingly less productive land, the need for animals that consume a diverse array of plant species is paramount.

Sheep and goats can assist in stopping the spread of some weeds and unwanted brush. This reduces the need for manual chopping or weeding. It has been said that goats are particularly destructive to an environment. However, used correctly, sheep and goats can be a conservation tool that helps protect biodiversity of plant species. These animals consume invasive plants allowing other plant species to grow and flourish. Proper management of animals and grazing is key in managing vegetation. Many of the problems associated with small ruminants, in particular goats, and environmental degradation are actually the result of man incorrectly managing these animals or trying to raise too many livestock in areas unsuited for the practice.

Exercises

1. What characterizes the integration of livestock and crops in the mixed production system?
2. What major problems exist under the mixed crop–livestock production system?
3. Briefly describe the type of production system or systems existing in your area.

References

Niftalem Dibissa. 2000. Sheep production on smallholder farms in the Ethiopian highlands — a farming system approach. PhD Thesis. Humboldt University of Berlin. Verlag: Dr. Hans-Joachim Koester. 2000. 130pp.

McCann, J. 1992. A rapid impact assessment of vertisol technology. ILCA (International Livestock Centre for Africa), Addis Ababa.

Jahnke, H.E. 1982. Livestock Production Systems and Livestock Development in Tropical Africa. Kieler Wissenschaftsverlag Vauk. 1982. 253pp.

Ministry of Agriculture (MoA). 1985. Project preparation report – sheep production project. Annexes: 1–6. Australian Agricultural Consulting and Management Company PTY. LTD. March, 1985.

Gall, C. 1981. Goat Production. Academic Press, New York, NY.

CHAPTER FOUR

Sheep and Goat Management

Girma Abebe and Alemu Yami

Objective

1. To highlight some management techniques used in sheep and goat production.

Expected Outputs

1. Understanding of the purpose and requirements of housing.
2. Familiarity with various types of facilities.
3. Ability to body condition score (BCS) sheep and goats.
4. Understand the purpose of castration and the techniques used.
5. Ability to list factors responsible for mortality of newly born animals.
6. Knowlegde of the management techniques appropriate for different classes of sheep and goats.

4.1. Site Selection for a Sheep and Goat Farm

Due consideration should be given to the following points in site selection for a sheep and goat farm.

- **Drainage:** The area should be slightly sloped for effective drainage.
- **Wind direction:** Animal houses should be partially or totally protected from the direction of strong winds depending on the wind intensity of the area.
- **Climatic factors:** Such as temperature and rainfall.

4.2. Sheep and Goat Facilities

Essential sheep and goat facilities differ according to the system of management and climatic conditions. In modern production systems, where large flocks of sheep or goats are raised and managed, facilities to handle sheep and goats are essential for efficient management. Some of these facilities are:

- Fences
- Handling pens
- Housing (house/barn – different kinds of buildings)
- Dipping vats/spraying area
- Isolation ward for sick animals
- Manure disposal pit (away from the house), and
- Equipment (feeding and watering troughs, etc.)

4.2.1. Fences

Fences are important not only to protect animals against predators or theft but also to isolate them from other animals. Fences could be constructed from locally available materials with considerations for cost and durability. Materials resistant against termites are most durable. Alternatively, wooden posts of treated eucalyptus could be used. Barbed wire is commonly used but can damage the skin when animals try to squeeze through an opening. Fences require regular supervision and maintenance. In some instances trees or brush may be grown and fashioned into a live fence.

4.2.2. Handling pens

Sheep and goats need to be handled, either in groups or individually, for vaccination, treatment, mating, weighing, etc. Handling pens are useful in reducing injury and stress on animals and workers. An ideal lay-out for a handling pen includes a receiving pen, forcing pen, crush, sorting gate, foot bath, dip or spray race (long and narrow passage wide enough for only one sheep or goat), draining pens and a holding pen. In particular, the receiving pen should match the number of animals expected to be handled at one time. Under the current smallholder conditions of Ethiopia, one handling pen per village may serve the purpose as long as complications with disease transmissions are minimal.

4.2.3. Housing

The type of housing varies with the production system, the objective of raising sheep and goats and perhaps tradition. Housing can range from very simple structures made of a roof and partial walls to complex structures fitted with automatic feeders and waterers. Animals may be kept either in an area within the family home or in a separate animal shed.

A separate house for sheep and goats with a raised wooden floor 30 cm above the ground is observed in some areas (Konso). The animal shed could be located outside the homestead or it could be adjacent or attached to the family home.

Despite variation in types, the common purposes of housing are to:

- Protect animals from climatic stress (extreme heat, cold, rain, wind, etc.), thus creating an environment suitable for the animals' physiological state;
- Provide protection against losses by predators and theft; and
- Make management easier and save labor.

4.2.3.1. Design of sheep and goat housing

Having an appropriate design for sheep and goat housing is crucial prior to beginning construction. The design should include floor plan, walls, roofing and other additional facilities.

Floor plan

The space requirement of the animals to be housed influences the design of the floor. Table 4.1 presents the suggested requirements for different classes of sheep and goats. Space requirements vary depending on whether animals are kept in individual or group pens. The space requirement also varies with the size of animals, i.e., bigger animals require larger space than smaller ones.

Table 4.1. Space requirements for sheep and goat housing.

Type of housing	Space (m^2/animal)			
	Breeding female	Breeding male	Young stock	Additional
Permanent confinement (zero grazing)	1.2	2.0	0.8	Exercise yard, feed racks and watering trough
Night housing and day time grazing	0.8	1.5	0.5	

Floor design is particularly important in wet climates, where dung and urine on a damp floor make ideal conditions for the multiplication of disease-causing organisms. In particular, kids and lambs are very susceptible to pneumonia and it is wise to avoid damp and poorly ventilated houses.

The floor should be sloped, porous or slatted for water drainage. A minimum floor slope of 5% is recommended; that is, for every 1 m there should be a fall of 5 cm. Houses with raised, slatted floors have a number of advantages including keeping the floor clean and dry. Ventilation is good and dung and urine drop through the floor, preventing build-up and reducing risk of disease spreading. The spaces between slats need to be big enough to allow manure to drop easily, but small enough to prevent feet from passing through. A spacing of 1.5 cm is optimal for adult sheep (slightly narrower for goats). For young lambs, 1.3 cm is enough.

In some cases, mobile wooden slats are placed on floors providing the advantage of easy cleaning. Where slatted floors cannot be constructed and concrete or earthen floors are used, it is important to control temperature of the floor and avoid muddiness. In such cases, bedding materials may be used. Straw or wood shavings or any material that can absorb moisture can be used for this purpose. Floors may be made from stones or bricks. With all floors, ease of manure removal and disposal should be given attention.

Roof

The roof is important as it protects animals against the sun and rain. The under-surface of the roof should remain cool and watertight. To ensure adequate ventilation, the height of the roof and the design should be considered. A high roof encourages air movement but is more likely to be damaged by strong winds.

In some cases a design with a chimney or roof vent could be useful to assist ventilation and remove ammonia that could easily accumulate.

The following materials are used for roof construction in different locations:

- Iron sheet
- Wood
- Earth
- Grass/bushes
- Stone/brick

The majority of houses have roofing made of grass/bushes.

Walls

In warm climates walls are partially open to allow movement of air through the house. In some cases, however, complete walling is needed to keep out predators.

Ventilation is important to remove heat, moisture and pollutants so that animals stay cool, dry and clean. Outer walls protect the animals from external influences while separation walls within the house prevent mixing among the animals. Attention needs to be given to construction of pens within the house. Pens serve as a means of controlling animals and for management purposes, such as controlling breeding. Areas for lambing/kidding and isolation of sick animals should be included. It is always wise to keep in mind the possibility of expansion when building houses for sheep and goats. An appropriate flock development plan has to be made to anticipate future construction needs.

a. Mobile dipping vat demonstrated to ESGPIP trainees Semera, Afar regional state

b. Dipping sheep at Lallo Mama Woreda, North Shoa

Figure 4.1. Mobile dipping vat.

4.2.4. Additional facilities

Dipping vat

Mobile dip vats have replaced the conventional dip vats made of concrete. Several years of effort to introduce dipping vats into tropical countries have had limited success, the major problem being maintaining the vats. Mobile dip vats made of plastic are meant to overcome the shortcomings of conventional, permanently placed dip vats. The size of plastic, mobile dip vats could vary according to flock sizes.

Feeding trough and hay racks

Feed troughs for concentrate and hay racks for forage feeding are required where these practices are conducted. The size of racks and troughs is determined by the body size of sheep and goats and by animal numbers. Approximately 30 to 40 cm per animal space is the minimum. Movable troughs are usually 2 to 4 m long. Fodder should not be put on the ground for sheep and goats. A feeding rack can be made from wood or other locally available material such as bamboo. The rack should be high enough to prevent adult sheep and goats from putting their heads in it and from jumping into the rack. The bottom should be above normal head height.

It should be noted that the feeding behavior of goats is different from that of sheep and a barrier is needed to prevent animals from jumping into the trough. In a system called 'tombstone or keyhole barrier', each animal puts its head through an individual wooden barrier to eat without being able to push its body into the trough. Suggested dimensions for a concentrate trough are a width of 30 cm with a depth of 15 cm, with the trough standing on 15 cm legs.

In general, troughs placed directly on the ground are not desirable because mud or soil can get into the trough, and sheep and goats are tempted to put their feet in. When only a limited amount of supplementary feed is given, it is essential that the trough is long enough to allow all animals to eat at once. Some troughs are fitted with a yoke to restrain animals during the short period of supplementary feeding. Such structures allow individual recording of the amount of concentrate consumed by each animal.

Watering trough

The need for watering troughs depends on the size of the flock. For small flocks, water tight tins, buckets or bowls can be adequate. Any type of watering trough used should be easy to clean.

4.3. Body Parts of Sheep and Goats and Body Condition Scoring

4.3.1. Body parts of a goat

Knowledge of the various parts of sheep and goats is important for different management purposes. The body parts of a goat are presented in Figure 4.2.

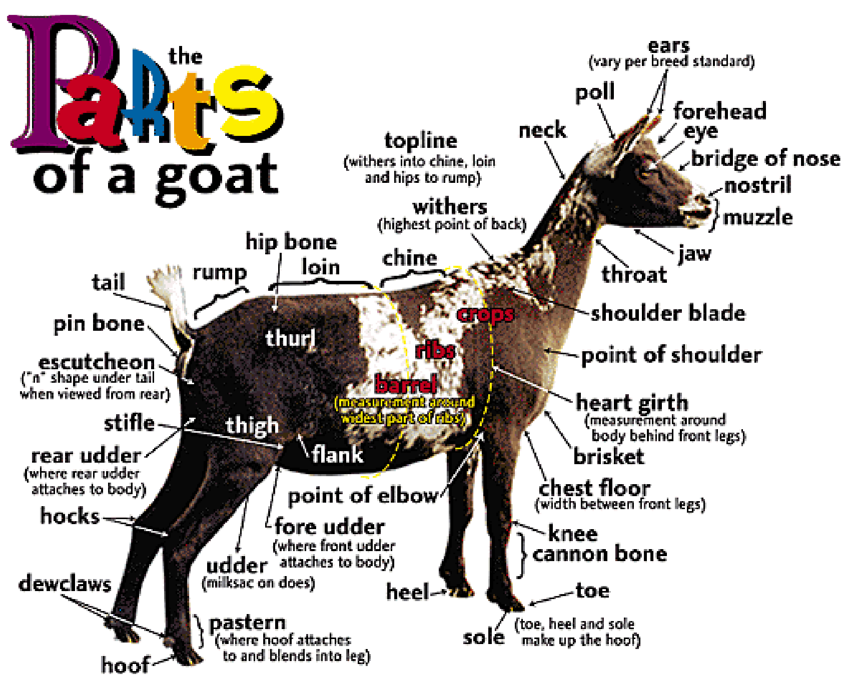


Figure 4.2. Body parts of a goat. http://www.goatweb.com/discover/goats/parts.shtml

4.3.2. Body condition scoring (BCS)

Condition scoring is a system of describing or classifying animals by differences in relative body fatness. It is a subjective scoring system but provides a fairly reliable assessment of body composition. Body condition at the time of mating has an important influence on the number of lambs and kids born and on the proportion of barren ewes/does.

Changes in body condition are inevitable with large fluctuations in feed supply. There are circumstances where body weight *per se* does not reflect an animal's condition, i.e., an animal with a large frame may have a higher body weight when at a low level of body reserves than another animal with a small frame but abundant reserves.

Large variation in gross live weight may also occur because of changes in gut fill, pregnancy and parturition. The nutritional plane to which an animal has been exposed over a reasonable length of time is reflected by the extent to which fat is stored or muscle mass has been diminished. This may be assessed visually and expressed as a condition score.

Body condition scoring is a simple but useful procedure which can help producers make management decisions regarding the quality and quantity of feed needed to optimize performance. It can also play an important role in sheep and goat marketing.

4.3.2.1. How to assign a score

It is important that the animals are touched and felt in order to assign BCS. Body parts to be examined are the lumbar region, the rib cage and the sternum.

Lumbar region

This area contains the loin muscle and is located immediately behind the last rib and before the hip bones. Scoring in this area is based on determining the amount of fat and muscle over and around the vertebrae. Lumbar vertebrae have two protrusions, the vertical protrusion called the *spinous process* and the two horizontal protrusions called the *transverse process*. Both processes are used in determining BCS.

Although the principle of body condition scoring is similar for sheep and goats, it is important to note differences that exist between sheep and goats.

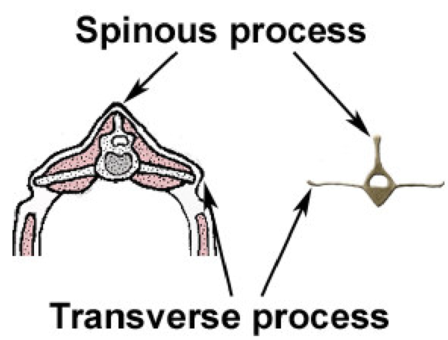


Figure 4.3. Spinous and transverse processes.

- Compared to sheep, goats have much less subcutaneous fat cover (most of the fat deposition in goats is internal around the intestines and kidneys). In fat-tailed or fat-rumped sheep breeds, the tail could serve as additional measure of body condition. These do not exist in goats.
- The sternum could be used as an additional area to assess condition in goats. This would be difficult in sheep that have a mane.

The following process may be followed during scoring:

Feeling the spinous process

- Feel the spinous process in the center of the sheep/goat back behind the last rib and in front of the hip bone and try to rank the animal based on the answer you give to the question: are the tips sharp or rounded?

Assessing the loin muscle

- Feel the fullness of muscle and fat cover on either side of the spinous process (either side of the backbone) and determine if the ridge of the spine is above the level of the muscle. Is the loin muscle shallow, moderate or full?

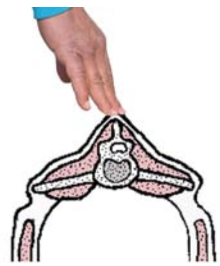


Figure 4.4. Spinous process.

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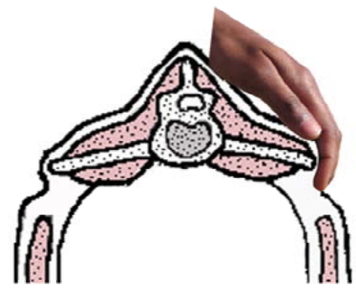

Figure 4.5. The transverse process.

Feeling the transverse process

- Feel for the tips of the transverse process. Is it sharp or smoothly rounded?
- How far will the tips of your finger go under the transverse process?

You should run your hand over this area and try to grasp these processes with your fingertips and hand as shown in Figures 4.3 to 4.5. The degree of sharpness or roundness of the lumbar vertebrae is assessed.

Different authors use different scales in scoring but a scale of 1 to 5 with 0.5 increments is the most common.

The rib cage

The second area to assess is the rib cage and fat cover on the ribs and intercostal (between ribs) spaces. Touch this area and determine if you can feel each of the ribs.

Figure 4.6. The rib area.

The sternum area

The sternum is the third part to assess. In goats, it is an important area to assess. The fat cover over the sternum (breast bone) is based upon the amount of fat that can be pinched.

In goats and sheep, scores range between 1 and 5 with the lowest-scoring animals being the thinnest and the highest-scoring animals being the fattest. An animal with average body condition would have a score of 2.5 to 3.

With practice, evaluating the BCS of an animal will only take about 10–15 seconds. By adding BCS as a regular part of your management program, you can effectively monitor your feeding and herd health program for a healthy and productive herd. To be more objective, two or three individuals (farm personnel) may assign scores independently and the average taken as a reliable score.

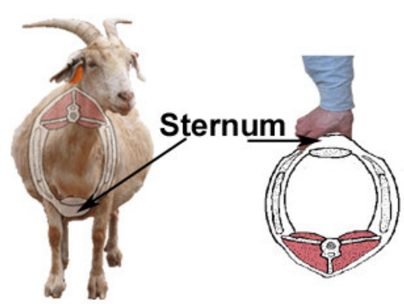

Figure 4.7. The sternum area.

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It is also important to note that BCS could vary according to the physiological status of the animal. An example which shows such a change is depicted in Figure 4.8 for ewes. At the time of mating does/ewes should have a score of 3 for optimum result with a range of 2 to 3 being acceptable. Pregnant females need to be watched closely to make sure they are close to a score of 3 throughout this period.

Table 4.2. Scales for body condition scoring of sheep.

Condition	Score	Description
Starving	0	Extremely emaciated and on the point of death. It is not possible to detect any muscle or fatty tissue between the skin and the bone.
Very thin	1	The spinous process is prominent and sharp. The transverse processes are also sharp, the fingers pass easily under the ends, and it is possible to feel between each process. The eye muscle areas are shallow with no fat cover.
Thin	2	The spinous process feels prominent but smooth, and individual processes can be felt only as fine corrugations. The transverse process is smooth and rounded, and it is possible to pass the fingers under the ends with a little pressure. The eye muscle area is of moderate depth, but has little fat cover.
Moderate	3	The spinous process is detected only as a small elevation; it is smooth and rounded and individual bones can be felt only with pressure. The transverse process is smooth and well covered, and firm pressure is required to feel over the ends. The eye muscle area is full, and has a moderate degree of fat cover.
Fat	4	The spinous processes can just be detected with pressure as a hard line between the fat-covered eye muscle area. The end of the transverse process cannot be felt. The eye muscle area is full, and has a thick covering of fat.
Very fat	5	The spinous process can't be detected even with firm pressure, and there is a depression between the layers of fat in the position where the spinous process would normally be felt. The transverse process cannot be detected. The eye muscle area is very full with thick fat cover. There may be large deposits of fat over the rump and tail.

After the lambs/ kids are born and during lactation, it is normal for condition scores in ewes/does to reduce. However, make sure they do not drop from a score of 3 to a 2 or 1 too quickly. Lactation is demanding in terms of nutrient requirements. If lactating animals are not fed properly during this period, body reserves could be mobilized, resulting in poor body condition. Lack of attention during this period will impact the growth of the nursing lamb/kid as well as milk yield.

Under ideal conditions, ewes/does should never be allowed to go below a BCS of 2. The same is true of the higher end of the scale. Ewes/does should not reach a BCS of 4, and should never reach a BCS of 5. Ewes/does with high scores often do not breed, and if they do they may have difficulties.

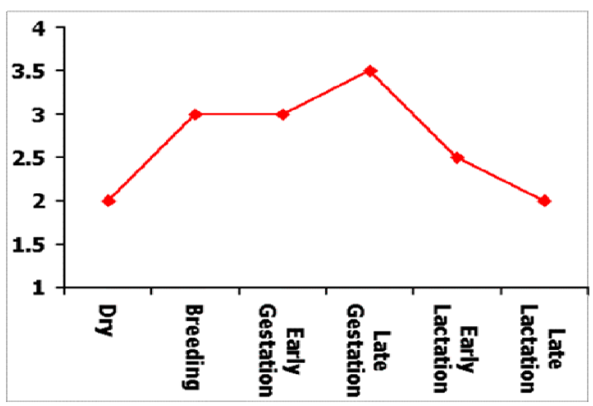


Figure 4.8. Expected body condition score changes throughout a ewe's production cycle.

Ewes/does can increase in body mass, even in early lactation, with adequate, good quality feed. However, in most cases, there is a decrease in body mass in early lactation when milk production is high and an increase in body mass in later lactation with declining milk production. In such cases, body condition score is useful in adjusting supplementary feeding up or down.

Exercises

The only way to learn about BCS is through experience. Practice body condition scoring as follows:

1. It is recommended to begin practicing with animals varying widely in body condition.
2. Ideally, scoring should be done independently and results compared with the score results of other group members.
3. Discuss with the group why you assigned your score and ask each member of the group why he or she has assigned a particular score.

4.4. Identification and Marking

Goat/sheep keepers on small farms often know all their stock by sight. This is more difficult with larger flocks or where flocks graze together. If grazed together, all animals belonging to one owner could be marked in the same way so that they can be identified and sorted. This can help to recover them if they are lost. Individual animal identification is required for genetic improvement (evaluating records for dam or sire selection) and provision of individual care. Identification is also very important for recording important events in the flock, such as vaccination dates, disease outbreaks, etc. Identification of animals and recording is an important management tool in intensive production systems.

Methods of identification

Three possible methods of identification may be used. Whichever system is used, it is important to ascertain that the method is safe and reliable. Three commonly used methods are tattooing, ear tagging and ear marking or notching. For farmers who do not have access to animal identification equipment, a rope collar with a washer having a number inscribed or punched on it can serve as an identification method. Problems occur when collars or numbers are lost.

Photo used with permission from the Meat Goat Production Handbook, Langston University

Figure 4.9. Tattoo plies, numbers and ink.

Tattooing: Animals can be tattooed on any visible part of the body. The ear is the most popular place. If done on other parts of the body, skin damage could occur, reducing its value.

The method involves use of tattoo pliers using tattoo numbers or letters that make a series of pierced marks through the ear into which tattoo ink is rubbed.

Ear tagging: Attaching a tag to the ear enables easy identification of an animal throughout its lifetime. An ear tag applicator and uniquely numbered ear tag are used. This can be very useful for recording management and breeding activities.

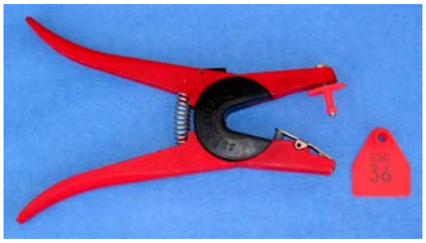


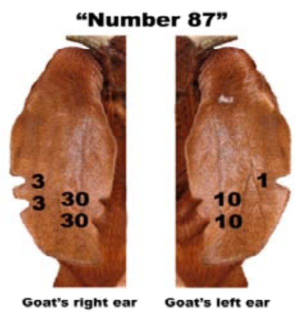
Figure 4.10. Ear tag applicator with ear tag.

Figure 4.11. Application of an ear tag.

Figure 4.12. Ear tag after application.

Ear marking (Ear notching): This involves cutting notches out of the side of the ear in a sequence. It can be done with a sharp knife or ear clipper. Generally, notches on the animal's left ear mean: 10 (top), 1 (bottom), 100 (end); and 1,000 (center hole). On the right ear notch values are: 30 (top), 3 (bottom), 300 (end); and 3,000 (center hole).
Thus, a goat with the number 135 would look as follows:

- 1 notch on end of left ear (100);
- 1 notch on top of right ear (30),
- 2 notches on bottom of left ear (2);
- 1 notch on bottom of right ear (3)
- with a total value equaling 135.

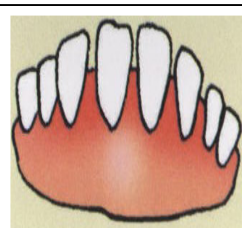


a. Ear marking (notching)

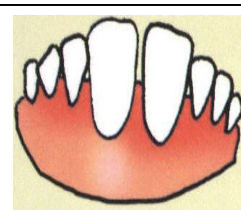
b. Ear notching pliers

Figure 4.13. Ear notching and pliers.

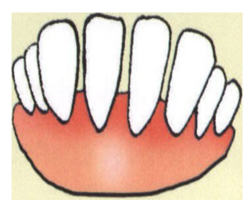
a. Dentition of sheep



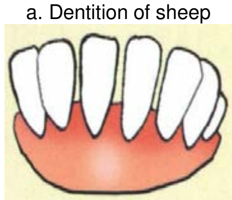
b. Milk teeth (<1 year)



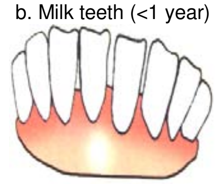
c. 2-tooth (1-2 years old)



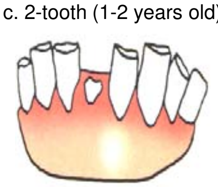
d. 4-tooth (2 years)



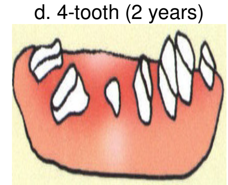
e. 6-tooth (3 years)



f. Full mouth (3-4 years)



g. Broken mouth (>4 years)



h. Gummy (aged)

Figure 4.14. Dentition and dentition class for sheep.

4.5. Age Determination of Sheep and Goats by Dentition

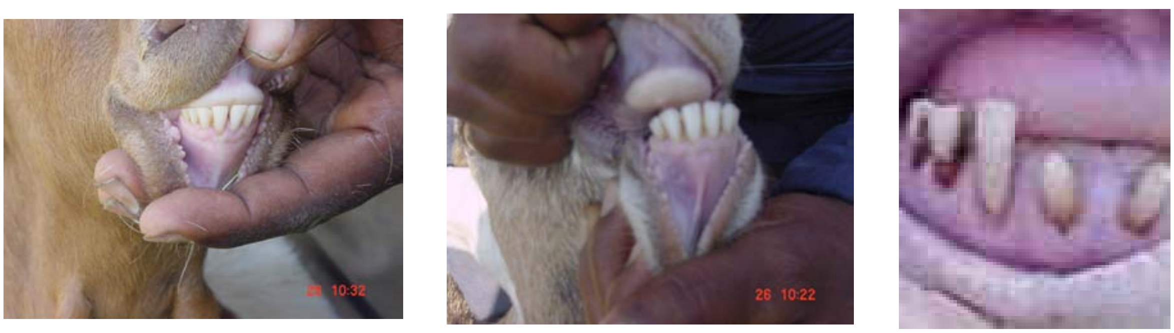
4.5.1. Why is it important?

Indirect ways of determining approximate age of sheep and goats are vital in systems where production records are unavailable. For instance, if the flock structure has to be determined, age of animals needs to be estimated. Application of drugs also requires knowledge of age and/or weight of the animal.

A few days after birth, lambs/kids will have milk teeth, also known as temporary incisors, arranged in four pairs in the lower jaw. These are replaced by larger permanent teeth as the age of the animal increases. There is a range of ages at which particular teeth appear because the speed of teeth growth will vary according to health and nutrition of sheep and goats.

The central pair of temporary incisor teeth is shed and replaced by the permanent teeth at approximately 14 months of age. At approximately 20 months, the second pair of milk teeth is replaced by a pair of permanent incisors.

At 3 and 4 years, the third and fourth pairs of permanent teeth appear. At 4 years of age the sheep has a "full mouth." When a ewe/doe loses some of her incisor teeth, she is called a "broken mouth."



a. A 10 month old doeling b. A 32-month old doe c. Broken mouth

Figure 4.15. Teeth of goats of different age.

Note that the doeling Figure 4.15a has her milk teeth fully grown and spread out. The doe in Figure 4.15b has had three pairs of teeth replaced.

Older sheep and goats that have worn teeth have difficulty in eating and will lose condition, become more prone to diseases and breed less than younger animals. Inspecting the teeth can be a very useful way of deciding when to cull. In an attempt to improve the precision of age determination, the following classes have been suggested (Table 4.3).

Table 4.3. Description of dentition with corresponding age estimates.

Description	Estimated age
Young without teeth often a new born	New born
With erupted and growing 1st and 2nd pair of milk teeth	1–2 weeks
With erupted and growing 3rd pair of milk teeth	2–3 weeks
With erupted and growing 4th pair of milk teeth	3–4 weeks
With fully grown milk teeth that started to spread out	9 month
The milk teeth have started to wear down, or are fully spread out	12 months
With erupted and growing 1st pair of permanent teeth	14–17 month
With erupted and growing 2nd pair of permanent teeth	18–23 month
With erupted and growing 3rd pair of permanent teeth	24–36 month
With erupted and growing 4th pair of permanent teeth	3–5 years
The four pairs of permanent incisors have started to wear down	4 years
The permanent incisors have worn down and have started to spread out	5 years
Worn down incisors are spread out and few are lost (broken-mouth)	6 years
Most of the incisors have been lost (smooth-mouth) or worn down to the level of dental pad	7 years

4.6. Castration

Castration is the removal of testicles from the ram/buck. In most cases, non-breeding males and males not slaughtered at a young age need to be castrated. Castration is done to control mating by preventing inbreeding and inferior males from breeding, or for production of fattened carcass.

Ideally, castration should be done at less than 3 weeks of age, but under Ethiopian conditions this is not usually the case. In the Southern Nations, Nationalities and Peoples Regional State (SNNPRS), farmers prefer to castrate male sheep at a later age, in most cases after sexual maturity is attained (yearling). The reason given for this is that early castration causes the development of a female-like body conformation and such an animal (early-castrated) lacks the desired muscling and market conformation and fetches low price. In Ethiopia there is a niche market for animals that are fattened to very high weight and condition (advanced age).

Figure 4.16. Elastrator with rings.

4.6.1. Common methods of castration

Three methods are commonly used:

- the application of elastrator ring,
- use of Burdizzo, and
- surgical method.

4.6.1.1. Elastrator ring

- A special applicator with rubber rings is used (see Figure 4.16).
- Castration using an elastrator ring involves putting a heavy rubber ring around the scrotum near the body. The ring stops blood circulation to the scrotum and testicles, causing these to dry, shrivel, and slough off in 10 to 14 days after application.
- The rings must be applied while the scrotum is still very small, i.e., from three days to three weeks of age

Figure 4.17. Inserting elastrator rings onto the scrotum.

Photos used with permission from the Meat Goat Production Handbook, Langston University.

depending on breed size, before the scrotal muscles and associated tissues develop.

- The ring is placed over the scrotum and spermatic cord, immediately below the supernumerary teats.
- When applying, care should be taken to ensure that both testicles are below the ring.

This is an easy method of castration, provided a continuous supply of rings is available. Animals castrated by this method will have female like appearance because of early castration.

One caution in the use of this method is the potential for tetanus to occur prior to the scrotum falling off.

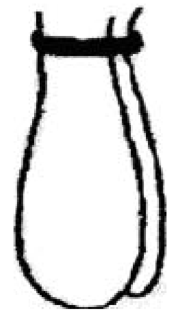


Figure 4.18. Proper placement of the rings.

4.6.1.2. Burdizzo method

A Burdizzo is a pair of pincers used to squeeze and crush the spermatic cords. After application, the testicles degenerate and are absorbed but the external surface of the scrotum is not damaged. Castration with this method can be done at any time; but when done at a later age, it may bring about a shock in growth.

The following steps may be followed to castrate animals using a Burdizzo:

- Take the Burdizzo and draw one testicle downwards.
- Place the spermatic cord between the jaws of the Burdizzo and apply pressure. Do not crush the septum or tissue between the testicles. Rather, do one side at a time.
- Repeat the procedure for the second testicle.
- Some operators prefer to crush each spermatic cord in two places to minimize the possibility of the ram/buck remaining fertile.

Figure 4.19. Burdizzo.

Figure 4.20. Location on the testis for proper application of the Burdizzo.

4.6.1.3. Surgical method

The testicles may be surgically removed. A sharp knife is used to remove the bottom one-third of the scrotal sac; then each testicle is slowly pulled down and away from the body until the cord breaks. If the animal is more than 4 or 5 weeks old, the cord should be scraped through with a knife rather than broken. This will result in less bleeding. The wound is allowed to drain and heal naturally. This method is the most painful and also has the greatest potential for infection and fly infestation. It is essential that a proper aseptic technique is used when castrating by the surgical method. It is not advisable for non-health professionals to use this method of castration.

4.6.2. Effect of castration

The main effect of castration is on the composition of the carcass and weight development. In general, the following effects are noted.

- Carcasses from castrated sheep/goats have more fat tissue.
- Castration could retard growth and reduce the quantity of lean meat if done late (after 6 months).
- In the case of goats, meat from castrated males has no ‘goaty smell’ as does the meat from entire bucks.

4.7. Tail Docking

Tail docking is not a common practice in Ethiopia except in some parts of the country, e.g., Gojjam and some parts of Arsi, and it is normally done for ewe lambs only. It is important to note that a sheep’s tail has a purpose. It protects the sheep's anus, vulva, and udder from weather extremes. Because of this, care should be taken while docking. Tails must be left long enough to cover the ewe's vulva and the ram's anus.

Docking has the following purposes:

- Even distribution of fat on the carcass.
- Easier ewe mating/breeding.
- Prevention of fecal matter from accumulating on the tail and hindquarters of sheep and lambs.
- Reduced fly strike (wool maggots).

4.7.1. Docking methods

Docking may be performed by using elastrator rings, Burdizzo or a knife.

4.7.1.1. Elastrator and rubber rings

This is a simple way of docking young animals. The rubber ring is placed between the vertebrate joints of the tail, leaving 3–5 cm of the tail, sufficient to cover the vulva in ewe lambs. Rings should be applied before two days of age and the tail will normally drop off in 7–10 days.

4.7.1.2. Burdizzo and knife

A large Burdizzo is used to crush the tail between the vertebrate joints. The tail is then cut off with a knife. Spraying the wound with antiseptic powder is recommended to prevent infection.

Although castration and tail docking can be used as management tools, some communities do not accept meat from docked or castrated sheep or goats. For instance, the Muslim Festival of Sacrifice requires unblemished lambs. An unblemished lamb is one that has not been docked, castrated, or had its horns removed.

Exercises

1. Is castration common in your area?
2. What is the main purpose of castration and what are the methods used?

4.8. Hoof Trimming

In management systems where sheep and goats are mostly confined and do not walk daily on hard ground-cover or climb rocks, abrasion of the hoof is not balanced with hoof growth. This will affect mobility and could lead to reduced intake from grazing. It may additionally lead to diseases such as foot rot. To avoid these problems, hooves need to be examined regularly and trimmed as needed.

A sharp knife or hoof shears such as those shown in Figure 4.21a can be used for hoof trimming. First use the point of the hoof trimmers to remove any dirt from the outside and the bottom of the hoof. The front of badly overgrown hooves can then be removed. The sides of the hoof should be cut back evenly with the sole of the foot. Continue to trim the sides around one toe and repeat the process on the other toe. Trim the frog and heel flat until the sole is parallel to the hairline of the pastern. Trim off thin slices. A good rule to follow is to stop when you see pink. If blood appears, stop trimming and finish the trimming at a later time.

a. hoof trimming tools

b. Using a hoof trimmer

c. Practical training of ESGPIP trainees on hoof trimming

Figure 4.21. Hoof trimming.

4.9. Dehorning

Dehorning may be performed as a management tool in intensive systems to avoid damage that could possibly arise from fighting or as a safety precaution for personnel dealing with the flock. Under extensive systems this may not be necessary as horns are a defensive mechanism and also may be used by producers in restraining animals.

Dehorning of sheep and goats will not be treated in further detail as it is not practiced in Ethiopia.

4.10. Flushing

Flushing is a feeding practice commonly used in some sheep and goat production systems. It is the practice of providing a high energy/protein diet prior to and during mating. The duration most commonly used is 2 to 3 weeks before and after mating.

The impact of this practice is evident on thin ewes and does. Flushed ewes/does respond to the increased level of nutrient intake by increased ovulation rate which leads to improved prolificacy. This practice is particularly useful when pasture quality and availability limits nutrient intake and digestibility.

4.11. Care and Management of Pregnant Ewes/Does

Knowledge of stage of pregnancy is important to provide necessary care to a pregnant animal. It is customary to divide the pregnancy period into early, mid and late gestation.

4.11.1. Early or first month of pregnancy

During this period, it is generally recommended that the body condition of the ewe/doe is maintained, thus minimizing embryo and early fetal losses. A very high level of nutrition can be as detrimental for embryo survival as a very low one.

4.11.2. Mid or second and third months of pregnancy

This period is characterized by rapid growth of the placenta. Growth of the fetus in absolute terms is very small. Loss in body weight should not exceed 5% over this period. Feeding during this period should be targeted at avoiding excessive loss.

4.11.3. Late or fourth month of pregnancy up to parturition

In this phase, the gain in mass of the fetus amounts to 85% of its birth weight. Nutrient intake should be increased during this period. Concentrate sources of energy should be available as the rumen size is limited because of the developing fetus.

However, care should be taken to avoid excessive feeding to reduce the chance of difficult birth. Multiple-bearing dams should receive more feed than single-bearing dams. It is advisable to separate dams at an advanced stage of pregnancy from the main flock. This will help to give them effective care.

Bring pregnant animals into lambing/kidding corrals 4 to 6 days before parturition and provide the maximum possible comfort. If possible, provide bedding material. It is not advisable to handle pregnant animals too frequently.

a. Cut fingernails

b. Wash hands with soap

c. Rinse with water

Figure 4.22. Preparation before assisting the ewe/doe.

4.12. Care at Lambing/Kidding

Parturition in healthy ewes/does is generally normal. Maiden ewes/does in poor condition or small-framed females mated to big males can have difficulty in parturition and may have to be assisted.

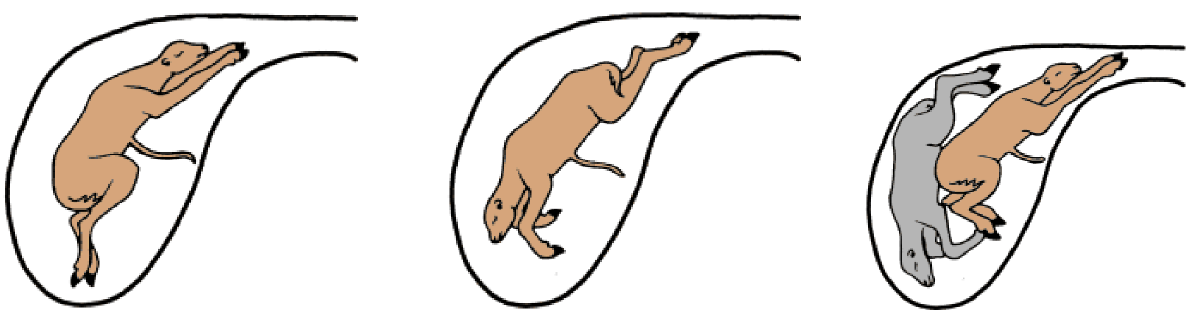
Assistance may also be required during instances of abnormal presentations (Figure 4.24).

You should first see the front legs and nose or head of the lamb if it is a normal birth. In this case, delivery can be expected within fifteen minutes. If the ewe/doe is still laboring after 30 minutes, you should seek professional assistance. If that is not available, proceed as follows:

- Hygiene, lubrication and care are most important when assisting ewes/does during parturition. Prepare a bucket of clean, warm water with soap and get some disinfectant, a good lubricant such as Vaseline and towels. Wash your hands and arms and wash the vulva and surrounding area of the ewe /doe.

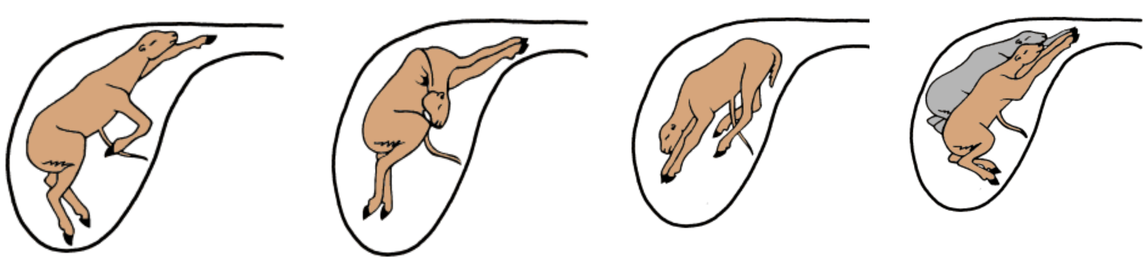
Wear latex gloves if available. There are some diseases that can pass to humans from assisting in birth.

- Apply a good lubricant and insert your hand into the reproductive tract to determine the position of the lamb/kid and take appropriate action.
  - ♦ If it is a normal birth, both front legs (hooves pointed up) and the head will be present.
  - ♦ If you feel the legs but no head, the lamb needs to be pushed in slightly, and the head found before the lamb/kid can be delivered.
  - ♦ If the head is coming but one or both of the front legs are missing, the lamb/kid will need to be pushed in slightly and the missing limbs retrieved, taking special care to cover the hooves to prevent tearing of the uterine wall. Once in normal birth position, the rest of the process should proceed smoothly.
  - ♦ If you find hind legs and a tail, this is considered a normal posterior position, although more stressful for the ewe/doe than the normal anterior position. There is a possibility that the lamb/kid will take in birth fluids.
  - ♦ You may also come along a breech delivery (tail but no legs). The lamb must be slightly pushed in and each rear leg needs to be retrieved one at a time with a lubricated hand.
  - ♦ As soon as the lamb/kid is born, remove all placental membranes and mucous from the nose so that the young can breathe. It can also be swung from its hind legs to clear out more mucous from the lungs and air passages.



a. Anterior presentation | b. Posterior presentation | c. Normal presentation of twins

Figure 4.23. Normal presentations during parturition.



a. One foreleg back | b. Head twisted backward | c. Abnormal posterior position | d. Abnormal presentation of twins

Figure 4.24. Abnormal presentations during parturition.

4.13. Care and Management of Nursing/Lactating Ewes and Does

Ewes and does have a great capacity to mobilize energy reserves for milk production, especially in early lactation and, thus, ewes with marked difference in energy intakes sometimes produce similar volumes of milk. The quality of feed offered and particularly that of roughage is important. When a portion of milk produced is used for home consumption a compromise should be made between the requirement of the young and family needs.

Ewes and does nursing twins or triplets need special attention. They need to be fed sufficient quantities of good quality hay and concentrate (if available) to meet the high requirements during early lactation. There is also a need to provide plenty of clean, fresh drinking water.

4.14. Management of Newborn Animals (Lambs and Kids)

4.14.1. Birth to weaning

Conceptually, the management of lambs/kids starts before birth. Proper feeding and care of the dams during the last trimester of gestation is necessary to have healthy, vigorous offspring. Lambs/kids with birth weight within the normal range for the breed can be raised without much difficulty. Lambs/kids with low birth weight or are weak at birth need special attention.

Studies have shown that there is a clear relationship between lamb/kid survival and birth weight. Very low or very high birth weights (related to dystocia or difficult births) are detrimental to lamb survival.

Immediately after birth, the umbilical cord should be trimmed if needed using clean scissors and then dipped in tincture of iodine. The recommended concentration is 7% tincture of iodine. As much as possible, protect newborn lambs/kids from cold, rain and wind.

In free-grazing flocks of sheep and goats where parturition occurs without any attendant, survival of the newborn depends on mothering ability and the firm establishment of the mother-offspring bond. If a large number of ewes or does are giving birth simultaneously, mismothering could occur. Such problems might occur in pastoral systems and where lambing/kidding is naturally synchronized, or when done artificially under modern practices.

Mothering instinct in primiparous mothers (first kidders/lambers) often needs some time to fully develop. Do not handle lambs/kids too frequently immediately after birth and let the dams lick and recognize them properly. In order to ensure the establishment of firm dam-offspring relationships, the dams and their offspring should be confined together soon after birth or stay around the homestead for at least 4 days.

If the lamb/kid is not licked dry or is born in a wet/windy place or does not consume colostrum immediately, it will develop hypothermia (very low body temperature), especially if small in size (triplet, premature, mother malnourished). If the lamb/kid is shivering or has a cool mouth and extremities and is not suckling, check rectal temperature. Normal temperature is between 38.5 and 40°C. Dry the lamb/kid with a cloth and tube-feed if the temperature is 37.8 to 38.5°C.

The lamb/kid may need to be warmed with a heat source or with a hot water bath or warming box, particularly if body temperature is below 37.8°C. If only one of a twin birth needs to be removed for feeding or warming, it is best to remove both offspring. If one is left, there is the risk that the dam will not accept the treated one when it is returned. A wool sock over the body is safer than a heat lamp. A plastic coat protects lambs from rain.

Check the condition of lambs regularly. If lambs appear thin and weak, check the ewe to see if she is milking. Check for a mastitis problem, whether the teats are open, and/or if she has claimed the lamb. Hand-feed the lamb with colostrum or milk replacer (if available) if any one of these problems is observed.

Intake of colostrum, the "first milk”, is crucial for successful rearing of lambs/kids. What is special about colostrum?

- Colostrum contains a high level of nutrients important for lamb health and performance.
- Colostrum also contains a high level of antibodies against a variety of infectious agents. At birth, the lamb/kid does not carry any antibodies because antibodies in the ewe's bloodstream do not cross the placenta.
- Colostrum imparts passive immunity.

Colostrum has to be fed during the first 24 hours; feeding colostrum later than this period confers little or no advantage. This is because the intestinal wall of the newborn is only permeable to antibodies (large protein molecules) during the first 24 to 36 hours and absorption is most efficient during this period.

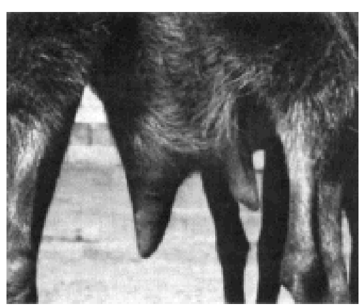
If the ewe/doe has inadequate colostrum, cow colostrum can be given. Normally, the newborn stands and suckles within 30 minutes of birth. In some cases, lambs/kids should be assisted to obtain colostrum. Plugs should be stripped out of each teat by hand and udder secretion inspected for any abnormalities.

Newborn lambs/kids are pre-ruminant animals in the early stage of development. It will take some time (usually 6–8 weeks) for the rumen to develop. When concentrate feed or hay is offered, consumption starts at about 2–3 weeks of age. Access to quality roughage feed or concentrate is essential as it stimulates early development of the rumen. It is recommended that forage be chopped and given to kids, and when possible concentrate feed should be offered but not in a dry form.

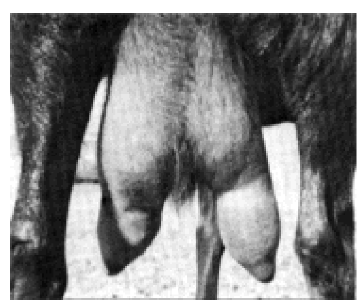
Growth of the young, particularly during the first weeks of life, is entirely dependent on milk of their mothers. For this reason, it is important to ensure that dams produce adequate milk. The health and structure of the udder should be examined.

Faulty udders may mean insufficient milk production for adequate lamb/kid growth (Figure 4.25). Females with faulty udders should be culled.

Pendulous udder



Udder damaged due to mastitis



Teats too large, bad udder

Fig 4.25. Types of faulty udder.

4.14.2. Grafting orphan lambs/kids

An experienced mother will accept a newborn covered with birth fluids immediately after delivering her own lambs/kids. If lambs/kids aren’t being cared for by their mother or are not receiving an adequate amount of milk, they may become orphan lambs. The sooner this is detected the higher the chance of survival. Grafting is defined as giving a lamb/kid to another ewe/doe. Always graft the stronger lamb, as the problem ewe/doe will normally take care of the smaller one.

Techniques to facilitate grafting include**:**

- Bathing the graftee in amniotic fluid from the new mother.
- A wooden stanchion to hold the ewe/doe in place while the orphan nurses may result in adoption in 7–10 days.
- If an orphan is older, tying its legs together so it appears helpless may help.
- If all this fails, the lambs/kids will have to be raised artificially:
    - Feed cow's milk. If they are newborns, they need to be fed frequently, i.e., 5–6 times daily. After the lambs/kids are 10–12 days of age, they may be fed only 3–4 times per day and offered creep feed.

4.15. Weaning

This is the time when lambs/kids stop feeding on liquid milk or milk replacer. After weaning, lambs/kids depend entirely on dry feed. This change has to be gradual to avoid losses due to faulty feeding management. Coccidiosis and pneumonia are the dominant diseases in this age group, particularly under conditions of confined housing. Decline of maternal antibodies and the stress of weaning appear to predispose kids to respiratory infection.

On the other hand, transition to solid feed encourages ingestion of coccidial oocytes while feeding. If lambs/kids are grazing during the rainy season, they become susceptible to gastrointestinal parasitism. Proper housing and hygiene are of paramount importance to reduce cases of death associated with these two diseases.

Retardation of growth commonly known as 'weaning shock' is common following weaning but every effort should be made to reduce it as excessive retardation might not be compensated for at later stages. Research results from Kenya have identified fresh leaves of sweet potato vines as the best weaning feed for kids. Hence, in areas where sweet potato is grown, e.g., in some parts of the SNNPRS and Hararghe, sweet potato vines could serve as a potential feed for weaning lambs/kids.

4.15.1. When or at what age to wean lambs/kids

In most production systems, lambs/kids are weaned naturally without attendant/shepherd intervention. Where intervention is made, weight development of the young rather than age should be used as a guide to weaning. Weaning should ideally take place when lambs/kids are consuming adequate amounts of solid feed.

Milk consumption by lambs and kids falls to a negligible level after 110 days. At the same time, consumption of herbage increases.

Some authors suggest that the young could be weaned successfully once the birth weight has increased 2.5-fold. This would mean a lamb with birth weight of 3 kg can be weaned at 7.5 kg body weight, which is attained at 2 to 3 months of age in Menz sheep. A weaning age of two months was found to negatively affect subsequent growth in Horro sheep, resulting in lower weights at six months of age.

Weaning age is variable for different production systems and depending on whether the milk is used as human food. However, in most production systems in the tropics, weaning at 120 days is common.

4.16. Mortality

Mortality of lambs and kids is one of the main factors adversely affecting sheep and goat production. Losses are usually as high as 50% of the lamb/kid crop.

An essential factor affecting return on investment in sheep and goat production is pre-weaning mortality. The highest losses usually occur during the first 30 days of life.

4.16.1. Causes of lamb/kid mortality

Causes of mortality are related to management and production system. Some of the causes are:

- Low birth weight
- Low environmental temperature at birth or shortly
- Litter type (single or multiple)
- Inadequate colostrum consumption
- Inadequate milk production of the dam
- Predators
- Diseases and accidents
- Season of birth

It has to be noted that all of these could be aggravated by poor management such as poor hygiene and overcrowding.

4.16.1.1. Low birth weight

Lambs/kids having low birth weight are consistently at risk of dying at all stages of development (pre- and post-weaning). Low birth weight is usually caused by inadequate nutrition of the dams during the last trimester of gestation. Low birth weight can be prevented where supplementary feeding of dams is practiced or when there is adequate forage of reasonable quality.

4.16.1.2. Low temperature

Very often this is a problem encountered in the cool highlands where the ambient temperature falls below zero during some months of the year. In such circumstances, the newborn can die as a result of hypothermia unless it is protected against freezing temperatures. The newborn could be put in a lamb/kid box for the first few days to provide protection against cold.

4.16.1.3. Predators

If ewes/does are giving birth unobserved on the range, the newborns are exposed to predators or kids/lambs may be abandoned by their dams. Abandonment may happen frequently with first time mothers. Losses due to predators have been reported to be a major cause of kid loss in the Alaba Woreda of the SNNPRS. According to the key informants, the breeding time of the fox, a time of high nutrient demand, coincides with the major lambing/kidding season; thus, kids become prey.

4.16.1.4. Diseases

If lambing/kidding is unattended and appropriate management measures such as dipping the navel cord in iodine are not done, the chance of infection increases. Proper preventive management and attention to health and cleanliness of the rearing area will decrease the chance of acquiring diseases.

4.16.1.5. Dehydration

If lambs/kids are allowed to join their mothers grazing on the range and travel long distances in their first days of life, they may suffer dehydration. If there is no shelter to protect them from the extremes of weather, they may suffer from heat or cold, especially if in combination with humidity. It is advisable to house the young and the dams for at least the first few days after birth before allowing them to graze with the flock.

4.16.1.6. Litter type

Mortality is higher in lambs/kids born in multiple litters than single-born lambs and kids. This might be a reflection of low birth weight, and inadequate nutrition in terms of milk from their dams as well as poor supplementary feeding management.

4.16.1.7. Season of birth

The effect of season varies for different places and seems to be related to nutrition of the dam, climatic condition and other factors as well as the presence of disease. For instance, kids born in the wet season had better survival than kids born in the dry season at Adami Tulu, while the opposite was true for kids at Awassa.

4.16.2. Reducing kid mortality

Reducing kid mortality focuses on two key issues.

- Improving birth weight of newborns by supplementary feeding of pregnant animals during the third trimester of pregnancy.
- Following standard hygienic practices to prevent/reduce incidence of diseases that affect young animals.

Exercises

1. Assess months and/or seasons when lamb/kid mortality occurs in your area.
2. What are the major causes?
3. Are there measures taken to reduce the incidence of mortality?

4.17. Taking Weight Measurements

Sheep and goats are weighed at different times for different purposes. In countries where the sale price is based on weight, live weight has a direct relation to the profitability of the enterprise.

Knowledge of animal weight is also essential for determining the dosage level of some drugs. On research stations, weight is an important and frequently measured parameter.

For light animals, a hanging weighing scale suspended from a tree branch as shown (Figure 4.26b) can be used.

a. Cage weighing scale with inlet and outlet door; ESGPIP trainees at Hawassa University weighing a goat using a mobile balance

b. Taking weight measurements using a hanging balance under field conditions

Figure 4.26. Weighing sheep and goats.

4.18. Estimating Live Weight

Under field conditions where scales are not available, weight measurements can be estimated using linear body measurements.

Chest girth, wither height, and body length are the most commonly used measurements, measured to the nearest centimeter.

4.18.1. Chest girth or circumference

Chest girth or circumference, sometimes called heart girth, is measured just behind the front legs.

4.18.2. Wither height

The highest point measured as the vertical distance from the ground to the shoulder tip. This can be measured with a tape but is best made with a special measuring stick made with two arms, one which is held vertically and the other at right angles to it and sliding along it (firmly not loosely). For higher repeatability, the measurement is best taken on firm and level ground.

4.18.3. Body length

Body length is measured from 'base of tail' (where it joins the body) to the first thoracic vertebrate or to the front of chest. Of the three linear body measurements, chest girth is the easiest to measure and also the least variable. Examples of equations developed to estimate weight from heart girth measurements are given in Table 4.4.

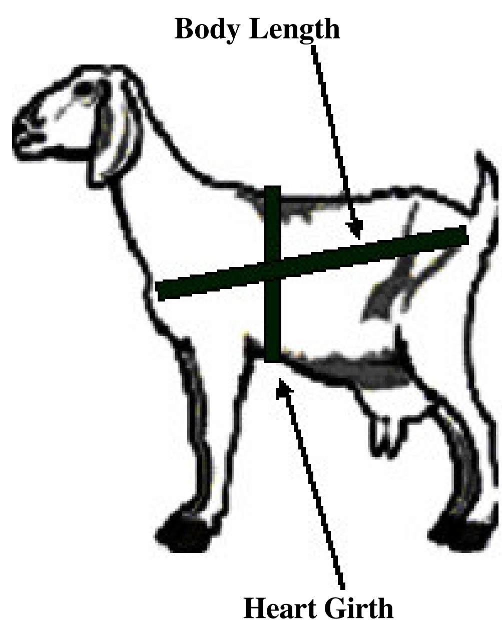


Figure 4.27. Linear measurement of body length and heart girth.

Table 4.4. Regression equations to estimate live weight at different stages of development.

Sheep/goat breed	6-month old	9-month old	12-month old
Menz sheep	-14.98 + 0.52 HG	-25.15 + 0.72 HG	-35.06 + 0.89 HG
Horro sheep	-17.89 + 0.58 HG	-28.71+ 0.78 HG	-40.36 + 0.99 HG
Somali goats	-17.66 + 0.57 HG	-22.79 + 0.68 HG	-

Example

The heart girth circumference of a Horro ram approximately at 9 months of age measures 70 cm. Estimate his weight.

Procedures:

1. Choose the equation found in column 3, second row
2. This is: Weight = -28.71+ 0.78 HG
3. Insert 70 cm into the above equation and solve.
4. Weight = -28.71 + 0.78 × 70
5. 25.89

The estimated weight of the ram is 25.9 or nearly 26 kg.

Exercises

1. Take heart girth measurements on 5 animals of different age categories and estimate their weight using the appropriate equation from Table 4.3.
2. If a weighing scale is available, weigh the same animals for which chest girth has been taken and compare the actual weight with the estimated weight.
3. Discuss the magnitude of the difference.

4.19. Culling as a Management Tool

Culling in sheep and goat flocks is an important tool for the development of a good flock. It helps to remove undersized animals and breed those closest to the desired ideal type. Selection criteria should be developed and followed when culling animals. For example, ewes that do not conceive after two successive matings should be culled. Animals with defects, poor udders, bad conformation, etc., should be culled. Culling should be stringent and used as a means of improving the genetic quality and productivity of a flock. Following such criteria could mean 10–20% culling annually. These animals can be sold to enter the meat market. Flock size can be maintained by replacing culled animals by ewe lambs or doelings in the flock.

References

Hailu Dadi, Mieso Guru, Nigatu Alemayehu, Fufa Dawo and Gemeda Duguma. 2006. The effect of environmental factors on pre-weaning survival rate of Borana and Arsi-Bale kids. Small Ruminant Research 66: 291–294.

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Chapter Five

Reproduction in Sheep and Goats

Girma Abebe

Objectives

1. To introduce the basic reproductive tract anatomy and physiology of sheep and goats.
2. To outline causes of reproductive failures.
3. To examine some reproductive traits.

Expected Outputs

1. Ability to locate various male and female reproductive structures and describe their respective functions.
2. Ability to list reproductive traits and factors affecting the level of performance.
3. Ability to list common causes of reproductive failures.
4. Adequate understanding to discuss the advantages and disadvantages of seasonal breeding.
5. Ability to discuss and suggest appropriate measures to be taken to improve reproductive efficiency.
6. Ability to list factors responsible for mortality of newly born animals.
7. Knowledge of the management techniques appropriate for different classes of sheep and goats.

5.1. Introduction

Simply defined, reproduction is giving birth to offspring. The survival of a species largely depends on its ability to reproduce its own kind. Reproduction is a series of events (gamete production, fertilization, gestation, reproductive behavior, lambing/kidding, etc.) that terminates when a young is born. Hence, reproduction is a vital function of all living organisms. Reproduction is a complex process. Sheep and goats are considered to be the most prolific of all domestic ruminants.

Reproduction determines several aspects of sheep and goat production and an understanding of reproduction is crucial in reproductive management. A high rate of reproductive efficiency is important for:

- Perpetuation of the species,
- Production of meat, milk, skin and fiber, and
- Replacement of breeding stock.

Males and females play different reproductive roles, and in most animal species, the role of females is not completed until a viable offspring is produced. Even after birth, females play a significant role in the provision of post-natal care and, in mammals, must lactate to provide nourishment for their young. Understanding basic anatomy and reproductive physiology of sheep and goats is important in implementing appropriate reproductive management.

5.2. Reproductive Organs and Their Major Functions

5.2.1. Female

The reproductive tract of ewes and does is similar and, hence, discussed together. The female reproductive tract consists of the vulva labia, vagina (copulatory organ), cervix, body of the uterus, uterine horns, oviduct (also called Fallopian tube) and the ovary.

Ovaries: The ovaries contain the ova (eggs), and secrete female reproductive hormones (progesterone and estrogens).

Oviduct: The oviduct opens like a funnel (the infundibulum) near the ovary. The infundibulum receives ova released from the ovary and transports them to the site of fertilization in the oviduct. The oviduct is involved in sperm transport to the site of fertilization, provides a proper environment for ova and sperm fertilization, and transports the subsequent embryo to the uterus.

Uterus: The uterus consists of two separate horns (coruna)**.** In animals with multiple births, each horn can contain one or more fetuses. The uterus provides a proper environment for embryo development, supports development of the fetus (supplying nutrients, removing waste, and protecting the fetus), and transports the fetus out of the maternal body during birth.

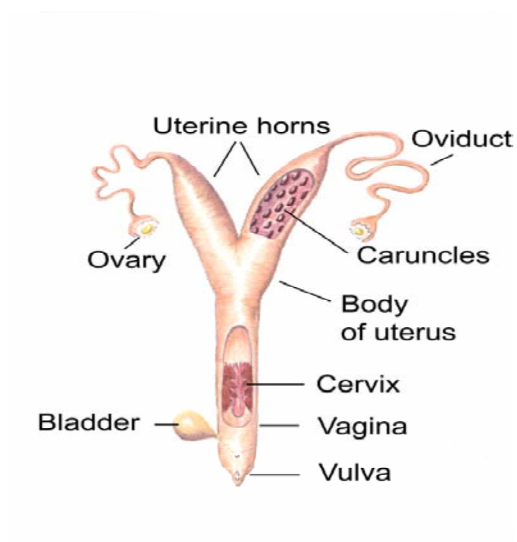

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Figure 5.1. Structure of the female reproductive tract.

Cervix: The cervix is the gateway to the uterus and is a muscular canal consisting of several folds of tissue referred to as “rings.” The cervix has relatively little smooth musculature. It participates in sperm transport, and during pregnancy, blocks bacterial invasion. The mucus produced during pregnancy (*also during the luteal phase*) forms a plug that makes the opening through the cervix impermeable for micro-organisms and spermatozoa.

Vagina: This is the exterior portion of the female reproductive tract and is the site of semen deposition during natural mating.

Vulva: barrier for preventing external contamination of the female reproductive tract.

5.2.2. Male

The male reproductive system consists of testicles, which produce sperm and sex hormones, a duct system for sperm transport, accessory sex glands, and the penis, or male organ of copulation, which deposits semen in the female.

Testes: The testes are paired organs which descend from the abdominal cavity during fetal development to lie in the scrotum. They produce the male gametes (spermatozoa) and secrete the male sex hormone, testosterone. Testosterone is essential for the development of male characteristics, maintaining normal sexual behavior and sperm production.

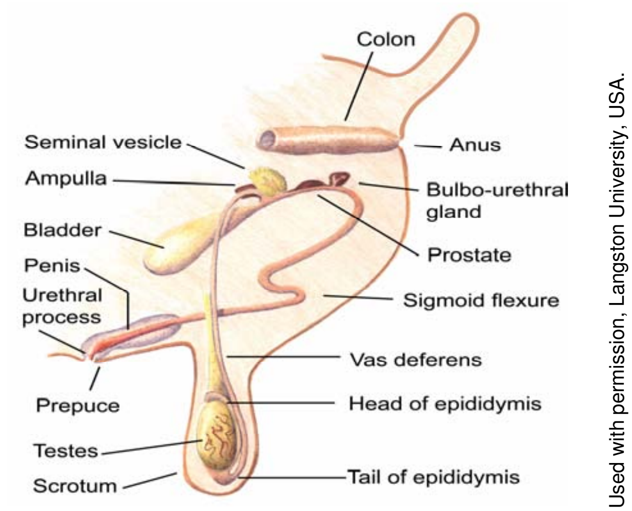


Figure 5.2. The reproductive tract of the buck.

Scrotum: The scrotum is a muscular sac containing the testes. It supports and protects the testes and also plays a major role in temperature regulation. It maintains the temperature 3 to 5^{o}C below body temperature for optimal function.

Single versus split scrotum: This could be breed-specific as in Somali goats. Some breeders consider the split scrotum as an undesirable trait and select against it. However, the important thing is to check if equal-sized testicles are present and sperm production is normal.

a. Single scrotum b. Partially split scrotum c. Split scrotum

Figure 5.3. Single versus split scrotum.

Epididymis: The epididymis is located in the testes and is a long and convoluted tube in which sperm cells produced by the testicles are stored and mature to a stage capable of fertilization. This change occurs as sperm cells move from the head to the body of the epididymis with mature sperm being stored in the tail of the epididymis.

Vas deferens: The vas deferens is the duct that rises from the tail of the epididymis into the abdomen, where it joins the urethra at the neck of the bladder. It is often referred to as the 'spermatic cord.' Removal of a section of the vas deferens in each testis is known as a vasectomy, preventing passage of sperm from the epididymis.

Accessory sex glands: The accessory sex glands include the bulbo-urethral, prostate, and seminal vesicle glands and the ampulla. Accessory glands secrete additional fluids, which when combined with the sperm and other secretions from the epididymis, form the semen. Some of the secretions contain nutrients like fructose while others produce alkali secretion to raise the pH of the ejaculate. These secretions are added quickly and forcibly during the mating to propel sperm into the urethra.

Penis: This is the final part of the male reproductive tract and its function is to deposit semen into the vaginal tract of the female. At the end of the penis is a narrow tube called the urethral process (or 'worm') that sprays the semen in and around the cervix of the ewe/doe. The preputial sheath protects the penis, except during mating.

5.3. Effect of Temperature on Reproduction

Increased body temperature can lower the reproductive rate in ewes/does by decreasing ovulation rate, delaying heat cycles or by increasing embryonic mortality. Heat stress in males affects the process of spermatogenesis and can render bucks and rams temporarily sterile for 6 to 10 weeks. For these reasons, it is important to assist animals in maintaining body temperature, especially during times of the year when ambient temperature is high. A simple provision of shade in range production systems could reduce the negative effect of heat. Physiological mechanisms in the male assist in regulating temperature.

- The external cremastor muscle contracts during cold weather to hold the testicles closer to the abdominal wall and relaxes during warm weather to allow the testicles to be more remote and hence cooler.
- Smooth muscle fibers in the scrotal sac, known as the *tunica dartos*, contract to reduce the total surface area and hold the scrotum closer to the body during cool weather and relax during warm weather to keep testicles away from the body.
- A network of blood vessels above the testicles, known as the *pampiniform plexus*, works to reduce the temperature of blood entering the scrotum. In this system of closely intertwined blood vessels, the cooler venous blood cools the warmer arterial blood as it enters the area of the testicles. This heat-exchange mechanism is especially important in animals where the scrotum is less pendulous (stallion and boar).

Activities

Activity 1:
Female as well as male reproductive organs of sheep or goats can be obtained from abattoirs or slaughter houses. Different parts of the reproductive tract and respective functions of each part should be examined and studied.

Activity 2:
Participants will be required to measure height of scrotum on bucks in the morning and in the afternoon and discuss their findings. This will help participants to appreciate mechanisms involved and the importance of regulating scrotal temperature.

5.4. Puberty in Females and Males

Puberty is generally defined as the point of sexual development at which the animal becomes capable of reproduction (first ovulation in the female and first spermatozoa in the ejaculate of the male), but animals are not yet fully sexually mature at this stage. Sexual maturity is the time when the animal expresses its full reproductive capacity. In both the male and female sheep and goat, puberty may often be reached without adequate physical growth to support reproduction, and in females the first ovulation may not necessarily coincide with first estrus.

In males, puberty is the time when complete separation of the prepuce and the penis occurs and motile spermatozoa are first detected in the ejaculate. In immature rams and bucks, the penis has adhesions that prevent it from being fully extended. At puberty, these adhesions dissolve under the influence of testosterone and the penis can be fully extended. This may occur as early as 5 months. However, full reproductive competence may not occur until 15 months of age. Spermatogenesis has been found to begin as early as 84 days of age, with spermatozoa present in the epididymis at 140 days of age.

5.4.1. What causes puberty?

Puberty is caused by an increase in secretion of pituitary hormones, which in turn lead to an increase in size and activity of the gonads.

5.4.2. Factors affecting puberty

Several factors such as nutrition, body weight, breed, season of birth and growth rate are known to influence the age at puberty. Nutrition is among the most significant factors influencing reproductive development and the onset of puberty.

- A low plane of nutrition delays first estrus and reduces uterine and ovarian development.
- Increasing the overall plane of nutrition generally advances the onset of puberty.
- Overfeeding will decrease subsequent fertility and impair mammary gland development and, therefore, care must be taken to avoid overfeeding.
- Energy and protein restriction influences age at puberty, with energy restriction having a greater influence on delaying onset of puberty than protein restriction.
- In most sheep and goat breeds, attainment of puberty is dependent on achieving satisfactory body weight, usually between 40 and 70% of the mature body weight. A late-maturing breed like the Somali goat is known to attain puberty at a later age.
- Age, weight and growth rate seem to be interacting in determining the process of onset of puberty. In general, faster growth rates resulting from higher planes of nutrition enable kids to attain puberty at a younger age and heavier body weight than kids reared on low planes of nutrition.
- Complete separation of males and females during the early growth period may delay the onset of puberty.

Different investigations on the reproductive performance of Ethiopian sheep and goats have shown the following: ewe lambs of the Menz breed attain puberty at 10 months of age and 16.9 kg mean weight or 56% of mature body weight. The onset of puberty was earlier in animals with higher weaning weights. Somali kids were 19 months and weighed 26 kg at puberty, indicative of a late maturing breed.

In Horro sheep kept under low-to-high nutritional regime, age at first mating was reported to be 206 to 285 days while weight was 18 to 21 kg. From on-farm monitoring work in Ada District, weight and age at first successful mating for sheep was reported to be 20 kg and 8.7 months, respectively, while for goats it was 17 kg and 7.4 months.

5.4.3. Appropriate age or weight at first mating

There are two schools of thought regarding the appropriate age of mating. One school of thought advocates early mating of ewes/does regardless of what is called ‘critical body weight.’ It is argued that this will increase the lifetime productivity of the females, despite the fact that some abortions are evident. However, the concept of ‘critical body weight’ is favored. According to this concept, animals should attain a minimum body weight in order to avoid growth retardation (in most cases two-thirds of mature body weight) before they are mated. This reduces reproductive wastage (abortion) that could result from mating small-sized and sexually immature animals.

Activities

Meet at least 5 knowledgeable farmers who have experience in sheep and goat production and find out the age at which sheep and goats are first mated.

1. What is the estimated age at first breeding for females in the area?
2. Are there differences in age at first mating between ewe lambs and doelings?
3. Are farmers/producers in your area aware of the advantages and disadvantages of early mating?

5.5. The Estrus Cycle in Ewes and Does

Once puberty is reached, large domestic animals such as sheep and goats display a polyestrous (repeated reproductive cycles) pattern of reproductive activity. The estrus cycle, defined as the number of days between two consecutive periods of estrus (heat), is on average 17 days in ewes and 21 days in does. The estrus cycle may be divided into two phases, namely:

- the follicular phase (growth and expulsion of the ova or egg), and
- the luteal phase, which starts after ovulation and formation of the corpus luteum (yellow body).

Further classification of the estrus cycle is possible as shown in Table 5.1. Estrus cycles show variation and thus are classified as short, normal and long. Short estrus cycle and irregular estrus periods may be seen in some goats.

Occurrence of estrus in Somali goats was shown to be positively correlated with monthly rainfall and monthly minimum temperatures, while a negative correlation was observed with monthly maximum temperatures and monthly sunshine.

Table 5.1. Different phases of the estrus cycle in does.

Stage	Day of cycle	Characteristics
Estrus	1–2	Final growth and ovulation of 1–2 pre-ovulatory cycles. Sexual receptivity of does. Cervical mucus thinner and more copious, cloudy towards ovulation.
Metestrus	3–4	Functional organization of corpus luteum.
Diestrus	5–18	Luteal phase.
Proestrus	19–21	Growth of pre-ovulatory follicles.

5.5.1. Hormonal control of the estrus cycle

- Estrus cycle is controlled by GnRH (Gonadotrophic Releasing Hormone) released by the hypothalamus.
- Just before the onset of estrus, the pituitary gland, under the control of the hypothalamus in the brain, releases an increasing amount of Luteinizing Hormone (LH) and Follicular Stimulating Hormone (FSH).
- Growth of follicles is regulated by pituitary hormones – FSH, LH.
- LH stimulates the final maturation of the follicle containing the eggs (oocytes) and stimulates the follicle to produce the hormone estrogen.
- Estrogen brings the ewe into behavioral estrus or 'heat.'
- The rising concentration of estrogen stimulates a surge in LH that stops further secretion of estrogen by the follicle.
- Once the egg has been released, LH transforms the follicle into a Corpus luteum (CL).
- CL produces progesterone, which in turn suppresses pituitary activity.
- If pregnancy does not occur, lysis (destruction) of the Corpus luteum occurs due to endogenous release of prostaglandin from the uterus, thus causing a fall in the progesterone level, and the cycle starts again.

5.5.2. Detection of estrus

The detection of estrus is very important when artificial insemination is conducted and when mating is controlled, i.e., sires do not run with females. For this reason it is important to know the signs of estrus.

5.5.2.1. Behavioral signs of estrus

Does

- Bleating continuously
- Swollen – red colored vulva
- Flagging of the tail
- Frequent urination
- Cervical mucus discharge, which causes hairs to stick together
- Restlessness
- Mounting other goats and seeking the buck

Ewes

The signs of estrus in the ewe are not obvious unless a ram is present. As in the doe, the vulva is swollen and redder than usual, and there is a discharge of mucus but is difficult to see in a ewe with a tail or fleece.

All of the symptoms mentioned may not be exhibited by a doe or ewe in estrus. The best confirmation of estrus is when the doe or ewe stands when being mounted. This is commonly called '*standing heat.'* The duration of estrus is variable in that it is shorter in younger ewes and does but longer in older animals. Normal duration will be 24 to 36 hours.

5.5.2.2. Estrus detection techniques

Estrus in sheep and goats is relatively easy to detect compared to that in cattle as heat signs are well pronounced, particularly in goats. Still, where controlled mating or artificial insemination (AI) is used, regular detection of estrus is necessary through:

- using a teaser ram or buck: Teasers are males that have been either vasectomized or epididymized.
- tying an apron made of leather or canvas around the body of a ram/or buck to prevent the penis from entering the vagina of females.
- using a teaser with a marking harness: When a ram/buck with a marking harness mounts a female in

estrus, some of the marking pigment will be transferred to the rump of the female.

The behavior of rams and bucks used for heat detection should be known as some may not do the job well.

Apron tied around body of buck

The buck can detect does that are in heat but cannot breed them

A ram wearing a crayon marking harness

Figure 5.4. Estrus detection techniques.

Caution

1. Frequent supervision is important when an apron is used as the canvas or leather can slip, resulting in unwanted pregnancies.
2. A mark is not an absolute indicator of estrus activity in the female because males may incidentally or purposely mount females that may not be in estrus. But with experience it is possible to differentiate such marks resulting from false mounting because the place and intensity will be different.

5.6. Measures of Reproductive Performance

Measures of reproduction commonly used in sheep and goats include age at puberty, age at first lambing/kidding, post-partum interval, parturition interval and fertility indices.

5.6.1. Age at puberty

It is difficult to have an accurate measure of puberty unless hormonal assays are done at certain intervals (bi-weekly). On experimental stations, puberty may be recorded as the first behavioral estrus observed. This estrus is called pubertal estrus. The manifestation is not strong and its duration is short, hence, requiring close attention for heat detection.

5.6.2. Age at first lambing/kidding

This trait can be recorded easily in a farmer's flock. There is a big variation among production systems and breeds for this trait (12–24 months). It is usually late in animals living in harsh environments.

5.6.3. Post-partum interval (PPI)

This is the time between parturition and the resumption of cyclic ovarian activity and it is a major component of lambing/kidding interval. It has a significant contribution to productive efficiency. A mean interval of 83.5 days (51–133 days) has been reported for Somali goats. Nutrition, suckling, parity (number of times kidded/lambed) and breed affect this trait. During lactation, the onset of a new cycle is actively inhibited so that the energy is preferentially reserved for milk production for the offspring. This is called lactational anestrous.

Ewes and does giving birth in the dry season have a longer interval compared to those lambing/kidding during the rainy season. Ovarian activity in most tropical breeds commences after weaning. Suckling interferes with hypothalamic release of GnRH, provoking a marked suspension in the pulsatile LH release, resulting in extended postnatal anestrous. Females at earlier parities take longer than older ones to return to reproductive status.

5.6.4. Parturition interval (lambing/kidding interval)

This refers to the number of days between successive parturitions. It is called lambing interval in ewes and kidding interval in does. Under normal circumstances (no drought), tropical sheep/goats should be lambing/kidding at least three times in 2 years. For this to be realized, lambing/kidding interval should not exceed 8 months (245 days). As the major component of parturition interval is post-partum interval (PPI), accelerated lambing or kidding revolves around manipulating PPI because a shorter PPI will result in a shorter parturition interval. Better nutrition and early weaning could impact this measure of reproductive performance.

Tests on an eight-month lambing interval under controlled mating in Horro sheep has shown acceptable results in both ewe and lamb performance. One of the most important ways of increasing offtake rate is through reduction of the parturition interval and, if done with optimal input, this may help in meeting the growing demand of the export trade.

5.6.5. Fertility

Various definitions of fertility exist in literature such as conception rate, fecundity, prolificacy, birth rate, etc. A general definition of fertility is the number of ewes lambing or does kidding divided by the number of ewes/does mated. Fertility is affected by factors such as nutrition, age, diseases and season of mating. In most cases, there is a positive effect of supplementation. Supplementation during the mating period (shortly before the mating period and afterwards) could increase the number of ova shed and improve embryo survival. This practice is called flushing and is discussed in the nutrition and management sections. Age of the ewe or doe is also an important factor. Fertility increases with age, and also starts to decline with old age.

5.6.6. Litter size (LS)

This is a combination of ovulation rate and embryo survival. Litter size (LS) varies between 1.08 and 1.75 with average of 1.38. Positive relationships between LS and age and LS and parity have been noted. LS increases with parturition number until the fifth kidding/lambing. Increases in ewe or doe weight (prior to mating) by 1 kg over the mean of the population results in an increase of about 3.8% in LS. Breed differences in litter size are common. Finnish Landrace and the Romanov breed are considered the most prolific sheep in the world. In Ethiopia, the Horro breed is said to be prolific as compared to the Menz sheep.

A litter size of 1.93 has been reported in Boer goats. This is said to increase to 2.5 with selection. Sheep and goats in the pastoral areas are known to give birth to singles only. This might be due to negative selection that has taken place in the environment. Heritability estimates suggest the possibility of genetic improvement in LS through selection.

5.6.7. Annual reproductive rate

This is defined as the number of lambs/kids weaned per ewe/doe of reproductive age per year. Some authors use litter size at birth rather than litter size at weaning. However, the latter is preferred as it takes the mothering ability of the dam into consideration.

Apart from single traits, a combination of two or more traits can be used as a measure of reproductive performance.

5.7. Seasonality of Breeding

Different sheep and goat breeds have developed in a wide range of environments and have consequently evolved a variety of reproductive strategies to suit these environments. Local breeds of sheep and goats in tropical conditions are either non-seasonal breeders or exhibit only a weak seasonality of reproduction. Females ovulate and exhibit estrus almost the whole year round, even though short periods of anovulation and anestrous are detected in some females. Two main hypotheses can be raised to explain the near-absence of seasonality: either the females are insensitive to photoperiod, or the amplitude of the photoperiodic changes is too small to induce seasonality.

The principal advantage of non-seasonal breeding regime is a continuous supply of milk, meat and surplus animals to producers and the low-input labor and management required. Yet this strategy produces low milk yields, lowers kid survival and growth whenever late pregnancy and birth fall into periods with suboptimal forage availability. Moreover, conception rate, prolificacy and kidding rates are compromised whenever mating occurs under poor nutritional conditions. It should be noted, however, that there are months with clearly reduced sexual activity. These months differ from region to region and appear linked with the temperature regime and to feed availability.

In the Ethiopian highlands, most conception in sheep and goats occurs during or following the periods of the short rains in March through May. In Zimbabwe, two major peaks of kidding (before the rains in October and November and after the rains in April) have been observed in small East African indigenous goats. Adult female Boer goats have shown a tendency towards greater sexual activity at lower ambient temperatures. In some goat breeds (e.g., Creole goat), monthly percentage of estrus was negatively correlated with minimal temperature. As seen in Figure 5.5, kidding in Ethiopia takes place all year-round. Peak kidding is observed in May–June on research stations and in August under farm conditions.

Most results show that in the absence of nutritional stress, there are no periods of the year when the whole flock is anestrus. A study conducted in the central highlands (Ada District) reported that most lambing and kidding occurred during the heavy rains (August–September), indicating that most of the conception occurred during or following the small rains in March–May.

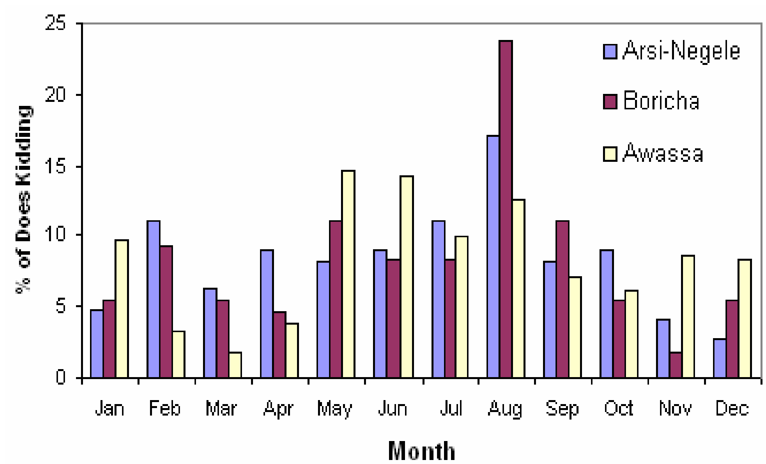


Figure 5.5. Kidding pattern of Arsi-Bale goats.

Questions for Discussion

1. When do most births (lambings/kiddings) occur in your area?
2. Are there any attempts to control breeding so that most births occur when feed is available?

5.8. Mating Systems

Once males and females are sexually mature, they will display characteristic behavior prior to mating. Unless restrained, both sexes will make an effort to reach each other and mate. Smell, sight and noise are the common attractants. In sheep, the fat tail of a ewe may make mating difficult or even impossible. Experienced rams push the tail aside to let the penis penetrate the vagina. Young and inexperienced rams may need assistance, i.e., hand-mating may be essential. The following types of mating could be practiced depending on the system of production.

5.8.1. Flock-mating

Fertile rams or bucks are allowed to remain continuously with a group of females. This mating system is commonly practiced by pastoralists. Under smallholder conditions, a flock may constitute all sheep or goats in a given village. This method avoids the need for heat detection but makes recording the mating date, the sire and calculation of the expected date of parturition difficult unless breeding males are fitted with a marking harness. Flock mating provides the best result in terms of fertility and lamb/kid crop given an appropriate male-to-female ratio. However, inbreeding and subsequent declines in productivity could occur unless males are rotated or replaced on a predetermined period.

5.8.2. Pen-mating

This involves confining a sire with a group of females, in a paddock for example, for mating during the service period. A variation of this method may include housing groups of females with a selected breeding ram/buck at night. Continuous supervision is important to make changes of sires if the assigned sire does not perform well. Sires may be fitted with a marking harness that enables calculation of the estimated date of lambing/kidding.

5.8.3. Hand-mating

This involves detecting females in estrus and bringing them to breeding males. In such a system, regular and efficient heat detection methods are essential. The PM–AM method of breeding is used, where females detected in estrus in the afternoon are bred early the next morning and those detected in estrus in the morning are bred in the afternoon of the same day.
In terms of fertility, this method is the least efficient as the male is restricted in breeding the female. A variation of this system is observed where a producer may have few female sheep or goats but no breeding male. One sire kept by an individual will serve sheep or goats of many surrounding owners who bring ewes/does in estrus to the male. In some instances ewes or does in estrus are brought to the market, where male animals are available for breeding.

5.9. Reproductive Phases of the Ewe

A ewe's reproductive timeline is depicted graphically in Figure 5.6. Critical time periods include the first and last months of pregnancy (nutritional stress) and the first month after lambing (period of environmental adaptation for the lamb). Periods in which reproductive wastage occurs are between ovulation and implantation for embryonic loss, between implantation and parturition for fetal loss and between parturition and weaning for lamb loss.

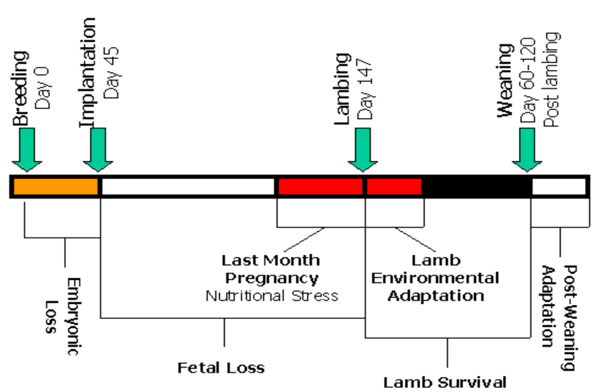


Figure 5.6. Reproductive timeline for sheep.

5.10. Reproductive Failures

The cause of reproductive failures is varied and often poorly understood. Individuals or entire flocks can be affected with acute or chronic problems that can have catastrophic consequences for livestock producers. Depression of reproductive performance can be broadly classified into:

- Failure to mate;
- Failure of fertilization in mated animals;
- Loss during any stage of gestation (embryonic, fetal losses);
- Neonatal mortality and subsequent loss occurring until the time of weaning.

The greatest economic losses occur with late gestation, abortions and neonatal mortalities or pre-weaning deaths. Reproductive failure can also result from structural defects or functional disorders affecting the genital tract. In males, the following could easily be detected:

- Testicular hypoplasia: This is characterized by undersized testicles and very low semen production. It can be diagnosed by semen, testicular palpation and a high return rate to estrus of females mated to that particular male. This commonly occurs in animals that are actually intersexes.
- Cryptorchidism: This is a failure of one or both testicles to descend from the abdominal cavity into the scrotum. Cryptorchidism can be unilateral (failure of one testicle to descend) or bilateral.

5.11. Breeding Soundness Examination

A buck should possess characteristics that will advance the production potential of the herd in which he is used, while being able to successfully mate to transmit these characteristics.

5.11.1. Physical examination

This is evaluation of overall condition of the ram/buck and includes:

- Health history, physical fitness, particularly of feet and legs, eyesight, etc.
- Pedigree, i.e., ensuring the sire is free from known hereditary defects.
- Evaluating the smoothness of the hair coat for evidence of malnutrition or chronic infection.
- Body condition scoring and noting of the score.
- Checking for and noting any defects that could interfere with the breeding process.
- A thorough examination of the scrotum, palpation of testicles, and examination of sheath and penis.

5.11.2. Scrotal circumference and diameter

The scrotal circumference can be measured with a specially designed tape or with any other measuring tape or even a cord whose length can be compared with a ruler. The circumference is measured at the widest part of the scrotum with both testes held at the same level. A male with large testicular size at a given age is likely to produce better quality semen.

Measurement technique

- Make sure that the scrotum is relatively clean.

- Measure scrotal circumference by passing a flexible tape around the scrotum (both testes) at the point of maximum circumference when the ram/buck is relaxed. This is most easily done with the animal standing.

For accuracy and repeatability, attention should be given to two aspects of the technique in particular namely placement and tension..

Placement and tension

Placement: It should always be with the tape at right angles to the long axis of the testes. This is most easily achieved in the standing ram, where the circle of tape should be parallel with the ground.

Tension: Tension on the tape should be standardized, particularly between different operators in different locations. The tension should be until a 'slight indentation' occurs on the testes.

Although size could differ between breeds and even within breeds, the following could be used as a guide.

Used with permission: Langston University, USA.

Figure 5.7. Measuring scrotal circumference.

- For large sized breeds, acceptable sires should have a scrotal circumference of no less than 30 cm for ram lambs and 31 cm for adult rams. However, it should be noted that scrotal circumference may be greatly decreased by recent weight loss as well as by season of the year.
- For dairy goat breeds weighing more than 40 kg, a scrotal circumference of 25 cm or greater is desired.
- For Horro breed of sheep, a range of 21–28 cm has been reported

Apart from scrotal circumference, testicular diameter and volume may be measured. But the repeatability of testicular diameter is low and measuring testis volume is a tedious exercise.

5.11.3. Semen evaluation

The third and final part of the breeding soundness examination involves the collection and evaluation of an ejaculate. In trained rams and bucks, this is achieved using an artificial vagina, but in most instances an electro ejaculator must be used. The method of collection has some effect on the ejaculate characteristics, the volume generally being larger when an electro ejaculator is used, but at times the semen may get mixed with urine. The ejaculate is immediately scored for gross motility under low (mass motility) and high (percentage of motile sperm) magnification of a light microscope on a pre-warmed slide. Morphological abnormalities and viability are determined from stained semen smears. At least 70% of the sperm should have normal morphological characteristics. In the final part of the examination, rams/bucks are allowed access to estrous ewes/does to evaluate libido and mating behavior.

Bucks/rams are classified as either sound, questionable or unsatisfactory, based on all components of the examination. No firm guidelines have been developed to assign bucks into these categories and interpretation rests largely with the experience of the examiner. Animals deficient in any part of the examination should be considered questionable and retested after several weeks. A second failed test would indicate reproductive deficiencies and such a buck should not be used in natural mating.

5.12. Libido (Sexual Desire)

Libido is a male's desire to mate. The willingness to breed ewes is highly variable among rams and can have a major impact on sheep production, especially in a single-sire mating scheme. Mounting and thrusting behavior, sniffing of the genital region and flehmen reaction (curling of the upper lip of the male in response to detecting sexual readiness of the female) are well established common behaviors of normal sheep and goats. This behavior is regulated by the release of testosterone, produced by specialized cells in the testes.
Some breeds show libido almost continuously once they reach puberty. In other breeds, there is a marked decline in libido during the non-breeding season. Underfed or excessively fat rams/bucks may show reduced libido. The desire to mate also decreases with age and disease conditions, such as arthritis. Some rams have inherently poor libido. Studies have shown that up to 15 percent (average of 8–10 percent) of rams are homosexual and will not mate with ewes.

5.12.1. Test for libido

A "Libido test" can be conducted to determine a ram's desire to mate ewes. In this test, rams are exposed to ewes in estrus and their breeding activity is recorded over a period of two weeks or more. This test, also known as "a serving capacity test," is useful for identifying low- and high-performing rams. Serving capacity or breeding behavior is a heritable trait. Lack of libido may be hereditary or may originate from endocrine imbalance or environmental factors.

5.13. Ram-to-Ewe Ratio

Maintaining the correct ratio of fertile rams/bucks and ewes/does (one ram/buck to 20–25 ewes/does or 3 per 100 ewes/does in a year-round mating) is important as it can affect the overall reproductive efficiency. The age of the breeding ram/buck, the length of the mating season and the environment in which the animals are kept may influence the ratio.

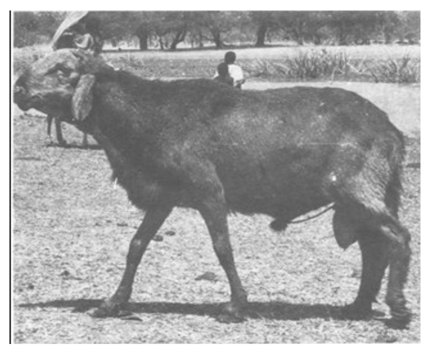
5.14. Culling

This is a method used to improve the overall productivity of the flock. Although reasons for culling could be different for different systems and agro-ecologies, from a reproductive point of view, it is essential to intensively cull ewes/does after 5–6 years of age.

It is important to detect barren ewes or does in the flock. Habitual aborters should be identified early and culled. This is of significance as abortion caused by *brucella* bacteria can be transferred to healthy animals within a short period of time. Frequent screening of the flock for *brucella* could be useful if diagnostic labs are found in the area.

5.15. Control of Mating

In some societies, breeding is controlled either to synchronize birth (lambing/kidding) or to reduce stress during the year when pasture is felt to be inadequate for normal reproductive processes. For instance, use of a leather apron to give a physical barrier to penetration is



A Sudan Desert ram in Southern Darfur with a 'Kunan'

Locations on the testis and the prepuce where the rope is tied

Figure 5.8. Use of a 'Kunan' to prevent breeding.

used in Massai flocks in Kenya. Similarly, 'Kunan,' a cord tied round the neck of the scrotum and looped over the prepuce to prevent extrusion of the penis, is used in West Africa and in some parts of East Africa such as south Sudan.

An attempt to use these methods, particularly the Kunan (Figure 5.8), on Horro sheep, has not been successful. Developing practical methods for mating control would have a very important contribution to controlling lambing and for genetic improvement.

Questions for discussion

1. Is there an attempt in your region to control breeding of sheep and goats? If yes, what is the main purpose? What are the methods used to control breeding?
2. Preliminary observations made at Awassa indicate that Somali bucks have poor libido. It is hypothesized that this is mainly related to the lack of twinning in the breed as research has shown single-born males are poor with respect to this trait. Have you had such experiences in flocks in your area?

5.16. Reproductive Biotechnology

5.16.1. Estrus synchronization

Estrus cycle control in sheep and goats is useful for synchronizing estrus in groups of animals to be bred or inseminated at a particular time or inducing out-of-season estrus where there is a distinct seasonality of breeding.

5.16.1.1. Why do we need to synchronize estrus?

Estrus in sheep and goats can be synchronized for one or more of the following reasons:

- To facilitate the practice of artificial insemination, either for genetic improvement or to reduce the number of rams/bucks needed to be kept.
- To match the period of lambing/kidding with feed availability such that lambs/kids are born during the period of the year when feed is available.
- Used as an initial step for super-ovulating ewes/does and subsequent embryo transfer.
- Induction of estrus in ewes/does with silent estrus to shorten the lambing/kidding interval.

5.16.1.2. Estrus synchronization techniques

There are two main methods of synchronization:

- Use of exogenous hormones or their synthetic forms, and
- The male effect.

Hormones

Among the hormones of reproduction, progesterone can be considered as the 'organizer' of the estrus cycle. Manipulation of the progesterone status of the animal provides a convenient means of controlling the estrous cycle. Estrus synchronization techniques revolve around the artificial shortening or lengthening of the period of progesterone dominance of the luteal phase.

Two classes of hormones are available for estrus synchronization. These are progesterone or one of its synthetic analogs and prostaglandins. Progestagens extend the luteal phase of the estrus cycle. Most commonly, progestagen-containing vaginal pessaries are employed. The 'Y'-shaped silicone-coated devices known as 'Controlled Internal Drug Release (CIDR)' impregnated with progestagen are also used (Figure 5.9). As an alternative to vaginal pessaries, implants impregnated with a highly potent synthetic progestagen 'Norgestomate' may be inserted under the skin on the upper side of the ear.

The period of application of exogenous progestagen is approximately equal to the life of the corpus luteum. Withdrawing the exogenous progesterone supplement will enable pulsatile release of GnRH, stimulating FSH and LH release leading to estrus and ovulation.

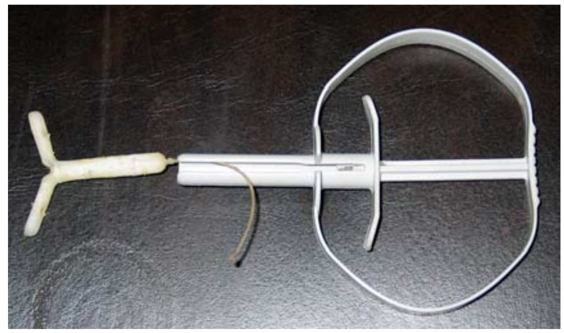


Figure 5.9 CIDR and applicator.

In the second class of hormones, prostaglandin $F_{2\alpha}$ can be used to regress the corpus luteum (interrupt the luteal phase). Prostaglandin $F_{2\alpha}$, by its luteolytic activity, can synchronize estrus, but only when an active corpus luteum exists at the time of application. In most cases, treatment with PG $F_{2\alpha}$ is given twice, 7 days or 11 days apart, to make sure all functional corpora lutea regress.

Caution

It is important to realize that prostaglandin can initiate fetal abortion in a pregnant animal. Hence, great care should be exercised not to expose animals to the product at any stage of pregnancy.

The male effect

The male can be used to stimulate estrus activity of females that have been previously isolated from males for a period of 3–4 weeks. After the period of separation, the male animal is suddenly introduced to the group of females.

In response to introduction of the male, ewes/does secrete increasing amounts of LH and FSH, which result in ovulation after 2 or 3 days of male introduction (in some ewes/does response may be slower, i.e., 4 to 7 days). In cyclic goats, highest frequency of estrus was observed within the first 3 days of buck introduction. The following factors affect response to male introduction:

- Within breeds, rams/bucks with greater sexual activity induce responses in more ewes.
- Rams that were given libido tests and ranked as highly sexual induce estrus more effectively than males with low libido test scores.
- Ewes/does that are on a high plane of nutrition will respond better than those nutritionally stressed.
- The longer lambs/kids have been weaned from ewes/does, the better the response of the ewes/does.

5.17. Artificial Insemination (AI)

Artificial insemination is a technique in which semen is collected from a ram or buck and put into the reproductive tract of a ewe/doe. The standard procedure of inseminating does involves lifting up of their rear quarters with their front legs remaining on the ground. With the aid of speculum and pen light the cervical opening or 'os' is located and, under visual control, an insemination pipette is passed into or through the cervix for semen deposition. If difficulty is encountered in passing through the cervix, semen has to be deposited intra-cervically or caudal to the cervical os.

Use of AI has the following advantages:

- High potential for genetic improvement.
- When introducing a new breed from foreign countries, it is often easier and cheaper to import frozen semen than to import live animals.
- The risk of introducing a new disease is much lower if semen is imported.
- Genetics (semen) from superior animals in other regions or countries can be used.

Three methods of semen preservation could be used:

- Fresh
- Refrigeration (Fresh chilled with an extender)
- Freezing

Three methods of insemination are available depending on the site of semen deposition during the process of insemination:

- Vaginal
- Cervical
- Intrauterine

a. Locating the cervical opening with the aid of a speculum and pen light

b. Semen deposition

Figure 5.10. Doe AI during ESGPIP training at Awassa

Vaginal insemination is successful for fresh semen, whereas intra-cervical insemination is used for refrigerated and frozen semen. However, in order to achieve high pregnancy rates (>70%) with frozen semen, intrauterine deposition of semen is required. While in many does it is possible to pass the cervix and deposit the semen intrauterine, in certain categories of animals (e.g., doelings), breeds (e.g., Nigerian dwarf) and individuals this will only be possible using other more technically challenging techniques such as laparoscopic insemination methods.

Fresh semen can be used when the male is present in the flock. The use of chilled, refrigerated semen is a useful strategy when the male is shared among groups of producers located within a relatively small area. In such cases, semen is stored at -4°C and can be used up to 24 hours from collection.

Semen is processed and frozen in liquid nitrogen for long-term preservation. In general the method of semen preservation dictates the preferred method of insemination. As a rule of thumb, the more damaged the semen, the deeper semen has to be deposited to achieve high fertility rates.

5.18. Embryo Transfer (ET)

Embryo transfer involves the flushing (removal) of embryo(s) from the donor and transfer to the recipient animal. Embryo transfer operations rely on provision of sufficient numbers of viable embryos (super-ovulated) to justify efforts involved. This is usually done to exploit the genetic superiority of the dam line. Prior to flushing, the candidate donor ewe/doe is super-ovulated (the production of more eggs than the female would normally produce) and bred or inseminated. For conducting embryo transfer, the estrus cycle of the recipient has to be synchronized such that when the transfer is made, the uterine environment of the recipient ewe/doe is conducive (the reproductive cycle is at a similar stage with that of the donor) for the embryo.

Achievements from multiple-ovulation and embryo transfer (MOET) have not been encouraging for widespread use since the results can vary from complete failure to total success without any variation in the standard operating procedure. The unpredictability of results, combined with high costs and the use of surgical procedures for collecting and transferring embryos, have prevented large-scale use of MOET in sheep and goat improvement programs.

5.19. Gestation

Gestation is the period from fertilization to delivery of the fetus. The average duration of gestation periods in ewes and does is fairly constant and ranges from 147 to 152 days. To some extent, it could be influenced by:

- **Age of the dam:** younger ewes and does have shorter gestation than older ones.
- **Litter size:** dams carrying twins have shorter gestation than those carrying singles.
- **Nutrition of the pregnant ewe or doe:** low level of feeding on range shortens gestation.
- **Breeds:** small and dwarf breeds have shorter gestation periods.

5.20. Pregnancy Detection

Establishing whether bred animals are pregnant or not is important to the commercial producer. The most accurate tests are those that measure or detect something that is only produced by a viable fetus and that is always present when the pregnant animal has reached a certain stage.

Methods of pregnancy diagnosis include:

Non-return to estrus

Frequent checking of animals after the normal estrus cycle (17 days for sheep and 21 days for goats) for visual signs of estrus is the simplest method. Animals not returning to estrus after the normal period are considered to be pregnant.

Progesterone test

Where facilities are available, progesterone assay in milk (in dairy breeds) or in blood samples is a common test. Although progesterone in goats is produced by ovaries only, measurement after 19 to 24 days of breeding will give an accuracy of 87 % for pregnant animals.

Ultrasonography

Ultrasonographic examination can be done as early as 28–30 days using intra-rectal examination. Transabdominal ultrasonography is done after 40 days post-breeding. Both methods can give good accuracy.

5.21. Parturition

The process of parturition in sheep and goats is complex. In the ewe, maternal plasma progesterone declines 7 to 15 days before delivery while in goats such a decline is noted 24 hours before delivery. Estrogens increase during the last days in ewes and gradually in goats. These events stimulate the muscles in the uterus to contract. The fetus and placenta are expelled and this is followed by the involution (shrinking of the uterus to normal size).

Signs of approaching parturition: Approximately 2 weeks before lambing/kidding some changes occur: the udder and teats swell (more prominent in dairy breeds) and the vulva becomes loose.

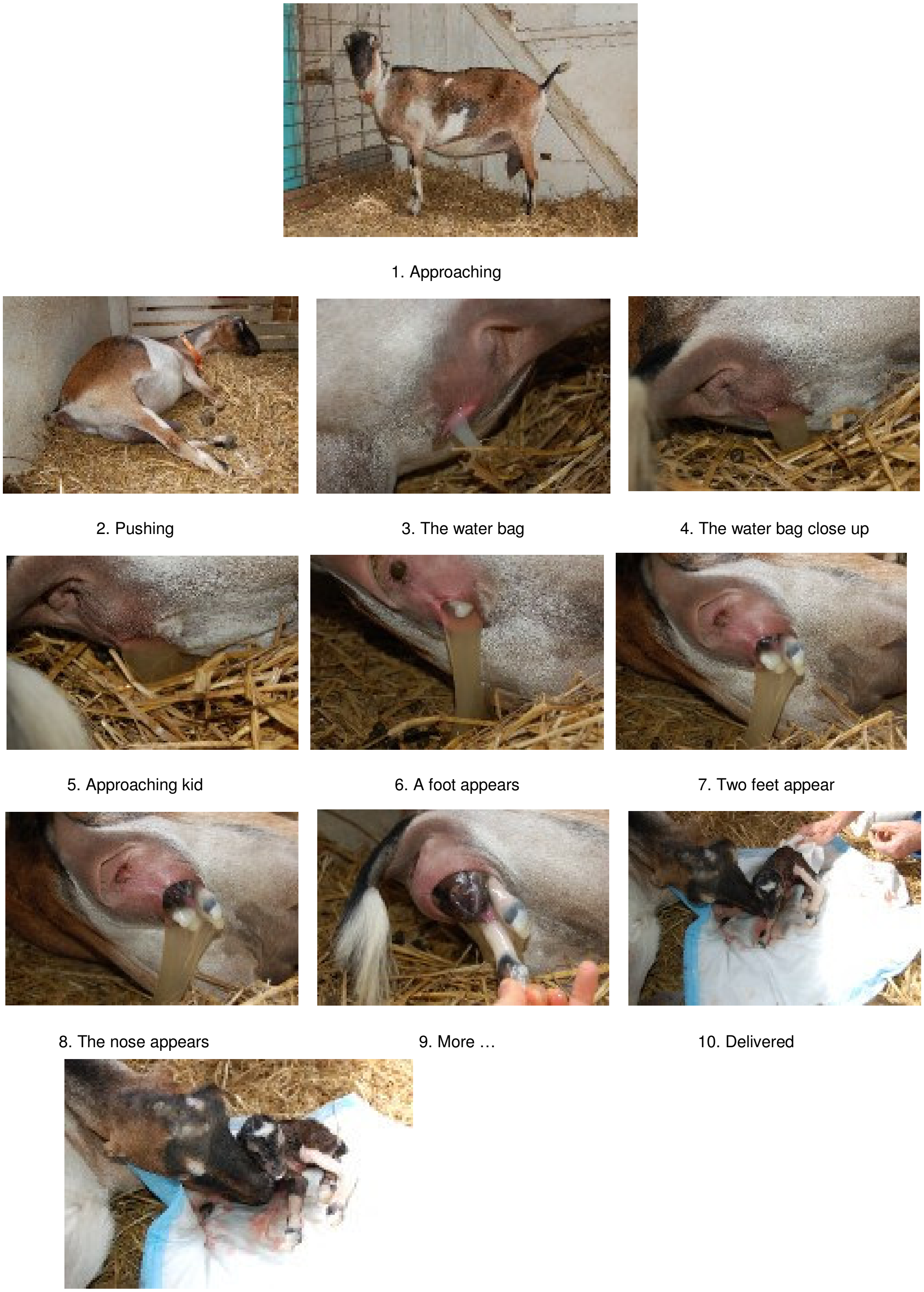
5.21.1. Stages in parturition

Parturition is traditionally divided into three stages:

Stage One	Stage Two	Stage Three
Is immediately before lambing/kidding (up to 12 hours). • The doe/ewe isolates itself from the flock, seeking a solitary place; • Becomes restless and uneasy; • Paws and scrapes the ground, sits and stands; • Stretches and strains with her neck skyward when sitting; • Forces placenta, fetus, and fluids against the cervix to dilate it; • The water bladder appears or has already ruptured; • The ewe/doe licks the fluid, wanders about.	Is typically faster and lasts about 30–45 minutes: • It is accompanied by straining (contraction of abdominal muscle) • The lamb/kid normally appears front feet and nose first. At this stage, the animal is normally lying on her side. This stage is completed by expulsion of the last lamb/kid in case of multiple births. • Once the lamb/kid is ejected, the dam will lick off the membrane covering of the lamb/kid. This uncovers the mouth and nose and stimulates breathing.	Involves: • Expulsion of the placenta normally within 4 hours, and • Involution of the uterus.

5.21.2. Assistance during parturition

In a majority of cases, ewes and does give birth normally without assistance. However, a few may need assistance. It is important to get acquainted with the normal birth presentation to be able to provide appropriate assistance. This subject is dealt with in more detail in the Management chapter.



1. Approaching

2. Pushing

3. The water bag

4. The water bag close up

5. Approaching kid

6. A foot appears

7. Two feet appear

8. The nose appears

9. More …

10. Delivered

11. Mother and offspring bonding

Source: http://fiascofarm.com/galleries/Goat_Care_and_Information/index.html

Figure 5.11. Stages in parturition and the normal birthing process in a doe.

References

Ulfina Galmessa, Fikru Terefe, Solomon Abegaz, Gemeda Duguma and Solomon Gizaw. 2000. Determination of the minimum body weight and its feeding requirement for early breeding in Horro ewe lambs. Proceedings of the 8th Annual Conference of ESAP. 24–26 August 2000. Addis Ababa, Ethiopia.

Mukasa, M.E., Ephraim Bekele and Tadesse Tessema. 1986. Productivity of indigenous sheep and goats in the Ada District of the Ethiopian Highlands.

Ministry of Agriculture (MoA). 1985. Project preparation report — Sheep production project. Annexes: 1–6. Australian Agricultural Consulting and Management Company PTY. LTD. March 1985.

Chapter Six

Genetic Improvement of Sheep and Goats

Solomon Abegaz and Kassahun Awgichew

Objectives

1. To introduce basic concepts of inheritance in animal breeding.
2. To identify the basic tools for attaining genetic improvement.
3. To describe methods for characterization and conservation of small ruminant genetic resources in Ethiopia.
4. To describe selection methods for small ruminant improvement.
5. To describe crossbreeding methods for improvement of small ruminants in Ethiopia.
6. To describe the main features of a genetic improvement program that is applicable to Ethiopian conditions.

Expected Outputs

1. Understanding of genetic concepts underlying sheep and goat breeding.
2. Understanding of methodologies and options in sheep and goat breeding.
3. Understand of the concept, rationale and methods of breed characterization and conservation.

6.1. Introduction to Genetic Concepts

The cell is the basic unit of life. At the center of the cell lies the nucleus, in which chromosomes are found. On these chromosomes are the genes which are the basic units of inheritance. Each animal species has a definite number of chromosomes arranged in pairs (called homologous pairs). Sheep have 27 pairs of chromosomes while goats have 30 (Table 6.1). Cells in the body are of two types, namely male and female somatic cells or sex cells, which are also called gametes. Male gametes are called sperm and female gametes are called eggs. The sperm and egg cells contain only one chromosome of each pair resulting in one-half the chromosome number (haploid) found in the somatic cells. When the sperm and egg unite, the full chromosome number (diploid) is achieved and the fertilized egg has all the genetic material needed for it to develop into a lamb or kid. Therefore, half of the genes each individual carries are contributed by either of the parents.

Genes are responsible for the many manifestations that we see within a trait, also called phenotype. For certain traits, the environment can also affect the phenotype. We can express this relationship as:

P = G + E where, **P** is the phenotype, **G** is the genotype or genetic makeup, and **E** is the environmental effect in which the animal makes its record.

Phenotype is what we can see or measure for a given trait. Examples are 2.2 kg for birth weight, 94 kg of milk for third lactation, 1.2 kg of wool at first shearing, red coat color, presence of horns, etc. Genotype (G) is the genetic contribution inherited from each parent, and environment (E) constitutes all the environmental (non-genetic) effects. Examples of environmental effects are plane of nutrition, frequency of deworming, ambient temperature, etc.

Certain traits are controlled by only one or a few gene pairs and are affected only slightly or not at all by the environment. These traits are called qualitative traits since they fall into discrete categories such as coat color or the presence of horns. An animal with the genetic makeup for hornedness will have horns regardless of the plane of nutrition, regardless of whether the animal is in Ethiopia, Somalia, or some other country, regardless of whether it is in the highlands or lowlands.

Other traits called quantitative traits are usually influenced by the action of many genes each with relatively small effects, and by the environment. Unlike qualitative traits, in quantitative traits the consequences of segregation of genes can no longer be seen because the different classes of the trait become more or less continuous. The continuity seen in quantitative traits increases as the number of genes involved increases. In other words, the number of possible gene combinations increases dramatically with an increase in the number of genes considered. An understanding of this is important when discussing heritability and potential for genetic improvement of animals.

Table 6.1. Numbers of chromosome pairs in farm animals and humans.

Species	Number of chromosome pairs
Cow	30
Sheep	27
Goat	30
Swine	19
Horse	32
Chicken	39
Human	23

Quantitative traits tend to differ among animals in degree rather than in kind. Most production traits are of this type. If the number of animals is large enough and the productivity of individual animals is plotted as a frequency distribution, such as a histogram, the distribution measuring phenotypic expression of a trait becomes continuous between the extremes. This frequency distribution often takes on a bell shape and approaches what is called a normal curve. In such a distribution, there are a few animals at each extreme – very low and very high performing – but the largest proportions are near the middle of the distribution with performance not far from the average. These traits are also influenced by the environment to which the animal is exposed. Growth and milk production in sheep and goats are examples of quantitative traits which show continuous distribution. The data in Table 6.2, histogram (Figure 6.1), and curve (Figure 6.2) show the distribution of weaning weight in Afar sheep. In our example of weaning weight, we know that it can be affected by plane of nutrition, disease status, milking ability of the dam, season of lambing, etc. All of these are environmental effects.

The performance of some important traits, however, is distributed differently. These include traits like number of offspring in a lifetime and number of offspring born per birth, where distribution shows discrete classes of observation such as single or multiple. Such traits can generally be regarded as quantitative rather than qualitative, because of the fact that many pairs of genes are involved in affecting the outcome and they can be greatly affected by the environment.

These traits may often be controlled by an underlying characteristic which is more continuously variable. For example, there is greater and more continuous variability in ovulation rate, which sets limits to the number of young born at a given parturition, than there is for litter size itself. Similarly, levels of hormones control ovulation rate.

Table 6.2. Data table of the distribution of weaning weight of Afar sheep.

Weight category (kg)	Number of lambs
5.1–7.0	71
7.1–9.0	189
9.1–11.0	421
11.1–13.0	788
13.1–15.0	877
15.1–17.0	494
17.1–19.0	140
19.1–21.0	30

There are two ways of improving the performance of sheep and goats, namely improving the environment of the animals and/or improving their genetic potential or genotype. There is a need to balance efforts in environment and genotype by examining cost-benefit relationships; either option taken alone will not result in optimal productivity. The following points need to be noted in the genetic improvement of sheep and goats.

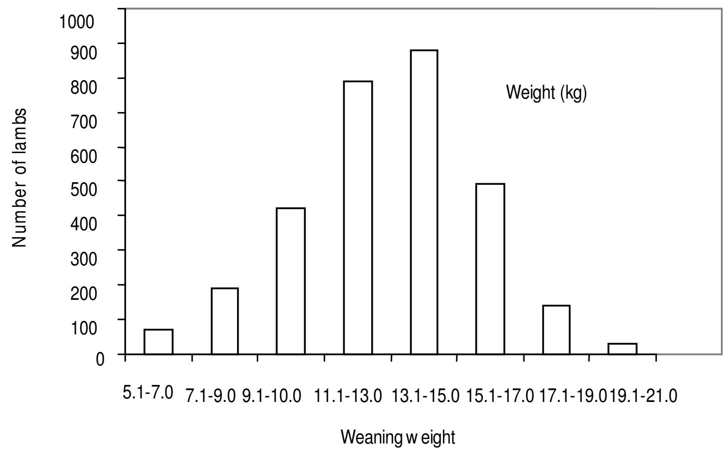


Fig. 6.1. Histogram of the distribution of weaning weight of Afar sheep.

- Ethiopia (and the world) is endowed with numerous sheep and goat genotypes. Knowledge of their relative merits and appropriate exploitation of these merits is required. It is important to evaluate available genotypes before a decision is made to introduce exotic animals (genotypes). Breeds adapted to environments similar to where they are to be introduced may have better chance of survival and productivity.
- Animals with high genetic potential may require better management than animals with low genetic potential.
- The genetic potential of sheep and goats can be improved by selection or by introducing other superior animals (breeds) for crossbreeding with local stock. Total substitution of local genotypes with exotics can also be attempted.

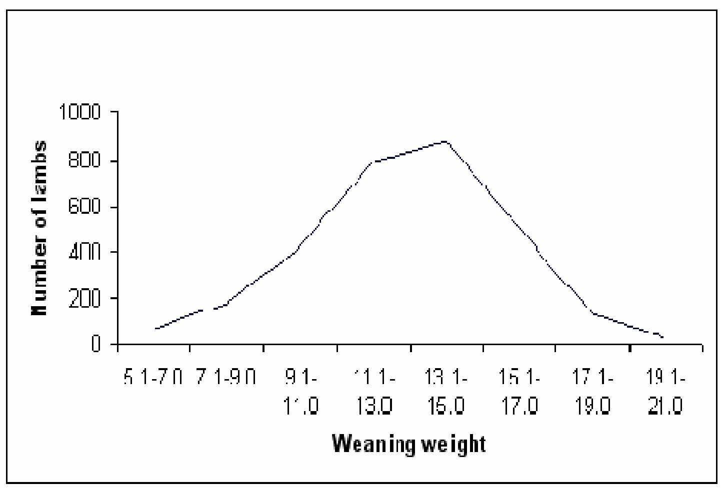


Figure 6.2. Frequency curve of the weaning weight of Afar sheep.

- The choice of breeding method, pure-breeding alone or crossbreeding, is perhaps one of the most important decisions to be made when designing a breeding program.

- Sheep and goats may show variation in productivity even when they are provided with similar management. Such variation which exists when animals are kept under similar management can be passed to their offspring.
- Selection allows animals with superior performance to be the parents of all or most of the next generation while those with inferior performance will not be allowed to mate.
- Some production traits have high heritability (greater genetic variability within the population and more responsive to selection) while others show low heritability.
- When there is no sizeable variation among animals of a given genotype or when the heritability of a desired trait is low, crossbreeding or replacement of the local animals could be considered.
- In a crossbreeding program, introduced animals and breeds should be selected very carefully for their own adaptability and the adaptability of their crossbred progenies.

Designing breeding programs

A breeding program can be defined as the set of activities and decisions undertaken by a breeder (producer) towards improving animal performance for a given trait. There are a series of steps to be followed to achieve the breeding aim from the breeding plan.

Approaches utilizing the potential of higher-producing or better-adapted indigenous livestock breeds must be developed whenever possible. Realistic ways of breed improvement must be chosen and applied in the context of environmental constraints, socioeconomic demands and within the management resources available. Aspects of sustainability and provision of future genetic diversity are critical. A basic principle to follow should be based on the assumption that there is no better way of conserving a breed for future generations than consistently keeping the breed or population viable by using an efficient, demand-driven long-term breeding program suitable to commercial or cultural needs.

An important feature of a genetic improvement program is that the effects of selection accumulate over time. The economic benefits of selection also accumulate. Breeding programs should therefore be seen as investments for sustainable improvements of animal stock and its potential to produce food or other goods.

6.2. Breeding Objectives

Any breeding program for sheep and goats should be implemented to achieve a certain clearly defined objective. Therefore, the first step in a breeding program is to define realistic and attainable objectives.

The main objective is to maximize output (meat, milk, wool, skin) per unit input. The quality of animal products must target the requirements of the end-user or target market. This may be an export or domestic market. Meat is the most important product of small ruminants in Ethiopia. Milk is also a highly valued product in some pastoral, agro-pastoral or mixed agricultural areas. The quantity of meat produced depends on the number and weight of surplus animals at age of sale. The importance of reproduction rate must be stressed in relation to the number of meat animals for sale.

Meat quality is poorly defined in Ethiopia. The market may require lean meat or a fat tail that would be a delicacy in some cases and there may be specific flavor requirements in some areas. Skins are valuable byproducts from sheep and goats used for meat but there is no clear definition of skin quality within a breed. Currently, the only wool produced by some sheep breeds in Ethiopia is the coarse (carpet) wool. The wool color found in Ethiopia could be desirable, e.g., for making patterns in carpet production, as opposed to apparel wool where white wool is usually preferred.

The most important measure of productivity for milk is yield per lactation or per year. Quality is less important as sheep and goat milk in most cases is for home consumption. Goat milk may be desired because of its flavor, and sheep milk because of its high content of solids.

To ensure genetic improvement for a particular trait, the available variation in the current population and the heritability of the trait should be known. The selection intensity should be determined to achieve the target within the time limit envisaged.

Example

Suppose the export market requires sheep with an average live weight of 30 kg as opposed to the current level of 27 kg.

Breeding objective: Increase the number of animals qualifying for the export market through genetic improvement of weight at marketing (e.g., yearling weight) with no or minor changes in management.

Breeding goal: Improve the average yearling weight of the breed from 27 to 30 kg (market requirement).

6.3. Breed Selection

There is a large variation among sheep and goat breeds in Ethiopia and the world. Different breeds have different environmental adaptability. Animals which are adapted to cool areas may not be suitable to hot areas. Animals which have evolved within a certain area are usually better adapted to that particular area than other breeds. Therefore, whenever possible, it would be wise to make use of such animals in improvement programs. In such programs, productivity improvement should come through selection and better management. Introduction of other animals (breeds) may be considered if their own – or that of their crosses with local breeds – adaptability to the area is proven and if their performance shows clear superiority to local animals under similar management conditions.

Selection among breeds must be based on performance data collected from groups raised in the same environment (cohorts). Comparisons need to be made in the actual environment in which animals will be raised, not on experimental stations. Comparisons must be thorough to give realistic estimates of not only lifetime production but also reproductive, mortality and morbidity rates.

6.4. Selection of Breeding Animals

You must develop a clear idea about the merits of individual traits to be successful in genetic selection. For selection to be effective, the selected traits must be: *heritable* (capable of being transmitted from parents to offspring), *variable* (differences must exist between animals for that trait), and *measurable*. Weight, for example, is an easy trait to measure because all that is needed is a weighing scale. Traits to be considered in a sheep and goat selection program include those that will enhance meat, wool, and milk production.

Where small ruminants are kept primarily for meat production, selection will be on the number and weight of offspring weaned per female per year. The number of offspring born per flock per year can be increased by decreasing the number of females which fail to lamb/kid, by increasing litter size, or by increasing the frequency of parturition. Females which fail to produce offspring after consecutive opportunities should be culled. With proper selection, it is possible to realize a sizeable increase in litter size. The acceptability of twins depends on the environment (particularly nutrition) and management system. Weights at birth, weaning, six months and one year are important in selection of animals for meat. Weight at birth would have an additional influence on survival of animals.

For wool sheep, selection is based on weight of fleece. Additionally, staple length could be important. In general, selection for increased fleece weight will also result in a longer staple, but it might be necessary to

pay particular attention to staple length for those sheep used for this purpose. Other wool quality aspects, such as crimp, diameter, etc., may not be important in Ethiopia, at least in the near future.
Selection of animals for milk is in terms of quantity of milk produced per year. This is a function of quantity of milk per lactation, lactation length and parturition interval.

Animals to be used for breeding purposes should be selected carefully and superior animals should be identified accurately. Sheep and goats can be selected based on records of performance and visual appraisal. Selection based on records is the best way to achieve good results. Additional visual appraisal of the selected animals is advantageous. Visual appraisal of a contemporary group of animals may be considered where record keeping is not practical or is nonexistent. Visual identification of superior animals is less successful compared to selection based on records. Differences among animals of the same age from similar dams (parity, age, condition) kept under similar management serve as indicators of genetic variability that can be exploited in a breeding program.

6.4.1. Visual appraisal

Selection of sheep and goats for breeding purposes based on visual observation is done by looking at the appearance, conformation and presence or absence of defects in the animal.

Appearance: Only an animal which is active, alert, healthy and attractive in appearance should be considered for selection.

Conformation: Sheep and goats to be used for various purposes would have different conformations. Animals meant for milk purposes have a different conformation than animals meant for meat. There are no specialized breeds in Ethiopia and animals are generally dual-purpose breeds. However, in areas where milk is an important product, it is wise to select animals with a conformation conducive for milk production. Milk animals should have a larger tract and udder. They have longer, thinner necks and a wedge-shaped appearance. Meat animals, on the other hand, have a stocky appearance and tend to have a rectangular shape.

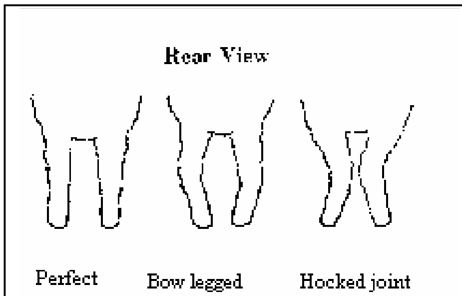


Figure 6.3. Rear view of leg types.

Defects: Sheep and goats to be used for breeding should be free of defects, particularly those of genetic origin, including defects of legs, teeth and testes. In a number of goat breeds, polledness is associated with reduced fertility. Polledness in an otherwise horned goat breed should, therefore, be selected against.

Legs: Legs of sheep and goats (particularly males) should not be extremely hocked or curved. The rear (hind) legs should be wide apart and straight when viewed from behind. Poor leg conformation is usually of genetic origin and can affect mating ability of males. Muscling will be demonstrated by a thick thigh and the depth of the twist. Most sheep and goats in Ethiopia have thin thighs which results in lower meat output from the hind quarter.

Adapted from Goodwin (1979).

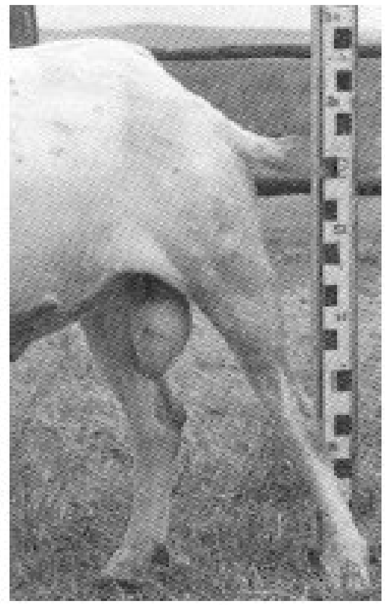
Figure 6.4. Undershot (left) and overshot (right) jaw.

Teeth: The incisor teeth on the lower jaw should perfectly meet the edge of the dental pad on the upper jaw for efficient grazing.

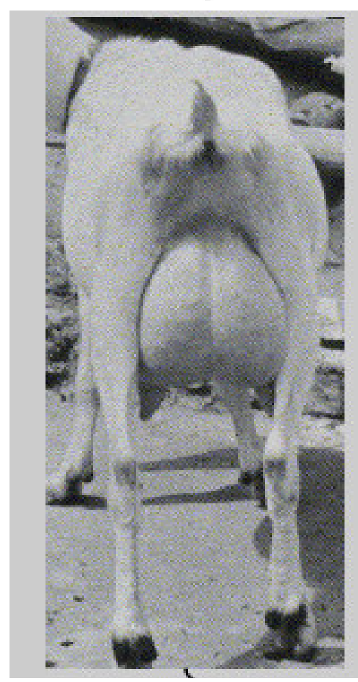
Some sheep and goats have an overshot jaw where the upper jaw is longer than the lower while others may have an undershot jaw, in which case the upper jaw is shorter than the lower. In other cases, the teeth are deformed. Such animals, particularly males, should not be used for breeding.

Testes: Male sheep and goats selected for breeding should have two large, well-formed, functional, equal sized testicles in a single scrotum (some breeds normally may have a split scrotum). Sperm production is related to the size (circumference and length) of the testicles (Figure 6.5). More semen is produced by males with greater scrotal circumference. Avoid selecting males that show overly pendulous testicles. Males with very hard, small, unbalanced testes and those with scars, bumps and lumps should not be selected for breeding. In addition, the epididymis area at the neck of the scrotum should be free of lumps. These defects may result in low fertility and/or transmission of reproductive disease as some of these defects are caused by pathogenic organisms affecting the reproductive system.

Udder: Ewes and does should have well formed udders with good attachment and two well-formed teats. It is important that the udder is constructed in a way that allows offspring to nurse unassisted. The external genitalia of the female should be well developed and properly structured. Vulvas which turn up at the end can cause a problem when the male is serving the female and result in poor fertility. A female that has not given birth or exhibited signs of pregnancy by 18 months of age should be culled.



Workneh and Rowlands (2004).



Source: Workneh and Rowlands (2004).

Fig. 6.5. Good udder placement in a doe.

6.4.2. Records

Wherever possible, selection of animals should be based on records of performance. Performance records are even more important for breeding schemes which involve the selection of superior animals from among a group. The interest of the farmer or the breeder could be performance of an animal at a certain age. In this case reliance on memory is of little value and very often not practical. An example would be selecting animals at 18 months of age for a particular market weight at 12 months of age. Unless records of animal weights at one year of age are kept, using personal memory would be valueless.

It is often necessary to keep simple pedigrees such as sire and dam, so that the performance of parents can be related to that of their offspring. This is essential for selection schemes. For crossbreeding, recording the breeds involved might be sufficient unless there is an additional requirement to avoid future inbreeding because of a small number of animals or a small geographic area.

Once a breeding program has started, more record keeping will be needed in order to execute the plan and assess progress. For the flocks from which actual breeding animals are chosen, or in which breeding animals are tested, all the animals should have the appropriate aspects of their performance recorded. In addition, at least a random sample of the herds and flocks associated with the improvement scheme should have performance records kept in order to monitor progress and assess the value of the breeding program. This sample might be from commercial herds, in which some of the newly improved animals (perhaps rams, bucks or their semen) are used. Records should be restricted to:

- Those essential for the conduct of the improvement scheme and its cost-effectiveness.
- Records that can be maintained and sustained.
- Records that can be analyzed.

6.5. Breed Improvement Methods

6.5.1. Selection within a breed

Selection is usually done within cohorts within a flock, i.e., among animals of the same age which have been raised together. Genetic progress through selection depends on heritability, selection differential and generation interval.

Selection differential: The average superiority of the selected parents relative to their flock contemporaries. Fewer males are usually needed for breeding than females; therefore, selection differential is generally higher for males. Sometimes selection differential can be very large, as it is possible to select very few males with exceptionally high performance for use through artificial insemination.

Heritability: The proportion of the superiority of the selected parents which appears in the offspring. It is useful to have an estimate of the heritability for the trait to be improved in order to predict the likely progress from selection. It is preferable if this estimate is made from the population considered for selection before selection starts. This, however, is usually difficult because of unavailability of appropriate records. Published estimates from a similar population kept under similar conditions would be valuable.

Table 6.3. Estimates of heritability (h^2) for some traits in sheep and goats.

Traits	Average h^2	Range of h^2
Sheep and goats		
Milk yield (lactation)	0.38	0.20–0.53
Milk yield (test day)	0.21	0.14–0.31
Birth weight	0.18	0.03–0.43
Weaning weight	0.34	0.08–0.62
Six-month weight	0.21*	
12-month weight	0.33*	
Adult weight	0.39	0.11–0.72
Fleece weight	0.36	0.17–0.57
Fleece quality traits	0.49	0.13–0.72
Number of lambs at birth	0.14	0.00–0.49
Litter weight at birth	0.06	0.00–0.12
Goats six-month weight	0.23**	0.10–0.71***
Goats 12-month weight	0.30**	0.13–0.60***
Goats birth weight	0.04**	0.05–0.68***
Three-month weight	0.16**	0.09–0.75 ***

Source: (Weiner, 1994); *(Solomon, 2002 estimates for Horro sheep); ** (Horst and Mathur, 1991); ***Shrestha and Fahmy, 2007).

Generation interval: Generation interval is defined as the average age of the parents when their offspring or, more strictly, those offspring which are used to replace the parents, are born. The genetic changes which occur as a result of selection happen only when one generation is succeeded by the next. In sheep and goats, the generation interval is affected by the age when the animals first start to breed. It is also influenced by the interval between successive parturitions and by the number of offspring born on each occasion which survive to breeding age. The earlier in the life of the parent its offspring are born, the closer parturitions follow each other and the more offspring per parturition, the sooner the number needed as replacements is reached. The generation interval for sheep and goats varies between 3 and 5 years.

In sheep and goat selection programs, depending on the objective, the focus could be on a single trait or on multiple traits. Selection for a single trait permits faster progress as compared with selection for more than one trait. Therefore, selection for more than one trait should be avoided unless it is very important (e.g., in case of negative correlation between traits).

6.5.1.1. Aids to selection

In selection of animals, different sources of information should be used. These include selection based on individual performance, ancestral performance, progeny performance and performance of other relatives (half sibs, full sibs, uncles and aunts).

Performance of an animal (Mass selection)

This is used when the animal's performance is a measure of its genetic merit. This is also used for traits of high heritability where an animal's performance is an accurate guide as to how its progeny will perform. Here, the best individual is selected from within a group of animals of similar age that have been similarly treated (cohorts or contemporaries).

When more than one record of an animal's performance is available (e.g., annual fleece weights or repeated litter performances of a ewe) there is a need to look into consistency of those repeated records to select an animal. Repeatability is a term used to indicate a relationship among consecutive records of an animal. High repeatability indicates consistency in repeated performances while low repeatability indicates a lack of consistency.

Repeatability of certain traits (Table 6.4) is useful in making culling decisions. If the repeatability of a trait is known to be high, the first one or two performance records of an individual animal are strong evidences of future productivity and are sufficient for basing selection decisions. The reverse is true if repeatability is known to be low. In cases of low heritability, all the records of an animal should be considered prior to selecting that individual for breeding.

Using both performance records and pedigree information provides the best base for correct ranking of potential breeding stock in developing countries, especially for animals held in nucleus herds with good record-keeping. Mass selection is also a valuable method for screening animals to form the initial nucleus population.

Animal selection systems that use existing indigenous traditional knowledge and simple methods such as scoring and ranking of only the top 5–10% of animals in the flock are good methods for using more accurate genetic evaluation methods, particularly where flocks are large as in pastoral or highland barley–sheep production systems. It should be noted that within traditional livestock production

Table 6.4. Some general estimates of repeatability for sheep and goats.

Species	Trait	Repeatability (%)
Sheep	Ovulation rate	60–80
	Lambs born per ewe lambing	30–40
	Birth weight	35
	Twinning	16
	60-day weaning weight	25
	Lamb growth (daily gain)	38–48
	Grease Fleece weight	40
	Wool traits (general)	50–80
	Staple length	60
Goats	Milk production (lactation yield)	36
	Daily milk yield	42
	Lactation length	9

systems, livestock keepers (e.g., pastoralists) can identify and rank their stock very accurately. Ranking methods used within these systems can be documented and practically applied if the livestock keepers are involved in the design of evaluation programs from the outset. For example, taking heart girth measurements at specific ages for part of the flock, and considering animals above a certain predetermined level is one method.

Performance of parents (pedigree information)

For traits with low heritability, it is wise to look at the performance of parents; but for traits with high heritability, measuring an animal's individual performance is more useful in evaluating progress. However, considering pedigree is useful in selecting animals before they reach the age where they can express their performance, e.g., milk production and litter size. Thus, breeding animals can be selected based upon the performance of their parents and grandparents.

Pedigree-based selection might also be used if there is no information on the performance of the animals themselves, perhaps because the trait is related to the sex of the sheep or goat or can be observed only at a later age (milk production, for example). Pedigree selection requires accurate information on the performance of the ancestors of the animals in question. This information is unlikely to exist for sheep and goats in Ethiopia. But in selecting animals for breeding, progenies of animals with proven ability to give birth and wean multiple offspring may need to be considered. This should have a close relationship with the breeding objective.

Pastoralists and farmers try to keep females that have good twinning rates and mothering ability (as judged by lamb growth). But at times, this may be confounded by the environmental effect of preferential management provided to such animals.

Performance of progenies

Sheep and goats can be selected on the basis of the performance of their own offspring. This is useful when the heritability of the trait is low, or where the trait can be measured only in one sex (milk production, for instance) or can be measured only after slaughter (carcass characteristics). To carry out a successful progeny testing scheme, a large enough number of offspring from each male may be required. This system may have limited value for the improvement of sheep and goat production in Ethiopia because of the time and cost required, as it prolongs the generation interval.

Performance of other relatives (family selection)

Information from relatives other than ancestors and progenies can supplement the information from the individual itself and thereby improve the accuracy with which the individual's breeding value can be assessed. These include full sibs (brothers and sisters from the same father and mother) and half sibs (brothers and sisters from the same father or mother). This can be helpful for sex-limited traits and for traits which need measurements that cannot be taken on the candidate animal (e.g., carcass traits).

6.5.1.2. Methods of selection for more than one trait

There are three methods of selecting for more than one trait; tandem selection, independent culling levels and index selection.

Tandem selection: This is selection for one trait or character at a time until it reaches an acceptable level followed by selection for a second trait, then a third trait, and so on. For instance, the milk yield of goats may be improved in the first case and then growth (meat production) would be addressed. Under tandem selection, if there is positive correlation between the traits to be considered, improvement can be realized in the second trait even as selection is applied only for the first trait. The disadvantage of this system is if a negative correlation exists between the two traits. In that case, performance of the second trait will decline as a result of selection for the first trait or selection for the second trait will erode progress made in the first trait.

Independent culling level: Selection of sheep and goats based on independent culling level sets a certain accepted level of means for automatic culling of animals. It is like an examination system with different pass marks for each subject, but if the student fails one subject, then he/she fails in all. There is no compensation for poor performance in one trait by superior performance in another. This method is most useful when there are a small number of traits (usually two) and where selection is done at different stages in an animal's life. For instance, we may cull some animals for poor performance in weaning weight and then later for reproductive performance. The disadvantage of this method is that exceptionally superior animals for one trait cannot be selected if they perform below the standard set for the second trait.

Index selection: In an index selection, traits are combined to provide a single criterion merit, often economic-based. This type of selection is usually closer to the desire of farmers. With selection done on an index, deficiencies in any one trait can be compensated by outstanding performance in other traits; an option which is not available when using independent culling levels. While index is the most efficient of the three methods, an index is the most complicated to create and requires a team of experts to construct the index weights.

6.5.2. Crossbreeding (indigenous with indigenous; exotic with indigenous)

Crossbreeding aims to:

- combine all desirable characteristics of two or more breeds in one progeny type, and
- exploit the hybrid vigor or heterosis that occurs in crossbreeding. Heterosis or hybrid vigor refers to the superiority in the performance of a crossbred individual above the average performance of the two parents.

Crossbreeding may improve the performance of sheep and goats under good management conditions if the parental breeds involved in the crossbreeding are carefully chosen.

6.5.2.1. The need for crossbreeding

Opportunities to raise productivity through the use of temperate breeds are minimal in many Ethiopian situations because these exotic breeds need an improved production environment, a costly exercise. Therefore, there is a need to improve indigenous breeds to raise their production potential. High-yielding exotic animals or their crosses could be maintained in specific niche areas where it is possible to provide high inputs. This could be targeted for specific markets where fast growing animals and more uniform products are required.

Native breeds are often well-adapted to local conditions — climate, nutrition, disease exposure and so on. These breeds are rarely thought to be perfect in all aspects and improvements in productivity are desired. Improvements in feeding and management will often, on their own, bring increases in animal productivity. However, changing the genotype will often improve productivity drastically, and may enable more efficient use of any extra feed and improved management that can be provided.

The most rapid way of making genetic change is to introduce some of the characteristics of a new breed by crossing it with an indigenous breed. The most popular way is to use males of the new breed either directly through natural mating or indirectly through semen used in artificial insemination.

The first expectation from crossing two breeds is that the performance of their progeny will be half-way between the average performances of the two parent breeds. A second expectation with crossbreeding is that of heterosis or hybrid vigor. Heterosis occurs to differing degrees for different traits of the animals and for different breed combinations. The occurrence of heterosis is directly proportional to the degree of hetrozygosity.

Examples

Example 1

Performance of a crossbred : additive gene action

- Post-weaning growth:
  - Breed A = 100 g/day
  - Breed B = 140 g/day.
- Expected post-weaning growth:
  - Crossbred = 120 g/day.

Example 2

Performance of a crossbred: the effect of heterosis

- Post-weaning growth:
  - Breed A = 100 g/day
  - Breed B = 140 g/day
  - Crossbred = 132 g/day
- Average of breeds:
  - A + B = 120 g/day
- Difference (estimate of heterosis):
  - = (132–120)
  - = 12 g/day

Heterosis can be to the extent that the crossbreds could show performance over both of the parents. This is important if farmers plan to mate two breeds where each is successful in the locality (two different indigenous breeds) with the desired result of the crossbred being superior to the two foundation breeds. If this is not the case, it would be more sensible for farmers to replace the poorer of the two breeds by the better. This can be done directly or by grading-up.

The expression of heterosis is always at its maximum (100%) in the first cross between two breeds (F1). Varying amounts of the heterosis are lost in later generations of crossing because some of the hetrozygosity in gene pairs is lost, which is called recombination loss.

Reciprocal crosses

For accurate comparison of crossbred performance with purebred performance, it is theoretically required that the cross should have been made in both of the two possible ways:

- females of breed A (e.g., local breed) mated to males of breed B (e.g., an exotic breed); or
- females of breed B mated to males of breed A.

These two variants are called reciprocal crosses. Though genetically alike, they differ because the reciprocal crosses have had a different maternal environment: one from dams of the local breed (breed A), the other from dams of the exotic breed (breed B). These maternal influences can be important for the offspring at the time of birth and, perhaps, up to the time of weaning. After weaning, the importance of the maternal effect usually lessens but sometimes never disappears completely.

The effect on the offspring arises because different maternal environments may provide the fetus and, later, the newborn animal with different advantages at the start of life. One breed may supply the crossbred offspring with better nutrition even before birth and may have better mothering abilities thereafter. Locally adapted dams may give the newborn a better supply of antibodies in the colostrum than dams of a recently imported or exotic breed.

Examples

Weaning weight (WW) of kids from reciprocal crosses of Afar and Saanen goats (hypothetical)

Afar goat (Male) X Saanen goat (female) F1 Crossbred progeny 17 kg (WW)	Afar goat (female) X Saanen goat (male) F1 Crossbred progeny 14 kg (WW)

The first crossbred progeny has a dam breed known for its milk production. Therefore, kids are likely to get adequate milk and show better growth rate than kids born from Afar dams with lower levels of milk production compared with the Saanen.

With crossbreeding, in addition to the quantity of product being changed, quality may also be affected. Sometimes the change in quality could be in an undesirable direction. Therefore, sufficient information on quality aspects needs to be gathered before embarking on a large-scale crossbreeding operation. For example, skin from most sheep and goats in Ethiopia is desirable for the leather industry. With crossbreeding, the quality of the skin may become undesirable for the leather industry. On the other hand, skin from lowland sheep is usually undesirable and crossbreeding (particularly local × local) may improve the skin quality of animals from this area. Crossbreds may also produce meat with undesirable taste or fat content (lack or excess) and this also needs to be considered in selection of the improver breed for crossbreeding.

Crossbreeding should be considered if:

- the trait to be improved has a low heritability;
- the current management of local animals is good, or if there is an effective extension program that is improving management;
- the environment has the potential to allow real improvements in management;
- quick results are needed; and
- there are no changes in quality of products from crossbred animals or these changes are acceptable.

Crossbreeding should be considered only if the crossbreds are going to live in an environment that allows them to express their improved potential and perform well. To get real benefits from crossbreeding, the environment should have the potential for improvement.

One major advantage of crossbreeding, which is rarely considered, is the effect it can have on an extension program. The crossbred sheep or goat is a new animal, it may look different, it can certainly perform differently, and so it quite quickly captures the interest and enthusiasm of producers. This can be a vital boost to extension programs and, in the process of breed improvement, can motivate owners to adopt the improved management strategies being promoted simultaneously.

In choosing improver breeds for crossbreeding, the following factors need to be considered:

- **Environment:** The crossbred should have the ability to perform well under the environmental conditions where production would take place.

- **Desired production characteristics:** The crossbred should show the type and level of production which is set as a goal.
- **Desired adaptation characteristics:** The crossbred should show the desired adaptation in terms of ability to survive, reproduce and produce.
- **Past experience:** It would be very helpful if information is available on the performance of the crossbred in the area or other similar areas to which the crossbred is to be used.
- **Ease of access to new breed:** Sustainability of a crossbreeding program usually depends on the availability of the two parental breeds. This should be considered before embarking on a crossbreeding program.
- **Cost of new breed:** Paying prohibitive prices to acquire one or two of the breeds involved in the crossbreeding program can affect the profitability and sustainability of a crossbreeding program.

6.5.2.2. Types of crossbreeding

There exist different systems of crossbreeding which may involve two or more breeds. Different objectives demand different types of crossbreeding.

Grading-up

Grading-up is the name given to continuous back-crossing using males of one breed, or a crossbred type, first on females of the breed intended to be graded-up and then on the succeeding generations of crossbred offspring which arise from the matings. This increases the percentage of genes from the desired sire breed.

Grading-up to an exotic breed: Grading-up is most commonly thought of in terms of using males of a breed imported from another country. Grading-up can equally be carried out using one local breed to replace another by continuous back-crossing.

Example

Grading up to an exotic breed

The Awassi sheep breed is crossed with the Menz; the first crosses are mated again to the Awassi; and it continues like this for every successive generation.

The proportion of Awassi blood (Awassi genes) increases from 0.50 to 0.75 to 0.875 to 0.9375 to 0.96875 to 0.984375. After four generations, the crossbred animals are practically indistinguishable from purebred Awassi.

Grading-up to 50% or 75% exotic genes: Establishing a population of animals with 50% or 75% exotic genes can be done in 4–5 generations of continuous back-crossing. Females of a local breed are mated with sires having either 50% or 75% exotic genes. The succeeding generations are continually mated with sires having the desired gene mix, ultimately giving offspring with the desired proportion (50% or 75%) of exotic blood. This type of grading-up is appropriate when there is prior evidence that the optimum proportion of exotic blood is either 50% or 75% for the conditions under which the animals have to perform.

Continuous production of F1s

Two pure breeds are used repeatedly to produce only first generation crosses (F1s). In terms of the additive genetic effects, the F1 is halfway between the performance levels of the two parent breeds contributing to the cross. However, the F1 generation displays the whole of any heterosis which is achievable as a result of crossing the two breeds.

Consideration needs to be given to the relative importance of the additive genetic and heterotic effects, and to the proportion of the population which can be maintained as crosses. This information will determine whether continuous production of F1 is feasible.

Rotational crossing

Two or more breeds are used in rotation. The males are always purebred. First one breed is used, followed by the second breed, and so on until the sequence is complete. It then starts again with the first breed used. The females to which the males are mated are purebred only for the first generation of mating. Crossbred females are used in subsequent generations.

Rotation of two breeds: The system of using two breeds in rotation, also called crisscrossing, produces the whole of the potential heterosis in the first generation (F1), half in the second (first back-cross) and variable proportions, between ⅔ and ¾, in subsequent generations. Due to the fact that all females are crossbred after the first generation, there is also the benefit of maternal heterosis for traits where this is important.

Rotation of three breeds: The males used are always pure and used in rotation, following the same principle as for crisscrossing.

Table 6.5. Example of rotational crossing using two breeds.

	Parents*			Genes (% from)		Heterosis
Generation	Female	Male	Offspring	M	A	(approx. %)
1	M	A	MA	50	50	100
2	MA	M	M/MA	75	25	50
3	M/MA	A	A/(M/MA)	37	63	75
4	A/(M/MA)	M	M/[A/(M/MA)]	69	31	62
5	etc.	A	etc.	34	66	69
etc.						

* M = Menz A = Awassi

Table 6.6. Example of rotational crossing using three breeds.

	Parents*			Genes (% from)			
Generation	Female	Male	Offspring	M	A	D	Heterosis (%)
1	M	A	MA	50	50	-	100
2	MA	D	D/MA	25	25	50	100
3	D/MA	M	M/(D/MA)	63	12	25	75
4	M/(D/MA)	A	A/[M/(D/MA)]	32	56	12	88
5	etc.	D	etc.	16	28	56	88
6	etc.	M	etc.	58	14	28	84

*M = Menz A = Awassi D = Dorper

New breed formation (synthetics)

New breeds formed from two or more constituent breeds are called synthetic, composite or blended breeds. New breeds can be synthesized from crosses combining breeds in virtually any proportion, first crosses or various back-crosses of two breeds, or combinations of more than two breeds.

The desired breed combination has to be determined on the basis of the early performance of crosses and from an estimate of the importance of heterosis. The desired crossbred type is then interbred for several generations. Selection can and should be used alongside this process to improve the production characteristics. This system has more sustainability once the new breed has been established.

Examples of new breed formation in the tropics and elsewhere are the Kenyan Dual-Purpose Goat, which involved two exotic breeds, i.e., Anglo-Nubian and Toggenburg and two indigenous breeds, namely the Small East African and the Somali-Boran goats and Dorper sheep which is composed of Dorset Horn and Blackhead Persian, hence the name Dorper.

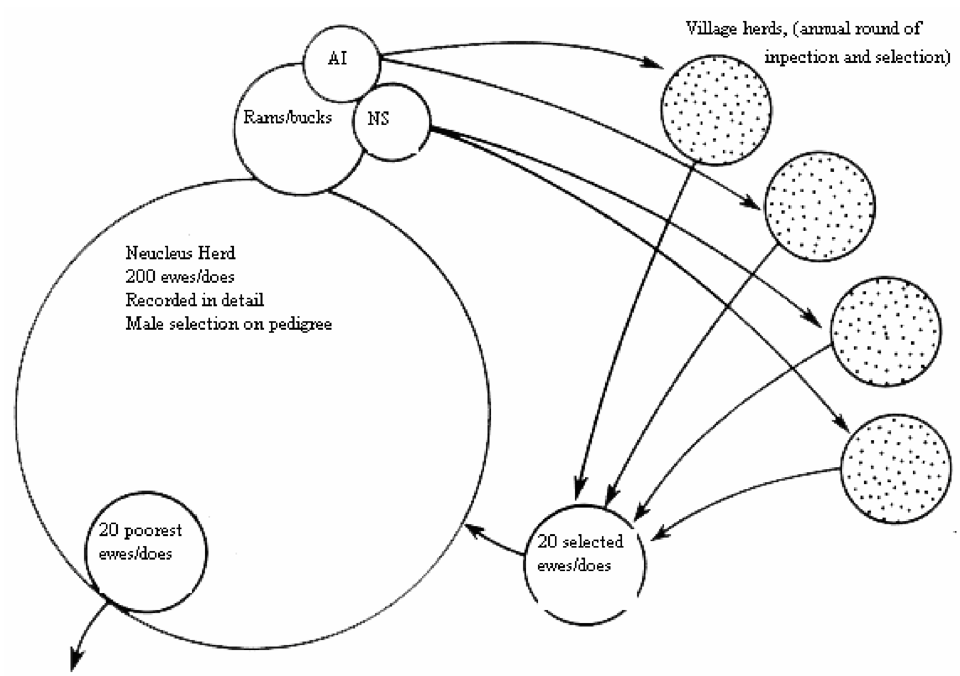
6.6. Breeding (Selection) Schemes

A selection scheme provides the framework for putting the various selection methods into practice. Sheep and goats in Ethiopia are kept in small flocks by individual owners. The small flock size limits selection. Selection works most effectively when large numbers of animals are involved. A system of selection by which farmers pool their sheep and goats together would be more appropriate.

6.6.1. Nucleus selection schemes

This is a system whereby a number of flock owners agree to cooperate by deciding on common breeding objectives and by pooling their animal resources. The key is the creation of a nucleus flock from the best breeding males and females from each participating flock. If the selection scheme goes according to plan, the animals in the nucleus flock will become genetically superior to any outside animals after a few generations.

If, however, the nucleus remains closed to all outside blood, whether from the cooperating flocks or from others, inbreeding may arise with deleterious effects. Also, the nucleus would not benefit from the introduction of exceptionally good animals which may occur in the cooperating flocks, or elsewhere. It is wise to keep the nucleus open to the introduction of animals for some generations. This is usually done by an annual introduction of the very best of the breeding females from the cooperating flocks. These females have to compete, in terms of their performance, with the females already in the nucleus. As a result of performance comparisons, they either replace some of the nucleus flock or are culled.



Adopted from Horst and Mathur (1991).

Figure 6.6. Open nucleus breeding scheme.

6.6.2. Practical breed improvement for individual farms

Breed improvement can take place at different levels in a sheep or goat population, e.g., from an individual or village flock standpoint. Individual owners should always try to improve their flock, whatever size it is.

What can an individual owner do to improve the genetic potential of his or her sheep and goats? In smaller flocks, there is little scope for selection, so the approach should be to try to counteract the negative effects of inbreeding, or grading-up through crossbreeding. In the Bako area, about 94% of the farmers sell either the best animals they have or sell indiscriminately. This eliminates the larger, faster-growing animals, leaving only smaller or stunted animals for breeding. This is negative selection and results in the production of inferior animals. Individual farmers should be cautioned against this practice.

A young male sheep or goat should be removed from its flock before it achieves reproductive maturity. This can be done through exchange sale or through castration. If the male is allowed to stay fertile in the flock in which it is born, then there is a high probability it will mate with its own dam and other full- and half-sib females. Females with ability to give and raise twins may be selected while females with poor ability to raise and bear twins are culled.

6.6.3. Sire rotation and utilization

Wherever possible, the best bucks in the flock should be selected and used for service. In order to reduce inbreeding, a buck should never be allowed to mate with his full sisters, his daughters, his granddaughters or his dam. Additionally, the number of years a male serves should be limited to one. The male should then be replaced either through exchange with other flock owners or through purchase of a new sire.

Farmers within a certain area may reach agreements to exchange the best rams from their flocks with other farmers engaged in the exchange on a rotational basis. If exchange is not done, males at the end of their service can be sold immediately or can be castrated for later marketing at good condition. In practice, farmers should be advised to exchange sires annually.

6.6.4. Problems in breeding schemes

Pure breeding schemes usually require a long period of time for realization of sizeable improvement whereas crossbreeding schemes result in fast change but may suffer from lack of sustainability. Use of F1 generations requires maintaining both parental breeds. This may be difficult, particularly if exotic breeds are involved.

The best option in many cases may be to form a stable breed (synthetic breed) after the formation of the F1 or after some grading up. Synthetic animals can mate among themselves and could result in a more sustainable system than production of F1 animals. Production of F1 animals could be considered if these animals would show exceptionally high levels of performance compared to the average of the two parents (positive heterosis), in which case, maintaining the two parental breeds could be beneficial. One important aspect of breeding at the smallholder level is absence of controlled mating. Male and female animals of reproductive age are herded together, and mating designed to bring genetic improvement is difficult to implement.

6.6.5. Inbreeding

Inbreeding results from the mating of related individuals, i.e., those with common ancestry. This may happen when the size of the breeding population decreases. Selection tends to increase inbreeding because it reduces the breeding population by restricting reproduction to a few animals, especially on the sire side. The key to searching a pedigree for evidence of inbreeding is to look for those ‘common ancestors’ that appear on both sides of the pedigree. If the parents of an animal (the subject of the pedigree) have common ancestors in the recent pedigree, then the offspring will be inbred. This degree of inbreeding can be calculated and expressed as the 'inbreeding coefficient.'

The level of inbreeding depends on the closeness of the relationship between the parents. Either or both parents may be inbred themselves, but if they are not related to each other then the subject cannot be inbred. The common practice of keeping male and female animals in the same flock and using sires in the flock in which they were born will increase inbreeding.

The consequences of inbreeding in sheep and goats have two aspects: inbreeding depression and expression of recessive defects.

Inbreeding depression is the gradual lowering in performance of traits, particularly those associated with fertility, survival and size. It reduces traits such as growth rate, disease resistance, reproductive performance and viability. Tracing the problem of inbreeding depression may take time. A very rapid rise in inbreeding usually brings out problems more quickly than a slow build up and some traits are more readily and severely affected than others.

Some genes, which are responsible for **defects**, such as undershot jaw, dwarfism, odd colors and so on, usually express themselves only when they are in a homozygous condition and the homologous pair is dominant. These traits are rarely seen as animals carry these genes in a heterozygous state (carriers). Inbreeding increases the chance that the genes will combine in a homozygous state and the defect will appear. Whenever such defects appear in a sheep or goat, its parents are assumed to be carriers and should be culled. This is especially true for males as they have more chance of transmitting the defects.

Should inbreeding be suspected, a completely unrelated sire guaranteed free from the defect should be used for mating. Known carriers of these defects can be used to mate with other animals for testing. An example of this could be the mating of a ram or buck intended for widespread AI use to about 15 to 20 of his own daughters. If there are any recessive genetic defects in the male, they should appear in offspring of these matings. Then the breeder will decide whether to accept the animal as a semen donor.

Increases in population size and careful monitoring of mating programs help to avoid inbreeding or reduce its level to a minimum. An inbreeding level greater than 6% cannot be tolerated in most circumstances.

Table 6.7. Examples of different intensities of inbreeding expressed as a coefficient of inbreeding (%).

Generation	Self-fertilization	Mating full sibs	Sire × offspring	One-sire flock	Three-sire flock	Five-sire flock
1	50	25	25	2.5	0.8	0.5
2	75	38	38	5.0	1.6	1.0
3	88	50	44	7.5	2.4	1.5
4	94	59	47	10.0	3.2	2.0
5	97	67	48	12.5	4.0	2.5

Adopted from: Dalton, 1980.

6.7. Breed Conservation and Utilization

6.7.1. Rationale for conservation and characterization

Indigenous breeds of sheep and goats may produce less milk or meat than improved breeds. But they usually fulfill a wider range of functions for their owners and are much easier to manage. Many marginal areas can be exploited only by locally adapted breeds or species. For example, camels are the only livestock in areas with less than 50 mm of rainfall. If these animals die out, it will no longer be possible to use large areas of arid lands to produce food.

Additionally, the genetic diversity they embody enables breeders to respond to changes in production, marketing and the natural environment. The adaptation of different species and breeds to a broad range of environments provides the necessary variability that offers opportunities to meet the increased future demands for food and provide flexibility to respond to changing markets and needs. However, currently, there is a threat of loss of genetic diversity in livestock populations to the extent that some breeds may be approaching extinction. This calls for strong conservation activity.

The first step in conservation is to know which breed to conserve. This can be done through characterization. The main reasons behind characterization of animal genetic resources include;

- Threats to the indigenous livestock.
- The existence of a number of different breeds similarly named after a location, ethnic group or by physical characteristics that may not necessarily be genetically similar.
- Most animal censuses in developing countries are done by species, which does not allow an accurate depiction of the population trend of individual breeds over time in order to determine populations at risk of extinction.
- Little knowledge of existing breeds to understand:
    1. Unique qualities of the breed, e.g., particular adaptation to the local environment.
    2. The potential contribution to productivity if treated as improved breeds.
    3. The potential genetic variability that could be useful in the future.
    4. Determination of any special genes of merit.
    5. The genetic variability (within and between breeds) available for future needs.

6.7.2. Characterization and conservation methodology

Characterization consists of collecting information on available stocks and the environment in which the stocks are performing. Basic information includes:

- Preliminary characteristics such as type/breed/variety; predominant location and climatic conditions; utility, management and production systems; physical and special genetic characteristics; production traits; and population status, and
- DNA information about genetic distinctiveness, and genes responsible for valuable traits.

Basically, conservation is categorized into *ex situ* and *in situ* conservation.

Ex situ conservation is done through cryo-preservation of animal germplasm by storing sperm, oocytes and embryos and also through preservation of live animals of endangered breeds out of the area where they are originally kept. For cryo-preservation technique to be effective, progeny of at least 25 sires should be stored. The facilities in Ethiopia for this technique are not well developed. The germplasm can be collected in Ethiopia and may be stored in countries where facilities are available.

In situ conservation is the preservation, multiplication and utilization of indigenous breeds in their native habitats and maintenance of pure breeds or strains. The minimum number of animals recommended for sheep and goats is 60 and the maximum is 1500 ewes or does. Special conservation flocks can be established as part of the cultural heritage for endangered breeds or breeds in critical status. Nucleus breeding flocks can be established in cooperative breeding programs to supply breeding stock to farmers.

In situ conservation requires good management of the conserved flock. Local communities which keep indigenous animals are crucial in conservation of animals through sustainable utilization. Practical ways of improvement in the productivity of indigenous animals would be an incentive to encourage local communities to continue keeping such animals.

The choice of conservation method depends on the safety offered and the cost involved. Breeds to be given priority in conservation programs should be selected based on their comparative advantage obtained through objective evaluation. Priority should be given to:

- Breeds that have reached critical or endangered status.
- Genetically diverse stocks.
- Breeds with unique characteristics.
- Stocks with high overall economic merit.

Transferable Messages

- Sheep and goats can be productive if they are provided with the right type of management (environment) and if they have the genetic potential. Therefore, farmers should be advised on ways of manipulating both management and genetics to improve the productivity of their sheep and goat flocks.
- Increases in production through genetic means can be realized by keeping the best animals as parents of the next generation. Progress can be achieved by advising farmers not to sell (with the intention of getting more money from the sale) their best animals and not to sell indiscriminately. Rather, farmers should keep superior males for exchange and superior females for replacement.
- Nucleus breeding programs are expected to expedite genetic progress more than can be realized in individual flocks. In areas where farmers are willing to be involved in this activity, a nucleus flock needs to be established. Exchange of selected rams and bucks among farmers is another option to improve productivity under smallholder farmer conditions.
- When heritability of a trait is low, within-breed selection usually results in slow change or improvement. Crossbreeding, on the other hand, results in faster progress, given there is improvement in management. Depending on prevailing conditions, crossbreeding may need to be practiced.
- Because of the usually small flock size and because of mating between closely related individuals, inbreeding in sheep and goat flocks of Ethiopia is likely to be high. Farmers should be made aware of this and taught ways to avoid inbreeding and use of inferior males (through selection of the right type of male and sire exchange).
- The genetic diversity of sheep and goats needs to be maintained for current and future use. Different conservation methods should be considered when animals are at risk of extinction.

Exercises

Describe how productivity in sheep and goats would be determined.

Under what situations do you decide to improve indigenous sheep and goats through

- Selection?
- Crossbreeding?

There are various aids in selection. What would determine the type of aid to be used?

What options do farmers have to improve small sheep and goat flocks?

What are the disadvantages of inbreeding and what advice can be given to farmers to avoid inbreeding?

What is the importance of conservation?

Glossary

Breed: Is either a sub-specific group of domestic livestock with definable and identifiable external characteristics that enable it to be separated by visual appraisal from other similarly defined groups within the same species, or a group for which geographical and/or cultural separation from phenotypically similar groups has led to acceptance of its separate identity.

Breeding (animal): The practical application of genetic principles for development of lines of domestic animals suited to human purposes.

Closed nucleus: A nucleus flock that, once established, does not allow introduction of new animals.

Conservation: All human activities, including strategies, plans, policies and actions undertaken to ensure that the diversity of farm animal genetic resources is being maintained to contribute to food and agriculture production and productivity, now and in the future.

Crossbreeding: A mating scheme utilizing two or more breeds.

***Ex situ* breed conservation:** Conserving a breed of animals by freezing sperm, oocytes, and embryos in liquid nitrogen.

F1: First generation offspring of a mating between two different breeds.

Full-sibs: Animals having the same dam and sire.

Gene: Basic unit of heredity that is located on chromosomes and affects a specific trait.

Generation interval: Average time between birth of an animal and birth of its replacement.

Genotype: The genetic make-up of an animal.

Grading-up: Repeated mating of females and their female offspring with sires of a particular breed to produce a crossbred animal indistinguishable from the desired sire breed.

Half-sibs: Animals having one parent in common.

Heritability: The amount of variation in a trait which is due to genetic differences.

Heterosis: The increase in performance associated with the crossbred animal when compared to the average of the purebred parents.

Heterozygous: A gene pair with different genes for the same trait.

Homozygous: A gene pair where both genes are identical.

Inbreeding: Mating of individual animals that have common ancestry and are closely related, e.g., dam and son, siblings, etc.

Inbreeding coefficient: A calculated numerical expression of the amount of inbreeding of an individual.

Inbreeding depression: Reduction in performance due to inbreeding.

Independent culling levels: A method of selecting for multiple traits where a minimum level of performance is set for each. Animals are culled when failing to meet any criteria.

Index selection: Combining traits, often based upon economics, to devise a single selection criterion.

Individual selection: Selecting parent stock based on performance or phenotype.

***In situ* breed conservation:** Conserving a breed by preserving, multiplying and maintaining live animals of the breed.

Locus: The position on a chromosome where genes are found.

Nucleus flock: A flock or herd of the best animals available for the purpose of developing superior stock. A breeding scheme used by a group of producers to pool their best animals into one flock for the purpose of developing superior animals.

Open nucleus: Nucleus flock that continually allows introduction of superior animals from cooperator flocks.

Pedigree selection: Selection of breeding individuals based upon performance of their relatives.

Phenotype: The expression of genetic traits.

Prolificacy: Ability to reproduce; rate of reproduction.

Puberty: Period in time during which the reproductive system acquires mature form and function.

Reciprocal crossing: Mating both females and males of two breeds with each other to evaluate each breed's maternal and paternal effects.

Rotational crossing: Mating scheme using two or more breeds in succession.

Selection: Any natural or artificial process that permits an increase in the proportion of certain genotypes or groups of genotypes in succeeding generations in relation to others.

Selection differential: Average superiority of selected parents relative to flock contemporaries.

Tandem selection: A breeding scheme selecting multiple traits focusing on one trait at a time.

References

Dalton, D.C. 1981. An Introduction to practical animal breeding. Low-Priced Edition. Granda Publishing, GB.

Goodwin, D.H. 1979. Sheep management and production (2nd ed.). Hutchinson & Co. (publishers) Ltd. London. pp.224.

Horst, P. and Mathur, P.K. 1991. Breeding objectives and strategies. In: Panandam, J.M., Sivaraj, S; Mukherjee, T.K. and Horst, P. (eds). Goat Husbandry and Breeding in the Tropics. Compiled papers presented in an international seminar carried out by German Foundation for International Development (DSE) at the Institute for Advanced Studies, University of Malaya, Kuala Lumpur.

Kirkpatrick, D.F. undated. Sheep judging and evaluation. Sheep Production Handbook.

Lush , J.L. 1945. Animal Breeding Plans. 3rd ed. Iowa State College Press.

Philipsson, J., Rege, J.E.O. and Okeyo, A.M. 2006. Sustainable breeding programmes for tropical farming systems. In: Animal Genetics Training Resource, Version 2, 2006. Ojango, J.M., Malmfors, B. and Okeyo, A.M. (Eds). International Livestock Research Institute, Nairobi, Kenya, and Swedish University of Agricultural Sciences, Uppsala, Sweden.

Shrestha, J.N.B. and Fahmy, M.H. 2007. Breeding goats for meat production 3. Selection and breeding strategies. Small Ruminant Research. 67: 113–125. (Review)

Solomon Abegaz. 2002. Genetic evaluation of production, reproduction and survival in a flock of Ethiopian Horro sheep. Dissertation, University of Free State, South Africa. pp. 107.

Turner, H.N. 1982. Basic considerations of breeding plans. In: Gatenby, R.M., and Trail J.C.M. (eds) Small Ruminant Breed Productivity in Africa. Proceedings of a seminar held at ILCA, Addis Ababa, Ethiopia. ILCA (International Livestock Center for Africa), Addis Ababa.

Warren, G. Undated. Sheep genetics and reproduction. Sheep Production Handbook.

Weiner, G. 1994. Animal Breeding. Coste, R., Smith, A.J. (eds.). The Tropical Agriculturalist Series. MACMILLAN Education LTD. London and Basingstoke.

Workneh Ayalew and J. Rowlands (eds). 2004. Design, execution and analysis of the livestock breed survey in Oromiya Regional State, Ethiopia. OADB (Oromiya Agricultural Development Bureau), Addis Ababa, Ethiopia, ILRI (International Livestock Research Institute), Nairobi, Kenya.

Chapter Seven

Nutrition and Feeding of Sheep and Goats

Alemu Yami

Objectives

1. To identify feed-related problems of sheep and goat production.
2. To identify alternative strategies for feed resource development.
3. To learn the structure and functions of the ruminant digestive tract and possible ways of manipulating it to improve utilization of coarse feedstuff.
4. To learn the feeding habits of sheep and goats and implications for feeding and nutrition.
5. To learn methods to improve the feeding value of roughages through chemical treatment.
6. To learn the advantages and disadvantages of urea treatment and supplementation using urea molasses blocks.
7. To identify strategies for feeding sheep and goats during drought periods.
8. To learn appropriate methods of grassland and grazing management.
9. To learn appropriate feeding practices for different classes of sheep and goats.
10. To identify the characteristics and feeding value of common feedstuff.

Expected Outputs

1. Recognition of feed-related problems of sheep and goats in different agro-ecological zones.
2. Knowledge and ability to practice alternative strategies for better feeding of sheep and goats.
3. Skills to transfer improved sheep and goat feeding methods to producers resulting in improved productivity of sheep and goats.

7.1. General Introduction

The nutrition of sheep and goats is the most important factor affecting performance. Poor nutrition results in low rates of production, often defined by growth and reproduction. It also affects the immune system and the ability of an animal to fight disease. In extreme conditions of malnutrition, death can occur. In many animal production systems, approximately two-thirds of improvements in livestock productivity can be attributed to improved nutrition. In economic terms, feed cost accounts for about 70% of the total cost of livestock production. The feasibility of livestock enterprises is, therefore, a function of the type of feed and feeding system. It is estimated that up to a five-fold increase in tropical livestock productivity can be attained if there is optimal feed resource utilization. Sheep and goat production in Ethiopia suffers from feed shortages at all levels with an estimated 40% deficit in the national feed balance. This is aggravated by seasonal availability of forage and crop residues in the highlands and by recurrent and prolonged drought in the lowlands.

Improving performance through better nutrition is determined by three interrelated considerations:

- the availability of nutrients;
- type of feeding system; and
- the level of feeding management.

7.2. Structure and Function of the Digestive Tract

Sheep and goats are ruminants. Ruminants have the ability to consume and digest coarse, fibrous feedstuffs that form the major feed base in Ethiopia. The digestive tract of ruminants is unique in structure and function, allowing them to digest the fibrous feeds they consume.

The following are some of the unique features of the ruminant digestive tract compared to monogastric animals (animals with a simple stomach such as swine, dogs, cats, humans, etc.):

- Ability to digest carbohydrate sources not digested by monogastrics.
- Ability to use sources of non-protein nitrogen (NPN) to satisfy part of their protein needs.
- Large stomach volume to accommodate and utilize bulky feeds.
- Mouth and teeth well adapted for prehension and grinding of fibrous feeds.
- Well-developed salivary glands for production of large volumes of saliva.

7.2.1. Structure of the ruminant stomach

The ruminant stomach has four compartments known as the rumen, reticulum, omasum and abomasum. Most fermentation and absorption takes place in the rumen and reticulum. The two organs are generally considered as a single organ (reticulo-rumen) due to incomplete separation.

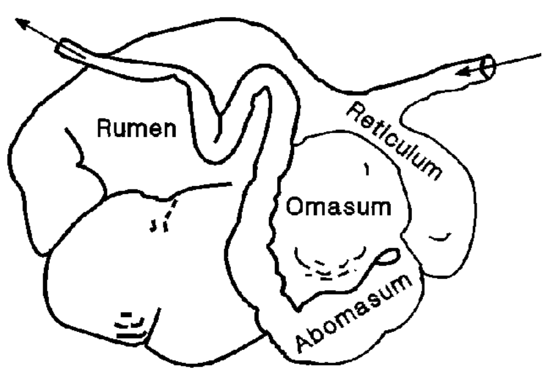


Figure 7.1. Structure of the ruminant stomach.

The reticulo-rumen is like a large fermentation vat where much of the physical and chemical breakdown of fibrous material occurs. Most of the chemical breakdown is a result of enzymatic activity of micro-organisms comprised of bacteria, protozoa and fungi. Physical breakdown is due to the strong movements of the reticulo-rumen and through rumination or chewing of the cud.

The rate at which digestion occurs is governed, to a large extent, by the number and type of micro-organisms present in the reticulo-rumen. A large and healthy population of micro-organisms results in faster digestion of feed and an added source of protein for the animal as the micro-organisms are broken down and digested later in the abomasum and small intestine. The population of micro-organisms is specific to particular diets and changes gradually in response to the type of feed eaten. The rumen can become upset when a sudden dietary change occurs because the micro-organisms cannot effectively digest the new feed. The sudden introduction of a new feed can lead to scouring, loss of condition or even death in severe cases.

7.2.2. Development of the ruminant stomach

Newborn ruminants have only a partially developed rumen and reticulum and are functionally monogastric animals. They are unable to use ordinary carbohydrates except lactose (the carbohydrate in milk) or grain-based feeds. Milk is digested in a well-developed abomasum. Milk bypasses the rumen and goes directly into the abomasum through the "esophageal groove," a tube formed from two folds of muscular tissue in the rumen that close upon suckling action of the lamb/kid. Digestive problems will result if the newborn is weak and unable to suckle. In this situation, it must be artificially fed using a tube (see the Health chapter for procedure).

Dry feed must be consumed for the rumen to develop. The rumen becomes inoculated with micro-organisms when the lambs/kids nibble on dry feedstuff. The development of the stomach complex enables lambs/kids to benefit from the action of the micro-organisms. They then have the capacity of:

Table 7.1. Development in the relative sizes of sheep stomach compartments (% of total).

Age	Rumen	Reticulum	Omasum	Abomasum
At birth	24	8	8	60
2 months	61	11	6	22
Adult	62	11	5	22

- microbial digestion of cellulose;
- incorporation of non-protein nitrogen into microbial protein; and
- synthesis of vitamin K and the B vitamins.

Ideally, the young animal should be confined and, from 2 to 3 weeks of age, supplied with a small amount of easily digestible feed. This will promote faster rumen development. The lamb/kid will increase its feed intake as the milk supply from the dam gradually decreases. Lambs and kids are very vulnerable to malnutrition. Weaning is a critical time unless they are adapted to consuming solid feed and weaned to high-quality diet.

7.2.3. Rumen environment and its manipulation

7.2.3.1. Rumen environment

An unhealthy and small population of rumen micro-organisms results in slow digestion and a slow passage of feed. The following conditions should be maintained in the reticulo-rumen to allow micro-organisms to grow and flourish.

- Constant temperature and pH (~6–7).
- Anaerobic environment conducive to rumen micro-organisms that are predominantly obligate anaerobes.
- Ruminal contractions to stir and mix the microbes and contents.
- Removal of the by-products of microbial digestion (volatile fatty acids, etc.).

Inadequate supply of nutrients, mainly nitrogen, sulphur and cobalt to the microbes will reduce microbial growth, and consequently reduce digestion. Supplementation of these nutrients is required in many cases. Often, the primary limitation is the concentration of ammonia (NH_3) in the rumen. Continuous availability

of NH_3 is critical for proper function.
Nitrogen metabolism in the reticulo-rumen is an example of rumen micro-organisms influencing the nutrition of sheep and goats. Most protein entering the rumen is broken into its constituents of a carbon skeleton, nitrogen (usually in ammonia form), and the side groups of amino acids. Any non-protein nitrogen entering the rumen, urea for example, is changed to ammonia. Ruminal micro-organisms use these breakdown products to manufacture microbial protein, allowing for growth and expansion of the microbial population. This microbial protein is later used by sheep and goats when the micro-organisms pass into the small intestine and are digested.

The solubility of feed protein in the reticulo-rumen varies with the source. In some feeds, such as some oilseed cakes, fish meal, feather meal, etc., a large proportion of the protein passes to the small intestine without being solubilized in the reticulo-rumen. These proteins, referred to as "bypass" protein, are digested in the small intestine. Because bypass proteins have not been altered by rumen micro-organisms, they retain their original amino acid profiles. In cases of high quality protein, this is beneficial to the animal. Forage legumes have intermediate rumen solubility. The solubility pattern of certain proteins can be changed through methods such as heating to increase the proportion of bypass protein.

7.2.3.2. Manipulation of rumen fermentation

The fermentation process in the rumen can be manipulated to improve the utilization of feed by sheep and goats by:

- Increasing the digestibility of complex carbohydrates in poor quality roughages.
- Altering the composition of microbial fermentation products (volatile fatty acids).
- Decreasing the degradation of certain nutrients in the rumen and encouraging nutrient bypass.

There are different ways of manipulating fermentation of feeds in the reticulo-rumen. Methods that have the largest effect on ruminal fermentation include chopping, heat treatment and chemical treatment.

Chopping: Results in increased digestibility largely because it increases the ease with which microbes can attack feed particles. Digestibility will be reduced if chopping is too fine. Finely chopped feeds may pass out of the rumen before microbes can adequately digest them.

Heat treatment: The effect of heat treatment depends on treatment conditions. Mild treatment can be used to increase bypass protein. High or moderate temperature treatment for a long time results in reduction of nutritive value, largely due to formation of insoluble protein complexes.

Chemical treatment: Protection of proteins (e.g., formaldehyde treatment of high quality proteins) is used to increase bypass protein for high producing animals. Digestion of structural carbohydrates can be increased by chemical treatment of poor quality hay and straws (e.g., alkali treatment, urea treatment).

7.3. Nutrients and Feedstuff

7.3.1. Nutrients

Nutrients are substances, supplied by feedstuffs, used by animals for maintenance and production.

Maintenance: All activities and body processes necessary for staying alive and maintaining an animal's bodyweight. Some specific components include:

- Energy to support essential physiological functions.
- Maintenance of body temperature.
- Repair of body tissue.

Production: Nutrients supplied above those required for maintenance allow for productive functions such as:

- Reproduction: Pregnancy and delivery make demands on the dam which should be met largely from her diet. The fetus increases in size quickly during the last third of gestation, drawing on the body reserves of the dam if she is not fed adequately.
- Growth: Any growth requires nutrients; sheep/goats require large quantities of energy and protein during the main period of growth between weaning and attaining mature body weight.
- Lactation: Milk production requires high levels of energy, protein, and water.
- Extra activity: Livestock in pastoral systems walk long distances in search of feed, particularly in the dry season. Animals may walk 10–15 km each day, which requires a great deal of energy.

There are six nutrients found in feedstuffs and animals, namely water, carbohydrates, fats (lipids), protein, minerals, and vitamins. Energy is not a nutrient but is derived from the breakdown of carbohydrates, fats, and protein. A major constituent of most feedstuffs is water. The other nutrients are said to compose the "dry matter" of a feedstuff and largely determine its feeding value. Plants contain mostly carbohydrates whereas proteins predominate in animals. Minerals and vitamins occur in relatively small quantities in both plants and animals.

Carbohydrates: Most livestock feeds are derived from plants and, thus, animal diets contain high proportions of carbohydrates. Most plant carbohydrates, due to their chemical nature, are used more effectively by ruminants such as sheep and goats than by monogastric animals. Carbohydrates are present in very small amounts in animals because they are directly used as sources of energy.

Carbohydrates can be classified as simple sugars or as complex carbohydrates such as starch and cellulose. Starch is the major component of grains and is readily available for digestion by both monogastrics and ruminants. Cellulose is often referred to as fiber and is not broken down by mammalian enzymes. Cellulose is degraded by enzymes produced by micro-organisms in the rumen. Roughages (hay, straw, browse, etc.) contain fiber and are not rich in available energy as are concentrates. The fiber in roughages can be used to provide energy through microbial fermentation in the rumen. Animals need a supply of carbohydrates in the diet at all ages. Carbohydrates consumed in excess of an animal's requirements are converted and stored as fat.

Fats: Fats are concentrated forms of energy that are generally present in small quantities in the common feeds of sheep and goats. Fats are important in the diet to increase the energy value. The fat in an animal is largely manufactured from carbohydrates. Fat deposited during periods of good feed supply may be mobilized at times of shortage as a source of energy. Sheep generally deposit more fat in the body than goats.

Proteins: Animals require a considerable amount of protein because their bodies and products (meat, milk) are composed of high levels of protein. Most common feeds are low in protein, and supplying proteins to livestock is a major challenge. Protein is costly, and the higher the percentage of protein in a feed, the greater the cost.

Minerals: Although required in small quantities, minerals are very important to the living organism. They form part of the structure of the skeletal system and play a role in most body processes. Plants obtain their minerals from the soil. The mineral composition of a feedstuff largely depends on the mineral composition of the soil. Mineral composition of plants is affected by plant species and stage of growth. Young, leafy materials generally have a good supply of all the essential minerals, particularly calcium. Cereal grains have satisfactory amounts of phosphorus and potassium but are poor sources of calcium. Roots and tubers are poor in all minerals.

Minerals are divided into two groups, macro-minerals, those required at 0.1% or more in the diet, and micro-minerals, those required at very small amounts (part per million (ppm)) levels. Macro minerals include calcium, phosphorus, sodium, potassium, chlorine, sulphur, and magnesium. Micro minerals include iron, copper, cobalt, manganese, zinc, iodine, selenium, molybdenum, and others. Mineral deficiencies can lead to decreased growth and reproduction. There are some areas of Ethiopia deficient in one or more minerals, e.g., copper in the Rift Valley region.

Vitamins: Vitamins stimulate the body's function or metabolism. Some vitamins have a general effect while others control a specific reaction or activity. In practical feeding of sheep and goats, the main vitamins of concern are A and D. Vitamin A is a general growth promoter and helps the stock resist infection while Vitamin D is important mainly for maintenance of healthy bones. The B-complex group and Vitamin K are synthesized by rumen micro-organisms, and hence there is no need to supply them through the feed. Even vitamins A and D are not a major concern in the tropics where sheep and goats generally have access to pasture or rangeland.

Energy: While not considered a nutrient, energy is vital to an animal's survival. The breakdown of nutrients, mainly carbohydrates, provides the actual physical energy an animal needs for maintenance and production. Excess energy is accumulated in the form of body fat, which is essential for production and to enable animals to survive periods of low feed intake. Energy is measured in megajoules or calories (1 calorie = 4.2 joules). Carbohydrates, followed by fats, are the primary energy sources. Excess protein can also make contributions.

7.3.2. Feedstuffs

Feeds are classified according to the amount of specific nutrients they supply. Two main classes of feedstuff are **roughages** and **concentrates**.

Roughages: These are bulky feeds containing relatively large amounts of poorly digestible material, that is, more than 18% crude fiber. They can be of two categories, namely dry and succulent based upon their moisture content.

Table 7.2. Nutrient composition of feeds used for sheep and goats.

Feedstuff class	Dry matter (%)	Crude protein (%DM)	ME (MJ/Kg DM)
Straws / stovers	88–92	3–4	5.5–7.5
Cereals	89–91	9–11	12–14
Grasses	20	10–22	9–12
Oilseed cakes	89–91	22–50	12–14
Green legumes	15–27	17–24	10–12

- Succulent feeds usually contain more than 75% moisture and include:
  - Pasture
  - Cultivated fodder crops
  - Tree leaves
  - Root crops
  - Silage
- Dry roughages contain only 10–15% moisture.
  - Hay and crop residues fall in this category

Concentrate: A feed or feed mixture which has high amounts of protein, carbohydrates and fat, contains less than 18% crude fiber and is usually low in moisture. Concentrates are rich in either energy or protein and are thus expensive. They can also be categorized on the following basis:

- Energy-rich concentrates: Feeds with high levels of energy but low in protein content. These can be of the following types:
  - Grains and seeds: best energy sources but generally expensive due to use as human food.
  - Mill by-products: cheaper and widely used (e.g. brans, shorts).
  - Root crops.

- Protein-rich concentrates:
  - Oilseed cakes: The by-products left after extraction of oil from oilseeds. The protein and energy contents of these products in Ethiopia vary widely depending upon the oil extraction method used, traditional/home extraction, expeller method or solvent-extraction method. Of these, the cake produced by the traditional method contains the highest amount of oil while the solvent-extraction method produces a product with the least amount of oil. Conversely, the protein content is highest in the solvent-extracted cakes and lowest in the traditional method.
  - Brewer's grain: These are by-products of the brewery industry. Dried brewer's grains contain about 18% crude protein and 15% crude fiber. There is substantial production of this product from home brewing.

7.4. Nutrient Requirements and Deficiencies

7.4.1. Nutrient requirements

Nutrient requirements of sheep and goats depends on their physiological state and function and contains allowances for maintenance and production. The larger the animal, the more feed it needs to maintain its body function. As production increases, so does nutrient demand and feed requirement. Nutrient requirements of sheep and goats are similar and will be presented together for the purpose of this handbook. Specific nutrient requirements for sheep and goats in Ethiopia are not available. Requirements for different animal functions derived from information on animals in the tropics are presented below.

The overall nutrient requirements of a particular sheep or goat are the sum of its maintenance requirement and other physiological functions (e.g., pregnancy, growth, lactation etc.). Maintenance requirements are presented in Table 7.3.

Table 7.3. Daily maintenance requirement estimates for energy and digestible crude protein (DCP).

Live weight (kg)	ME (MJ/kg dry matter)		DCP (g/day)	
	Confined	Extensive	Maintenance	Pregnancy
10	2.32	3.25	15	30
20	3.91	5.47	26	50
30	5.30	7.42	35	67
40	6.58	9.21	43	83
50	7.78	10.89	51	99
60	8.92	12.49	59	113

Source: Devendra (1982); NRC (1981).

Requirements for lactation depend on the level of milk production and its composition. Requirements for lactation are presented in Table 7.4.

Table 7.4. Daily nutrient requirements per kg of milk production.

Fat content of milk (%)	ME (MJ)	DCP (g)	Ca (g)	P (g)
3.5	4.5	47	0.8	0.7
4.5	5.2	59	0.9	0.7
5.5	5.7	73	1.1	0.7

Source: Devendra and McLeroy (1982).

The nutrient requirement for pregnancy rises substantially during the last two months of gestation. It is particularly high if the dam is carrying twins or triplets. There is a need to increase nutrient content of the diet during this period to prevent low birth weights and/or serious loss of body condition by the dam.

Table 7.5. Micro-mineral requirements and toxic levels.

Mineral	Requirement	Toxic level
Copper	7–11	25
Molybdenum	0.50	10
Cobalt	0.10–0.20	10
Manganese	20–40	1000
Zinc	20–33	750

Source: NRC (1982).

Table 7.6. Water content of various feeds.

Feed	%
Succulent feeds (roots, tubers and green fodders)	80–90
Silage	75–80
Cereal grains, milling by-products, hay	12–16
Crop residues	8–12

The nutrient requirements for growth are dependent on growth rate. A supply of 0.035MJ ME/day is required per gram of growth.

Water is the most critical of all nutrients required by sheep and goats, and yet it is an often forgotten nutrient. Water is necessary for all life functions including digestion of food. The animal's body is 70% water. Water availability is one of the first limiting resources for livestock production in many parts of the country. Inadequate water supply will dramatically decrease the production of livestock. They will eat less, digest feedstuff poorly, and are more prone to digestive and metabolic problems. The animal body can lose nearly all fat and over half of its protein and still live. However, if the animal loses 20% of its body water it will die.

Animals can get their water from the following sources:

- Drinking water.
- Free water found in feed.
- Metabolic water from nutrient oxidation in the body.

Animal feeds contain variable quantities of water. The percentage variation is summarized in Table 7.6.
In the wet season, or in humid areas, sheep and goats may eat forage composed of 70–80% water and may need little or no drinking water. However, most feeds in the tropics have low moisture content and thus drinking water is essential for animals. Coarse, fibrous feeds need to be accompanied by adequate drinking water for proper digestion. The feed needs to absorb water in the rumen for it to be effectively digested by ruminal micro-organisms.

The amount of water an animal needs depends on the species, breed, climate, type of feed eaten, the type and level of production desired (milk, growth, etc.). Tropical breeds kept in arid and semi-arid areas may only need to drink once every 2–4 days in the dry season. They have better ability to reduce water loss through urine and feces than temperate breeds that may need twice as much water in the same environment.

Goats are able to extract almost all excess water from the digestive system, making very efficient use of whatever amount of water is available. This is one reason goats can survive in arid regions.

It is normally recommended that sheep and goats be supplied four times the amount of water as the amount of feed dry matter (DM) consumed, i.e., 4 kg water for 1 kg feed DM. They may need more water at higher temperatures. The situation is different with lactating animals. Milk is more than 90% water and the recommendation for lactating animals is to provide an additional 2 liters of water per liter of milk produced. The water requirement of sheep and goats is about 1.5 to 2.5 liters per day.

7.4.2. Nutrient deficiencies

Energy and protein: This is a major problem limiting production. Protein deficiency is most serious during the dry season while energy deficiency is more serious and visible during the wet season. Apart from weight loss and possible death under extreme conditions, fertility is reduced due to energy and/or protein deficiency.

Minerals: Mineral deficiencies can cause metabolic problems that bring about reductions in productivity, and in extreme cases, death. Mineral deficiencies are often difficult to detect since their only manifestation could be reduced productivity, which can also be to the result of poor nutrition or parasite infestation. However, severe deficiencies are more readily apparent and can be recognized from specific symptoms. Mineral deficiencies are best confirmed by the analysis of blood samples.

There is evidence of sodium, phosphorus, copper, cobalt, zinc and manganese deficiencies in scattered areas of the country. Copper deficiency has been identified in many parts of the Rift Valley. Areas of copper, manganese and iron toxicity have also been identified (Figure 7.2). Mineral deficiency symptoms and possible supplementation sources are summarized in Table 7.7.

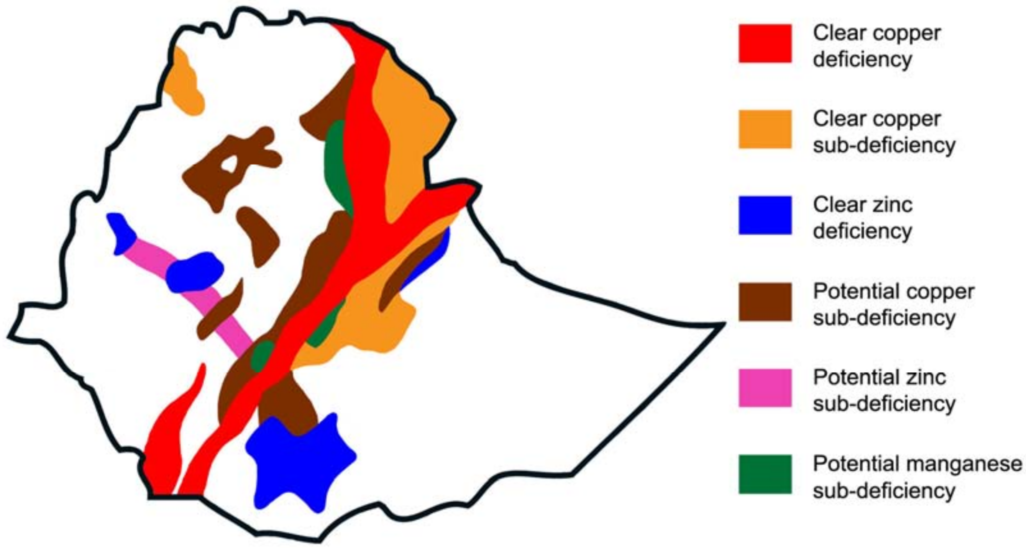


Figure 7.2. Mineral deficiency sites in Ethiopia.

Table 7.7. Mineral deficiency symptoms and possible supplementation sources.

Mineral	Deficiency symptoms	Types and classes of animals most affected	Feed source
MAJOR MINERALS			
Calcium	Deformed bones, retarded growth	Young animals, newly kidded does and newly lambed ewes, finishing sheep and goats on high grain diets	Milk, green feed, ground limestone
Phosphorus	Deformed bone, retarded growth, poor fertility, soil eating	Young, growing animals	Milk, cereals
Magnesium	Falling on side with legs alternately rigidly extended and relaxed, frothing and profuse salivation, weight loss, excitability	Young and growing animals, can also occur in adults	Bran, oilseed cakes
Sodium	Chew on wood and/or lick dirt, loss of appetite, slow growth	All classes	Common salt
MINOR MINERALS			
Copper	Swayback – young ones unable to walk on their back legs, scouring, stiff legs, dull coat	Young lambs/kids	Seeds, trace-mineralized salt containing copper sulfate at 0.5%
Manganese	Difficulty in walking, deformed forelimbs, poor fertility	Young lambs/kids, Adults	Bran
Zinc	Stiff joints, salivation, swelling of feet, poor testicular development and low libido, reduced growth rate, reduced conception rates and high incidence of abortions	Young lambs/kids, Adults	Cereal grains, corn gluten feed and meal added to trace-mineralized salt

Vitamins: All sheep and goats require dietary vitamins A, D and E. Dietary sources of the B vitamins and Vitamin K are required by lambs and kids before the rumen becomes functional. Consumption of green vegetation provides adequate carotene (Vitamin A precursor), which can be stored for up to six months and can thus be used during dry periods when animals have to depend on dry vegetation. Vitamin D deficiency is not a problem unless animals are confined for a long period of time without exposure to the sun.

7.5. The Feeding Habits of Sheep and Goats

Sheep and goats differ in their feeding habits. Selection and intake of forage depends not only on the available plant resources but also on the feeding behavior of animals. Knowledge of feeding habits that have nutritional implications is important in improving sheep and goat nutrition. A comparison of the feeding habits of sheep and goats is presented in Table 7.8 and Figure 7.3.

Goats prefer to consume a wide variety of feedstuffs. Goats are more selective and browse more, especially under extensive conditions, than sheep. The selectivity of goats is reduced under intensive management. Goats generally have better body condition compared to sheep under the same grazing conditions, mainly due to their ability to select a nutritious diet.

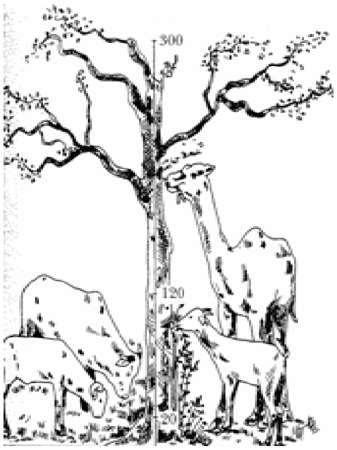
Goats prefer to eat feed at a height of 20–120 cm. They have the ability to stand on their hind legs for long periods and can even climb trees in order to reach parts of trees they prefer. They also have mobile upper lips and tongues that enable them to consume leaves between thorns.

The preference of goats for consuming browse can be used in the control of invasive species on grasslands. Keeping a mixture of browsers and grazers can maintain rangeland grazing areas rather than allowing them to become overgrown with brush. The mixed species of livestock kept by pastoralists enables simultaneous use of vegetation at different heights.

Table 7.8. Comparison between sheep and goats.

Characteristics	Goats	Sheep
Activity	Can stand on its hind legs to access browse; Can walk longer distances	Walk shorter distances
Feeding pattern	Browser; more selective	Grazer; less selective
Variety in feeds	Preference greater	Preference limited
Salivary secretion rate	Greater	Moderate
Recycling of urea in saliva	Greater	Less
Dry matter intake:		
For meat production	3% of body weight	3% of body weight
For milk production	4–6% of body weight	3% of body weight
Digestive efficiency	With coarse roughage higher	Less efficient
Retention time	Longer	Shorter
Water intake per unit dry matter	Lower	Higher
Water economy	More efficient	Less efficient
Water turnover rate	Lower	Higher
Dehydration:		
Feces	Less water loss	Higher water loss
Urine	More concentrated	Less concentrated
Fat metabolism	Increased during periods of water shortages	Less evident

Source: Devendra,C. 1986. Feeding systems and nutrition of goats and sheep in the tropics. In Adeniji, K.O., and Kategeli, J.A. Proceedings of the workshop on the improvement of small ruminants in eastern and southern Africa. 18–22 august 1986. Nairobi Kenya. pp.91–110.



a. Feeding heights (cm) above ground for different livestock species

b. Goats browsing

Figure 7.3. The feeding habits of sheep and goats.

7.6. Available Feed Resources for Sheep and Goats

Natural grazing land is the predominant feed source for sheep and goats in Ethiopia. Very little land is planted to introduced pastures or forage crops. This is especially true for the pastoral and agro-pastoral areas. Grazing areas are usually communally owned. Crop residues and agro-industrial by-products represent a large proportion of feed resources in the mixed crop–livestock system. Reliance on crop residues for animal feed is ever-increasing as more land is cropped to feed the fast-growing human population. This has decreased available grazing land and has forced livestock to graze more fragile, less productive lands not suited for high livestock numbers. Erosion and environmental degradation result in decreased soil fertility and forage productivity. This, in turn, leads to poor animal productivity. Table 7.9 presents a summarized listing of feed resources in Ethiopia by cropping system.

Table 7.9. Availability of feed resources by cropping system.

Coffee–*Enset* system	Coffee–crop system	Crop production system	Pastoral–agro-pastoral system
Natural grazing	Natural grazing	Natural grazing	Natural grazing
Hay	Hay	Hay	Standing hay
Enset by-products	Cereal crop residues	Cereal crop residues	Browse
Sugar cane tops/leaves	Oilseed cakes	Pulse crop residues	
Root crop leaves	*Enset* by-products	Oilseed cakes	
Local brewery by-products	Sugar cane tops/ leaves	Sugar cane tops/leaves	
	Root crop leaves	Local brewery by-products	
	Local brewery by-products	Molasses*	
	Molasses*	Milling by-products*	
	Milling by-products*		

*available only near sugar factories.

7.6.1. Natural pasture and browse

Natural pastures supply the bulk of sheep and goat feed. They are composed of indigenous forage species and are subject to severe overgrazing. Grazing occurs on permanent grazing areas, fallow land and on land following harvest. Both fallow land and crop stubble provide poor grazing for a very short period just after harvest. The availability and quality of native pasture varies with altitude, rainfall, soil type and cropping intensity. Average pasture yield for the highland areas is estimated to be 4 tons/ha. In many areas, natural pastures are invaded by species of low palatability. The wearing out and/or loss of teeth induced by unpalatable and tough vegetation is a problem that reduces the grazing ability of sheep and goats at an early age.

Grazing and browsing comprise the feed supply in pastoral areas. The higher rainfall areas of the pastoral zone are characterized by dense thorn bush of low carrying capacity.

When compared with tropical grasses, browse is richer in protein and minerals in the dry season. The crude fiber content of browse also tends to be lower than that of grasses and usually ranges between 20 and 40% and is even lower in shoots and leaves. The low content of crude fiber suggests that the energy content of browse is higher than that of dry grass. Browse could, therefore, supplement the low protein content of grass forage during dry periods.

7.6.2. Crop residues and fallow grazing

Crop residues are fibrous materials that are by-products of crop cultivation. Crop residues have low crude protein content in the range of 3–13% of the dry matter. This is a basic limitation in residues such as straw and bagasse with crude protein contents around the border-line level of 6–7% required to create an appropriate rumen environment to promote dry matter digestibility and intake. Most residues are deficient in fermentable energy and minerals. Crop residues have low palatability and digestibility that leads to poor intake, particularly when fed as the sole roughage.

The availability of crop residues is closely related to the farming system, the type of crop produced and the intensity of cultivation. Teff, wheat and barley straws are the major residues available in the highlands. Pulse crop residues like chickpeas, haricot beans and lentils are also important. Residues of maize and sorghum form the bulk in the lowlands. The common practice in utilizing crop residues is feeding in the long dry form.

a. Wheat straw

b. *Enset* residue

c. Sweet potato vines

d.Corn stover and cobs

Figure 7.4. Crop residues.

Crop residues are often left in the field or accumulated in places where the crop is threshed. Transportation of crop residues, even over short distances, can become difficult and costly because of their bulk. The production of crop residues is also seasonal, available in very large quantities right after harvest and less available thereafter.

7.6.3. Agro-industrial by-products

Agro-industrial by-products result from the processing of agricultural produce such as oilseeds, sugarcane and citrus, and from slaughterhouses during the slaughter and processing of livestock. In comparison to crop residues, these products are very good in their composition of useful nutrients and digestibility. The feeding value of such by-products varies considerably.

Most of the oilseed produced in Ethiopia is exported whole without processing. This represents a loss of by-product oilseed meal that could be fed to livestock. The case of molasses is similar in that it is exported rather than kept and used in-country.

Figure 7.5. Sheep feeding on local brewing by-product and sweet potato tubers.

7.6.4. Thinnings and leaf strips from maize and sorghum

Thinning and leaf stripping from cereals such as maize and sorghum are widely practiced in eastern Ethiopia, serving as important sources of feed. This is a useful practice that should be expanded to other parts of the country.

Thinning: Farmers use high seeding rates initially. The extra seedlings are eventually thinned out as necessary and fed to livestock.

Leaf stripping: Farmers start stripping maize leaves about 90 days after planting or as soon as the cob can be seen, with removal of one leaf per plant per week starting with the bottom leaves. If properly implemented for an extended period of time, this could supply 800 kg/ha of valuable fodder with an average crude protein content of 13% and digestibility of 64%.

7.7. Voluntary Feed Intake and Its Improvement

The amount of feed an animal eats will affect its health and productivity. Generally, the more feed an animal eats, the better. Feed consumption is a voluntary activity and it is difficult to force an animal to eat. Understanding the factors that affect feed consumption and how these factors can be manipulated is important.

The factors that determine the quantity and quality of feed consumed can be categorized as those related to the animal, the feed and the presentation of the feed. This applies whether in situations where an animal is stall-fed as well as where it is free-grazing.

- **Feed-related factors:** These include factors such as taste, smell and physical ease with which the animal can eat the feed.
  - ♦ If the feed is contaminated with urine and feces, smells bad, or tastes bad, the animal will reduce its intake.
  - ♦ Long, coarse grasses or crop residues like maize stover are difficult for sheep and goats to consume. They should be chopped to facilitate intake.
  - ♦ If coarse feeds are used, the animal will need access to plenty of water as such feeds with high dry

matter content need to soak up water to be digested. Highly digestible feeds are rapidly degraded and absorbed, passing quickly through the digestive tract. This stimulates appetite because the animal soon feels empty.

- **Presentation factors:** Animals are very selective in what they consume. If excess feed is offered, the total amount eaten by an animal will be more than if it had only a small amount from which to select. In very hot climates, the heat can reduce the amount that the animals eat. Animals may stop eating during the hottest part of the day because they have difficulty regulating body temperature rather than because they are full. In hot environments, allowing animals to graze early in the morning and late in the evening can significantly increase the amount eaten.
- **Animal factors:** These include the effects of the physiological state of the animal (e.g., pregnancy, growth, etc.)

Supplementation is one method used to improve feed intake. Supplementing a deficient nutrient in a diet will improve intake. Supplementation of available nitrogen (protein and/or non-protein nitrogen sources) to diets with poor fermentable nitrogen will improve digestion, and consequently intake, by promoting multiplication of micro-organisms in the reticulo-rumen. Supplementation of sulphur will also promote digestion and intake.

7.8. Feed-Related Constraints of Sheep and Goat Production in Ethiopia

Constraints of sheep and goat production related to nutrition and feeding can be summarized as follows:

- Inadequate feed supply mainly due to small land-size and overstocking brought about by the shrinking amount of land reserved for grazing.
- Low feeding value of available feed resources resulting in low efficiency of utilization.
    - Much of the feed consumed is utilized to fulfill maintenance requirements with little surplus for production.
    - Fibrous feeds with poor digestibility and low intake result in low levels of overall production.
    - Poor quality of feeds for lambs/kids at weaning, causing a sharp drop in weight and possible death.
    - Poor nutrition of lactating dams, resulting in low milk yields and poor rates of growth and survival among lambs and kids.
    - Deficiencies of protein and energy, which are the main nutritional factors limiting productivity of sheep and goats. Mineral deficiencies, such as a lack of sodium in feeds with high moisture content or in a specific area are also of concern.
    - Poor presentation methods of feed to confined sheep and goats.
    - Uncertain availability and high cost of supplements (e.g., oilseed cakes) and other alternative feeds.
- Inability to make maximum use of the limited total feed resources.
    - Crop residues and agro-industrial by-products that could be fed to animals are largely wasted or inefficiently used because infrastructure for transporting, processing and marketing feedstuff is underdeveloped. One example is the large amount of bagasse from sugar factories.
    - Efficient use of the rangelands by pastoralists is hampered by the lack of information on where adequate grazing conditions exist. Institutionalized information in pastoral communities as to where to move herds to find grazing exists based upon previous experience. Such information may be of little value when drought occurs.
    - Shortage of grazing resources as a result of bush encroachment caused by overgrazing, cultivation of marginal areas and inadequate water supply.
- Marked seasonal variation in the quantity and quality of feed supply.
    - Dry season:
        - Acute shortage of feed during the dry season. Available feeds during this period are of

very poor quality (low in protein and high in fiber).

- Low digestibility and low voluntary intake of available feeds.
  - Adequate rumen function is necessary to digest and utilize nutrients in feeds. A crude protein content of below 7% is inadequate for proper rumen function. This occurs when the protein content of pasture forage falls below this level and/or when animals are fed only on crop residues.
  - Limited intake of feeds with poor digestibility: Poorly digested feed leaves the digestive tract slowly, thus occupying digestive tract space and limiting intake of additional feed.
  - Poor availability and access to water.

- Rainy season:
  - Low dry matter intake from grazed forages due to high moisture content of vegetation.
  - Reduction of grazing area due to cropping of most of the land in crop–livestock production systems.
  - Wastage and/or deterioration of valuable grazing resources that animals can't utilize at this time of year.

7.9. Improved Feeding Strategies of Sheep and Goats

Strategies for ensuring appropriate nutrition of sheep and goats include:

- Matching sheep and goat production systems to available feed resources;
- More efficient use of agricultural and industrial by-products as sources of feed; and
- Encouraging increased intake.

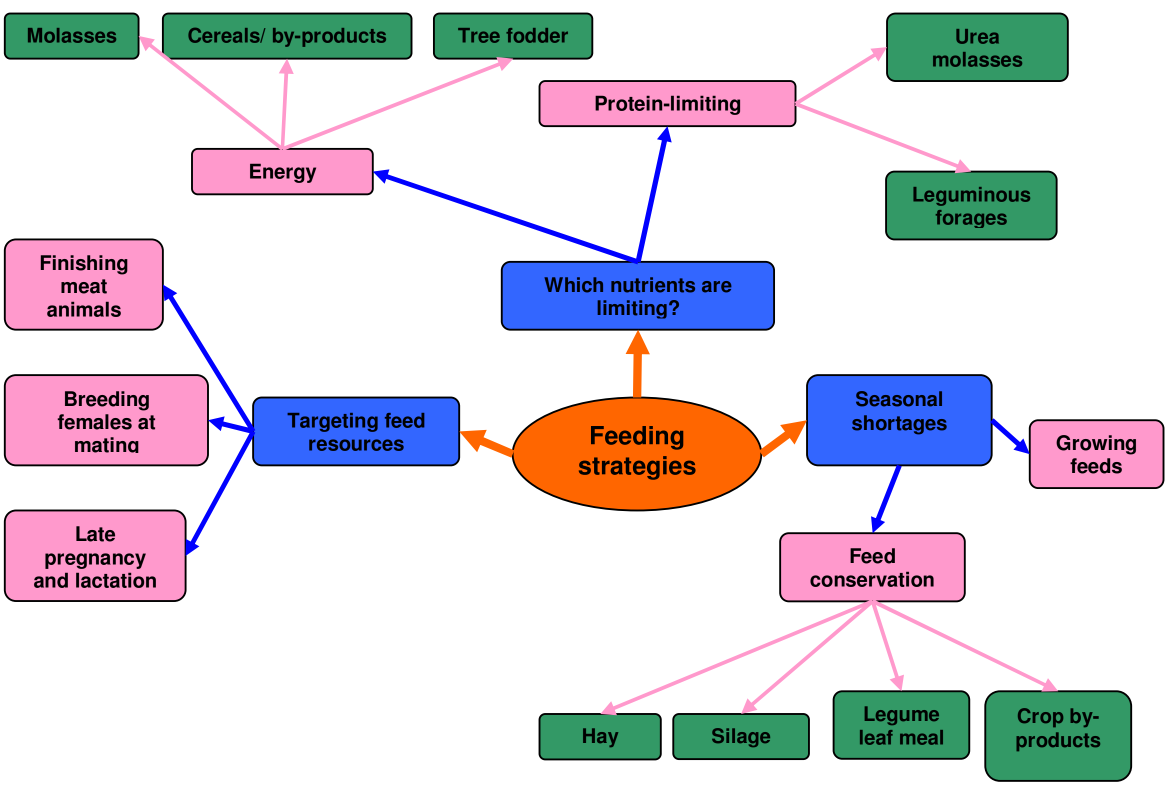


Figure 7.6. Feeding Strategy Considerations.

Adapted from: http://www.smallstock.info/info/feed/feed-strat.htm

7.9.1. Matching sheep and goat numbers to available feed resources

One of the strategies of increasing feed availability is through increasing offtake of animals through sale (destocking). This will increase the amount of feed available to the remaining animals. Feed efficiency can also be increased if older, mature animals are sold leaving younger, growing animals that utilize feed nutrients more efficiently.

The scope for increasing offtake can be attained by taking the following steps. (Improvement of marketing is presented in more detail in the Marketing section of this handbook.)

- Organizing producers into marketing cooperatives.
- Improving the infrastructure of livestock marketing.
- Providing market information through the mass media (i.e., prices and volume of livestock traded in various markets).
- Regulating the standards of products and services and negotiating favorable trade agreements in export markets.

7.9.2. More efficient use of feed resources

There are various means of improving the efficiency of utilization of available feed resources. The following are some of the possibilities.

7.9.2.1. Supplementation

Ruminant diets are generally based on fibrous feeds that have low digestibility and are deficient in protein, minerals and vitamins. These characteristics keep intake and productivity low. Provision of appropriate supplementary feedstuff during critical periods of the year is important to enhance productivity or at least avoid body-weight loss. This is especially true for livestock consuming poor-quality pasture and crop residue-based diets.

A supplement is a semi-concentrated source of one or more nutrients used to improve the nutritional value of a basal feed, e.g., protein supplement, mineral supplement. Supplementation may be at various levels and for different reasons. It may be done to assure survival, to assure maintenance or to assure production and reproduction. Supplementation can be done by providing a complete feed or by giving specific nutrients. Supplementation can enable animals to consume more forage, to digest the same quantity of forage more efficiently or to overcome a nutrient deficiency that critically limits performance.

Grazing stock may sometimes be supplemented with hay or straw to provide bulk for prevention of nutritional disorders. This is when the pasture is very lush with high moisture or protein content or where there is a danger of bloat in legume-rich swards.

Bypass nutrients, with the exception of those from legume leaves, come generally from rather expensive feeds which are either in demand for human nutrition (cereals) or exported for foreign exchange (oil seeds). However, because recent research has shown that inclusion at a low rate in the diets is beneficial, these supplementary feeds should be economical in many situations.

Most supplements are expensive and their use in ruminant nutrition competes with monogastric animal and/or human nutrition. Moreover, they are generally not easily available. Optimum utilization of these scarce resources is, therefore, essential. This targeted use of supplements is referred to as "strategic supplementation" and is designed to have maximum effect and optimum economic benefits. This can be achieved by identifying and providing critically deficient nutrients based on the following considerations:

- Supply rumen microbes with the necessary rumen-degradable nitrogen and other essential nutrients to enhance their capacity to degrade poor-quality roughages in the rumen. This is a first priority.

- Supply small amounts of bypass nutrient sources to increase utilization of absorbed nutrients and animal performance.
- Supplement during times of most critical deficiency of a nutrient, giving priority to supplementation of the most critically deficient nutrient.
- Make better use of supplements by giving priority to the physiologically most vulnerable groups of sheep and goats, e.g., pregnant animals during the last third of gestation, lactating females, young growing lambs, etc.

The main objective of supplementation is to catalyze the more efficient utilization of poor-quality roughages. For this reason the term "catalytic" supplement has also been used to describe these effects. The role of a supplement ceases to be "catalytic" when it exceeds about 30% of the diet dry matter, at which point it assumes a major role and substitutes the basal roughage source.

Steps in the provision of supplementary feed

Three levels of supplementation are recommended for effective utilization of roughage resources and improving animal productivity. The first creates an appropriate environment in the reticulo-rumen for effective fermentation of poor-quality roughages. The second step is to further improve fermentation through additional supplementation with a small quantity of highly digestible forage. The third stage is supplementing a source of protein that can bypass rumen fermentation and be utilized in the small intestine for high productivity. The level of the forage and the bypass protein source can be increased as much as possible to support further productivity. These steps are presented below in more detail:

Step 1. Fermentable nitrogen sources: The first supplement to be considered should be a source of fermentable nitrogen (usually urea) to ensure a crude protein level of at least 7% of the total diet for effective fermentation of roughages. As a general rule, if a deficiency is suspected, urea should be added at the rate of about 1–2% of the organic matter in the diet. Feeding molasses/urea blocks or high-urea (10%) liquid mixtures with molasses is a convenient way of ensuring a continuous supply of ammonia-nitrogen in the rumen, as is treating poor quality roughages with urea. Urea treatment of roughages has the added advantage of improving the feeding value of the roughage.

Step 2. Highly digestible forage: The second supplement should be a source of highly digestible forage, preferably legume, given at about 10–20% of the diet. This helps to ensure a more efficient rumen environment for the digestion of fiber.

Step 3. Bypass protein source: The third supplement should be a source of bypass protein such as an oilseed meal, cereal bran, etc., that should be given in amounts not to exceed 30% of the total diet dry matter. The 30% limit is to prevent depression/substitution of the intake of the basal poor-quality roughage diet. Lower amounts may be more economical. The optimum economic level and the degree of response to the supplement will depend upon the fermentability of the basal diet. Providing bypass protein to sheep and goats owned by small farmers is often difficult, and at times, too expensive. Oilseed cakes and other protein sources that have been heat-treated have considerably higher proportion of bypass protein.

Types of supplements

Concentrate supplementation

Supplementary concentrates such as oilseed cakes, cereals and cereal by-products provide readily fermentable carbohydrates, nitrogen and other essential nutrients. Problems associated with concentrate supplementation and justifications for its use are outlined below.

- Problems of concentrate supplementation:
    - ♦ Concentrates are expensive and may not be readily available.
        - Availability and prices of agro-industrial by-products are generally lower in and around

urban areas. Prices in rural areas are higher because of the high cost of transportation in Ethiopia.

- ♦ Many smallholder farmers scattered in the rural areas have limited market access for sale of animals. This reduces the economic incentive to supplement concentrate feeds to increase sheep and goat productivity.

Despite these problems, the following points justify concentrate supplementation:

- Scarcity of nutrients from other cheaper sources for high production.
- Restriction in energy uptake imposed by roughages.
- Beneficial economic return, i.e., increased sale price of produce higher than the cost of concentrate required for production.

Supplementation with forage legumes

Dietary protein, rather than energy, is the main limiting factor in many situations. A realistic alternative approach to supplying protein through oilseed cakes or other purchased feedstuff is the use of good quality leguminous forages as sources of supplementary protein. Forage legumes may be in the form of herbaceous, shrubby or tree legumes. Forage legumes have the following advantages:

- Are rich in protein and other nutrients such as minerals and vitamins.
- Can enhance the utilization of poor-quality roughages in smallholder mixed farming systems.
- Have the added advantage of improving soil fertility by fixing nitrogen, and thereby enhancing crop yield and maintaining soil fertility.
- Wilting or drying improves the feeding value of the foliage from fodder trees possibly due to:
  - ♦ Increases in proportion of bypass protein reaching the intestine due to decreased solubility in the rumen.
  - ♦ Reduction in anti-nutritional factors in the legumes.

The legume used should have high protein content and supply both fermentable and bypass protein. Legume forages rich in tannins are superior as bypass protein sources since tannins link with proteins during mastication and reduce their degradation in the rumen. The ideal concentration of condensed tannins is 20–40 g/kg diet dry matter; higher levels are detrimental. Sheep can adapt to high tannin levels. Condensed tannin-containing forage in the diet is beneficial provided that it is only used as a supplement (e.g., less than 25% of the diet dry matter). Tropical legumes are generally richer in tannins than temperate legumes and therefore function better as sources of bypass protein. Examples of tropical legumes known to contain tannins are leucaena, glyricidia and sesbania. The presence of toxic substances in some species can cause problems in unadapted animals, especially if offered in large quantities. It is, therefore, advisable to gradually adapt animals to such feeds.

The protein content of forage legumes is generally related to stage of maturity. Protein content decreases with age while yield increases with age. The appropriate compromise between composition and yield needs to be made. Do not harvest the last regrowth before the dry season starts. This will ensure a better stand during the dry season. The effect of stage of maturity on protein content is presented in Table 7.10.

Table 7.10. Effect of stage at harvest on protein content of legumes.

Grade	Maturity of Legumes	% CP
Prime	Pre-bloom	>20
1	Early bloom	17–19
2	Mid-bloom	14–16
3	Full bloom	11–13
4	Beyond full bloom	8–10

Methods of increasing the supply of forage legumes: The supply of forage legumes can be increased by promoting the integration of forage legumes into the farming system. Integration of forages into the farming system is presented in more detail in the Forage and Pasture section of this handbook. The following conditions need to be considered in integrating forage legumes into a farming system.

- Limited increase in the competition for land and other resources.
- Availability of labor and planting materials at the right time.
- Availability of market outlets and attractive profit margins for sheep/goats and their products.

Many approaches can be used to integrate forage legumes into the farming system. The major ones are:

- **Fodder banks:** Concentrated units of legumes usually planted near homesteads in order to ensure proper management and minimize misuse.
- **Use of forage legumes in crop mixtures:** Involves intercropping in the form of undersowing a cereal with a compatible legume at the right time. This practice has advantages of increasing the nutritive value and yield of the overall material harvested (grain, crop residue and legume).
- **Use of forage legumes in crop rotations:** Provides similar benefits to intercropping forage legumes in crop mixtures. Association of forage legumes in crop rotations has also been demonstrated to improve the nitrogen content of the soil, thereby benefiting future crop production.
- **Incorporation of tree legumes:** Forage tree legumes can be incorporated into the farming system in different forms. These include alley farming, as hedgerows, as a fence line along the homestead, along the borders of crop land and as fodder banks. Browse plants especially leucaena, glyricidia and sesbania need to be developed further for areas receiving good rains. In addition, new feed resources in rangelands should be identified and developed. The leaves of trees can be used as a high quality supplement to crop residues and grazing. Tree legumes such as glyricidia, erythrina and leucaena have great potential as sources of legume fodder, particularly as they are high-yielding perennials and possess deep-rooted systems that may have access to ground water and nutrients that may not be available to smaller leguminous plants.
- **Use of legumes with feed/food value:** Such a tree legume is pigeon pea *(Cajanus cajan)* with the pod serving as food and the leaves serving as animal feed.

Table 7.11. Composition of leguminous trees/shrubs.

Fodder Trees/shrubs	Protein	Fiber
Leucaena – leaves and shoots	22	20
Glircidia – leaves and shoots	23	21
Pigeon pea – leaves and shoots	23	30
Sesbania grandifloria – leaves and shoots	26.9	12.3
Calliandra – leaves/pods/stem less than 8 mm	36/17.9/29.1	

Supplementation with legume straw

Residues of food legume crops such as peas, beans, peanuts, etc., are relatively high in crude protein content and can serve as supplements.

Other **feedstuffs** *of supplementary value*

There are also feedstuffs other than those mentioned above that can be used as supplements. Examples of such supplements are:

- Brewery by-products that could be available to farmers in the vicinity of breweries. Local brewery by-products are also available in many areas.
- Poultry waste is a product that can be used as a supplement for sheep and goats, replacing other protein concentrates, in areas where intensive poultry production is practiced. There could be two types of poultry waste, namely:
  - Poultry litter: a product from poultry farms where birds are raised on floors. It contains poultry

droppings, bedding material and spilled poultry feed. Poultry litter is a product with 15–35% protein depending on the proportion of the above constituents. It is also characterized by its high ash content with substantial levels of calcium, phosphorus, potassium, magnesium, sulphur and copper. This product can thus serve as a good source of fermentable nitrogen and essential minerals to sheep and goats.

- Poultry excreta: obtained from poultry raised on cages. It is free from other constituents (bedding material and generally from spilt feed). As a result, it is higher in its nitrogen content than poultry litter. It can serve as a good supplement in the dry form.

Mineral supplementation

Figure 7.7. Local mineral lick being bagged for sale in the Rift Valley.

Very little is known about the mineral nutrition of sheep and goats in Ethiopia. The limited studies available indicate that clinical and sub-clinical mineral deficiencies are wide spread. It is, for example, known that there is widespread deficiency of sodium, phosphorus and copper in sheep and goats in the Ethiopian Rift Valley area. Mineral deficiencies can result in substantial reductions in performance of sheep and goats. Using plants at a young stage supplies the highest amount of minerals to the animal as mineral content of plants declines with maturity. Mineral supplementation can be done through the use of multi-nutrient blocks that contain the deficient minerals. Ideally, specially formulated mineral supplements are provided in the form of a mineral lick. Such a lick is manufactured in Awassa but it is not widely available in other parts of the country. Supplementation of common salt is widely practiced in many parts of Ethiopia. Salt supplementation is especially useful in hot areas where sheep and goats lose large amounts of salt through perspiration.

Farmers in many parts of the country use local mineral soils as mineral supplements. Supplementation of *Bole* to Arsi sheep resulted in higher gains than unsupplemented sheep and ranked similar to sheep supplemented with a commercial mineral lick. The licks were found to be good in their sodium and copper compositions. Encouraging farmers to regularly feed local mineral licks such as *Bole, megado*, etc., traditionally used in many parts of the country, is beneficial. Goats obtain higher amounts of minerals because they consume more browse and consume a wider array of vegetation than sheep.

7.9.2.2. Fodder conservation

The supply of feed fluctuates in most parts of the tropics. Preserving surplus feed in the wet season for use in the dry season is one method of making the supply of feed to livestock more evenly distributed throughout the year. Any surplus forage should be conserved for use during the dry season when feed supply is scarce and feed quality is poor. Hay- and silage-making are two main methods of preserving forages.

7.9.2.3. Effective utilization of crop residues

Generous feeding: Goats are the most selective feeders of all domestic ruminants. They are able to select the more nutritious leaf and leaf sheath components against the less nutritious stem. Offering crop residues to goats and sheep at a 50% refusal rate instead of the conventional 10–20% results in increased feed intake in terms of quality and quantity. This will lead to improved body weight gain.

Such a feeding strategy of allowing 50% refusal of the residue could be wasteful. The practice is justified only if the rejected straw could also be utilized by less selective ruminants like cattle or alternatively used for other purposes such as fuel, bedding, compost, soil mulch, etc.

Urea treatment: This is one method of improving the feeding value of roughages. It involves spraying a solution of urea onto dry roughage and covering it with locally available materials to create a sealed condition.

7.9.2.4. Proper exploitation of natural browse

The widespread traditional use of browse as an available source of quality feed during the dry season is vital to maintaining seasonal and yearly stability of livestock production in drier areas. Browse supplies goats with the bulk of their nutritive requirements and complements the diet of sheep with protein, vitamins and minerals. Foliage from trees and shrubs in pastoral areas provides more edible biomass than pasture.

Moreover, browse remains green and high in protein content when pastures become dry. Proper and strategic use of these feed resources as supplements during dry periods can help minimize seasonal fluctuation in productivity.

- Plant browse trees.
- Maintain the necessary balance of forage species by selective bush clearing.
- Feed browse either by trimming or lopping leaves and branches or by beating down the fruits or pods.

Acacia species, once mature, produce large quantities of protein-rich seed. Herders move their flocks to these areas during the dry season and feed their flocks on the pods. Herders use long poles to shake pods down from the trees for consumption by their animals. There is scope for storing these pods and using them as a supplement for weaners or for sheep and goats suckling twins. Pods are also a marketable commodity.

Figure 7.8. A herder using a long pole to shake the pods down from an Acacia tree.

Figure 7.9. Acacia pods.

7.9.2.5. Specific strategies for arid and semi-arid areas

Arid areas

Development strategies in arid zones should focus on preserving and improving productivity of the rangelands.

Rangeland improvement techniques include:

- Reduced stocking rates.
- Allowing range vegetation an opportunity for regrowth by:

  - ♦ controlled and deferred grazing, or
  - ♦ periodic resting.
- Providing extended and additional watering facilities for stock.
- Reseeding.
- Shrub planting.
- Controlling cultivation in areas unsuited for sustained crop production.
- Moving excess animals to areas of higher forage availability.
- Establishment of a monitoring system to better inform users where grazing is abundant or scarce would help pastoralists use rangelands more productively. This will also warn them of possible future feed shortages due to drought so that they can take steps to mitigate the potential impact of drought on their livelihoods. The following can help to do this:
  - ♦ Encourage locally managed and controlled land- and water-management systems.
  - ♦ Use of Geographic Information Systems (GIS) to improve management and monitor rangeland use and degradation.
- Give due attention to the development of high potential sites, such as river valleys, for feed production.

Semi-arid and sub-humid areas

The major task here is to improve the utilization of natural forages and crop residues and introduce more nutritious fodder and pasture crops.

Focus should be on:
- The planting and establishment of improved fodder crops, leguminous tree crops, pastures and especially forage crops that will provide more energy and/or protein.
- Use of chemical and mechanical interventions to improve the digestibility of crop residues and other low-quality roughages.
- Use of non-protein nitrogen, bypass protein (protein that is resistant to degradation in the rumen), and other protein supplements to correct dietary deficiencies and to improve protein utilization.
- Mineral supplementation to correct the major and minor mineral deficiencies of grazed forages, fodder crops, and crop residues.
- Use of improved methods of storing high protein or high energy feeds harvested in the wet season for consumption during the dry season.

Exercises / Points for Discussion

1. What feed resources are available in your area?
2. Do farmers supplement their animals? If yes,
   a. *With what?*
   b. *Are all animals supplemented indiscriminately?*
   c. *Targeted to specific categories?*
   d. *Are times of year and/or physiological state considered in supplementation?*
3. Describe the feeding practice in your area — Are there unique experiences you want to share?
   a. *What are the main feeding/nutrition related problems?*
   b. *What attempts have you made to improve the situation?*
   c. *What more will you do after this training?*
4. How is grazing land owned in your area?
   a. *Describe actual problems related to grazing in your kebele.*
   b. *Are there traditional arrangements that can and should be encouraged?*

Transferable Message

Utilization of communal grazing lands can be improved with know-how and cooperation.

1. Teach users of a communal grazing area about the need for collaboration in managing the communal grazing.
2. Show them the problems of the current system of management.
3. Show them options for better utilization.
4. Enquire about traditional practices of utilization and base your improvement proposals on these practices.

7.9.2.6. Improving poor quality roughages

Treatment of roughages

Sheep and goats in tropical environments will have to eat feeds that contain a lot of fiber during most parts of the year. The bulky and fibrous nature of coarse feeds results in poor nutrient supply and reduced intake.

Such feeds have to remain in the rumen for extended periods of time before they are sufficiently digested to move out of the rumen and allow more feed consumption. It is common for animals to lose weight and condition, produce less and even have difficulty breeding when fed on these low quality roughages.

One approach to improving the feeding value of poor quality roughages is through treatment. Treatment of roughages, either physically or chemically, is aimed at rendering the structural constituents more accessible to microbial digestive enzymes in the rumen.

Treatment methods

Physical treatment

The main objective of this method is to reduce the size of the roughage to expose more surface area for microbial degradation in the rumen. This involves hydration (soaking) and chopping.

Soaking coarse crop residues such as maize stover: Dryness increases time spent chewing per bolus and thus reduces total intake. Hydration has a potential to overcome these constraints. Soaking causes swelling of cell-wall structures, making them more accessible to cellulolytic microbes. In addition, it reduces the dustiness and dryness of the feed. Soaking per se has potential to overcome some of the constraints to intake of maize stover. The voluntary feed intake of chopped maize stover can be improved by 23% by just increasing moisture content from 30 to 60%. Results of work at Bako Research Center indicate that sheep performance improved from losing 54 g/head/day to gaining 21 g/head/day as a result of soaking. Supplementation with 5% linseed meal (fermentable nitrogen source) doubled the consumption of the stovers and resulted in a daily gain of 53 g/head/day.

Chopping: Chopped feed can be easily eaten. Chopping also minimizes selection and facilitates mixing with other feeds. Chopping some of the coarser green feeds such as elephant grass will also increase the amount eaten. Chopping can be done using a machete knife or by special manual or motor-driven choppers that are very efficient. Moistening chopped dry roughages can also improve utilization through increasing intake and digestibility.

a Chopping stover

b. Chopping fodder beet

c. Feeding chopped sweet potato tubers in the southern region

Figure 7.10. Chopping and feeding roughages.

Chemical treatment

Chemical methods are relatively efficient and easy to put into practice. The effects of chemical treatment include hydrolysis of chemical bonds that involve lignin. The chemicals used in treatment of roughages are mainly alkalis. The most effective alkali is sodium hydroxide or caustic soda. It is, however, not commonly used due to its high cost and risk of use.

The most common methods of chemical treatment use either ammonia or urea, which are relatively less effective but are cheaper and less hazardous to use. Moreover, treatment with ammonia or urea has the added advantage of improving the nitrogen content of the treated roughage. Treatment is recommended where roughage constitutes over half the diet or where higher levels of production are desired. The type of treatment will depend on local circumstances.

Ammonia treatment is suitable for large operations such as cooperatives in areas where there is a supply of anhydrous ammonia and where the necessary infrastructure of tankers is available for its distribution. The application of this treatment method will not be discussed in detail because of low applicability under present Ethiopian conditions. Urea treatment is more applicable for smaller quantities of roughage treated on small farms. Urea treatment of crop residues is being practiced in Ethiopia.

Ammonia treatment: Ammonia (anhydrous, gaseous) treatment requires a supply of industrially produced ammonia together with a distribution network. Factors for the success of ammonia treatment include:

- Amount of ammonia used: 2.5–3.5 kg per 100 kg DM of straw.
- Temperature and duration of the treatment: generally, a longer period of treatment is required at low temperatures and shorter period at higher temperatures.
- Moisture level: optimum moisture level for successful treatment is between 15 and 25%.
- Sealing: an air tight seal is required.
- Nature of the forage to be treated: low-digestible roughage.

Figure 7.11. Ammonia treatment from a tanker.

Figure 7.12. Baled straw waiting ammonia treatment.

Urea treatment: The fact that fertilizer-grade urea is available in many developing counties like Ethiopia makes it a preferred treatment technique for improving the nutritional quality of low-quality roughages (LQR) such as crop residues and agro-industrial by products, e.g., bagasse. The simplicity of its application is an added advantage of the technique.

Ammonia is released through urea degradation done by the action of micro-organisms. These micro-organisms are normal inhabitants of LQR that produce urease in the presence of moisture. With adequate moisture and suitable temperature, urea is degraded to ammonia which then permeates through the straw. Nitrogen released through this process is bound to the straw, thus increasing the total nitrogen content. Digestibility of the fibrous LQR is also increased by the action of the treatment.

Urea treatment of LQR improves the crude protein content, digestibility and intake of LQRs. The magnitude of improvement is shown in Table 7.12.

Table 7.12. Nutritive values of straw before and after urea treatment.

	Before	After
Crude protein	3–5%	7–10%
Digestibility	40–50%	45–55%
Intake		+20–40%

The most common recommended level of urea is 5 kg per 100 kg of material (5% urea measured on air-dry LQR). The moisture or water level in the LQR to be treated determines how much water should be added. It may range from 0.3 to 1 liter of water per kg straw with the minimum being applied in areas with water scarcity.

An appropriate level of water is necessary for effective urea treatment as well as packing of the material to exclude air. However, care should be taken to avoid use of excess water as it will lead to risk of mold growth and leaching of urea to the bottom of the pit or trench. Table 7.13 lists the recommended amount of water to be added to achieve a final moisture content of 30%.

Table 7.13. Recommended amount of water to be added to achieve a final moisture content of 30%.

Water to add (liter or kg per 100 kg of residue)	Initial dry matter of LQR (%)	Expected moisture content in the final treated material
23	85	30
30	90	30

With some experience, the initial dry matter content of LQR can be estimated by handling. A very dry material (i.e., 90 or 95% dry matter) is brittle and does not stick to the hands. Conversely, a wetter residue (i.e., 85% dry matter) feels a little sticky and moist. It also tends to bend rather than break easily.

The water to be added per 100 kg of roughage can alternatively be calculated using the following formula:

$$W\ to\ be\ added/100\,kg\ of\ R = \frac{Initial\ \%DM\ of\ R + weight\ of\ U}{100\,kg\ of\ R + W\ to\ be\ added} = \%\ of\ final\ DM\ to\ be\ achieved$$

Where,

W = water
R = roughage
DM = dry matter
U = urea

For example, if:

1. Initial dry matter of roughage = 94%;
2. Final moisture content to be achieved = 50%
3. Urea level = 5%

Then, the amount of water to be added (W) is calculated as:

$W = (94 + 5) / (100 + 5 + W) = 0.50$
$W = (99)/105 + W = 50/100$
$W = 99 \times 100 = 50(105+W)$
W = 93 liters of water

Exercise

Calculate the amount of water needed for urea treatment using the following information:

1. Initial dry matter of roughage = 94%;
2. Final moisture content to be achieved = 40%
3. Urea solution used for treatment = 4%

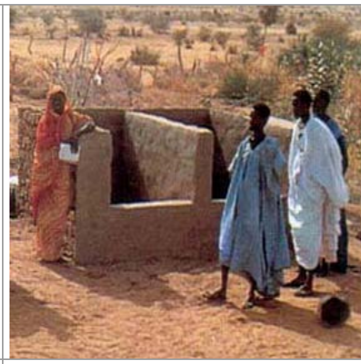
Urea is weighed and dissolved in a measured quantity of water according to Table 7.12. A hanging scale can be used to weigh the urea, and a measuring cylinder or any locally available material can be used to measure water.

Urea is added to the LQR by first mixing the weighed amount of urea in the water to be added. The urea-water solution is then sprinkled on the residue as it is added to the pit in different batches. A good way of doing this is to add 10 kg of residue and then sprinkle the appropriate amount of urea-water solution (this would be 2.3 liters for 10 kg of straw with an initial dry matter concentration of 85%, or 3 liters for dry matter content of 90 %).

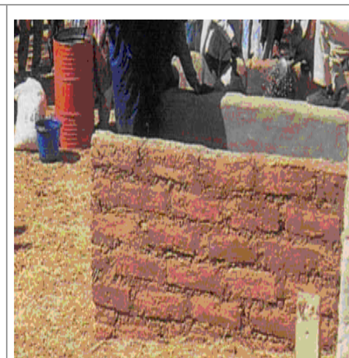
After each batch of LQR and urea-water solution is added to the pit, there should be thorough mixing with a stirring rod/stick or by hand so that the solution is uniformly spread on to the LQR to be treated. This can be done in the pit or on a plastic sheet on the ground prior to packing in the pit.

There are many different designs of pits or trenches for urea treatment. A common recommendation is 1 m wide, at least 2 m long and 1 m deep (Figure 7.13a). A 1 × 2 × 1 m pit will typically hold between 150 and 200 kg of common LQR, with the top of the pile being at or slightly above ground level.

a. An empty 1 × 2 × 1 m pit



b. Above-ground pits



c. Above-ground pit made of bricks

Figure 7.13. Types of pits for urea treatment.

a. Pit lined with *Enset* leaves

b. Pit with grass lining

c. Pit with plastic lining, mixing sprinkled straw

Figure 7.14. Pits with different lining materials.

Figure 7.15. Treatment of traditional stacks and bales of roughage.

The pit should not allow air or rain water to enter the LQR being treated. Therefore, the pit is typically lined with material such as heavy plastic.

A concrete pit, placed above ground, lined with plastic will produce a good result. But concrete, bricks, and plastic may not be available or may be too expensive, in which case, other alternatives can be used. For example, Figure 7.14a shows lining a pit with *Enset* leaves, green ones nearest to the sides of the pit and dried leaves on top, closest to the treated material. In fact, except for the shape, the pit is similar to that normally used in *'kocho'* fermentation. Depending upon availability, banana leaves or bamboo leaves could also be used. In areas with more rain, stacks can be placed against a wall or, as is seen in India, a fine meshed wire such as chicken wire can be used to contain the straw. The treated residue should be packed (Figure 7.16).

It is useful to construct more than one adjacent pit so that treated LQR from one pit can be used while the next pit is being treated. This helps to ensure a continuous supply of treated residue for feeding.

Apart from pits or trenches, plastic bags (Figure 7.16b) that can hold 20–25 kg of treated straw may be used. Such bags have an advantage in that individual bags can be opened when they are actually needed to feed animals.

An airtight condition is easily achieved by applying a plastic cover. When straw is stacked against firm structures (walls, inside pits, meshed wire), it can be compacted by trampling. Wet straw compacts better and will not allow air to enter. Chopping LQR such as maize and sorghum stover before treatment helps better compaction and treatment.

a. Packing *teff* straw mixed with urea-water solution in a pit lined with heavy plastic

b. Packing treated straw in a plastic bag

Figure 7.16. Packing treated straw to remove air.

After sealing the pit with plastic or other locally available material such as green leaves, placing soil over the pit will aid in packing and ensuring that rain water does not enter the treated LQR. Construction of a shade over the pit will further prevent entry of rain water into the pit in high-rainfall areas (Figure 7.17).

Figure 7.17. A shade over urea-treatment pit.

A number of factors influence the length of time needed for most effective urea treatment. One of the most important is outside temperature. Higher temperatures lessen the length of time needed, and cooler temperatures increase the length of time required. Because longer treatment times than necessary do not have adverse effects, it is commonly recommended that the pit remain closed for at least 3 weeks, and preferably 1 month.

Figure 7.18. Treated straw (left) and untreated straw (right).

The effectiveness of the urea treatment process can be evaluated using the following physical measures.

Color: Well-treated roughages will have a uniform, dark-brown color throughout the treated material (Figure 7.18). Dark areas indicate over-dosage while lighter color indicates under-dosage of the urea solution. Non-uniform coloration is a result of the urea solution not spread uniformly during mixing and packing the treated material.

Smell: A strong pungent smell of ammonia should be present when the sealed material is opened. Absence or lack of such odor, a weak smell or presence of a moldy smell indicates poor treatment. The presence of the ammonia smell doesn't generally repulse animals especially if they are used to it.

Texture: Well-treated roughage is soft. A wide variation in texture indicates non-uniform treatment.

Absence of mold: Mold doesn't develop in a well-sealed environment of ammonia. Absence of mold is an indicator of good treatment.

When feeding urea-treated LQR, the pit should be opened from one side as necessary to remove the needed amount of residue. The remaining part should remain closed. This prevents air from entering to minimize chances for spoilage. It is best to open the pit as seldom as possible, such as no more than once per day.

The treated LQR will be higher in digestibility and crude protein than the untreated material. Therefore, some farmers will feed urea-treated LQR to their animals with the highest nutritional requirements, such as lactating or fattening animals. Other farmers will feed limited amounts of the treated LQR as a supplement, with the remainder of diets being untreated LQR or grazed forage.

An adaptation period may be needed for animals that have not previously consumed urea-treated LQR. This allows them to become familiar with the feedstuff and, in particular, with the ammonia odor. The level of treated LQR being fed can be gradually increased over a period of 1–2 weeks, perhaps being mixed with feedstuff previously being given. Adaptation will be most rapid when animals are given little choice. Such an adaptation period is also a good idea when adapting ruminants to any diet containing non-protein nitrogen, although this is rarely a concern for crop residues properly treated with urea. In some cases, residual ammonia might lower intake. In such circumstances, the treated straw should be aerated for a few hours or overnight before feeding to allow the ammonia odor to disappear.

By treating with urea, animal performance can be increased or a greater number of animals can be fed with the same level of performance (i.e., growth or milk production). Animals fed urea-treated LQR may require no supplemental concentrate or will need lower levels to achieve a desired level of animal performance compared with animals fed untreated LQR. Feeding urea-treated LQR alone will lead to some increase in production, but the full potential will only be realized when the correct supplements are added. A supplement of bypass protein such as cottonseed cake or *nougseed* cake is required for high performance.

There has to be a good economic reason for a farmer to feed treated straw, and the effect has to be visible. For these reasons straw treatment has been most successfully undertaken when fed to responsive animals as a basal diet, for example, in fattening programs. The following points require attention to promote this technology.

- The cost of sealing the pit can be reduced by using cheap local materials to create the required airtight conditions.
- Strategic feeding of treated residues (e.g., to pregnant and milking animals) should be encouraged.
- Adequate explanation and demonstration is necessary.
- Adaptation to local conditions should be made; e.g., use of local measurements for the amount of urea and residue to be treated.

The treatment of crop residues can be done any time as long as the residue, water and urea required for the treatment are available. The best period recommended, however, is just after harvest, because:

- water and forage supplies are still available at this time;
- the farmer has ready cash for purchasing the urea and the time to do the treatment: a family of 4 can treat about 1 ton of straw in 4 hours;
- the treatment operation can be carried out whilst the traditional stack is being constructed; and
- the weather is conducive.

Exercises / Points for discussion

Have you previously tried to demonstrate urea treatment of roughages to farmers in your *kebele*?

1. If yes, what is your experience?
2. If not, why?

Transferable Messages

Urea treatment of roughages improves poor quality roughages and sheep and goat performance.

1. Select 5 model farmers from different areas in your *keblele* and convince them about the value of treating low-quality roughages with urea.
2. Demonstrate urea treatment to the model farmers.
3. Ask the model framers to treat roughage at their farms following the demonstrated procedures.
4. After one month, organize a demonstration for other farmers at each of the model farms on the procedures of treating and using treated roughages to feed sheep and goats.

Supplementation using urea and molasses

Reasons for using urea and molasses

The micro-organisms in the rumen synthesize enough protein to meet maintenance requirements of ruminants provided there is sufficient nitrogen and energy available in the rumen for their growth and development. Urea is a non-protein nitrogen (NPN) product which can be used as a nitrogen source when transformed to ammonia by the micro-organisms in the rumen. Molasses, which is an excellent carrier for urea, can be the supplementary energy source.

The nitrogen from urea is used by rumen microbes to make protein known as microbial protein, which is later utilized by the host ruminant when the microbes are digested by the ruminant in the small intestine. The microbes also require sulphur (S) to use nitrogen efficiently. It is not necessary to add sulphur where high levels of molasses are fed because of the sufficient level of sulphur in molasses. Supplements based on a low-cost mixture of molasses and urea were developed and used in different countries for this reason.

Methods of feeding urea supplements

Methods of feeding urea have primarily been concerned with providing it in sufficient quantities to be of value to the animal, and at the same time reducing the risk of mortality from urea toxicity. The following guidelines should be followed for use of urea in sheep and goat diets.

Table 7.14. A typical basic liquid mixture of urea and molasses.

Ingredients	Parts by weight
Urea	1
Water	10
Molasses	10

- Do not include urea at more than 1% of the total diet or 3% of the concentrate portion.
- Do not use urea in creep diets because of reduced intake of creep diet or potential urea toxicity.
- Introduce urea into the diet gradually over a two- to three-week period.
- Feed urea-containing diets at regular intervals for efficient utilization.

Urea can be supplemented to sheep and goats in different forms. Some of these methods are described below.

Urea supplement as a liquid in troughs

This involves feeding urea and molasses in troughs placed in the grazing area. This is a cheap and simple method of feeding urea that requires low labor. It involves use of a roller-drum lick feeder. Urea intake is regulated by changing the concentrations of the components of the mix. A typical basic liquid mixture is shown in Table 7.14.

Roller drums like that shown in Figure 7.19 can be used for cattle. For sheep, a type of wooden float has been developed for use with troughs, as sheep are unable to rotate the large drums. Some farmers have developed a very light small drum for sheep with apparently successful results.

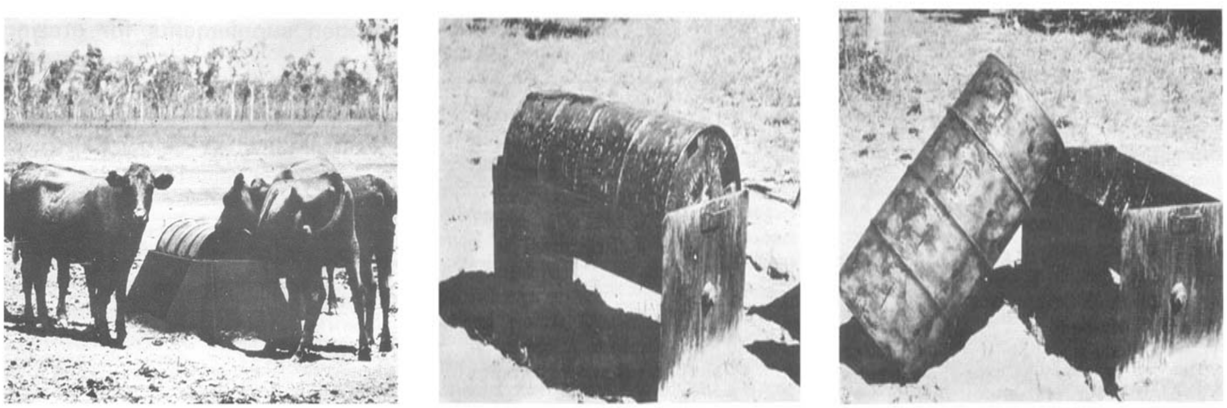


Figure 7.19. Cattle licking a roller drum.

Urea supplement as a block lick

Mixtures of liquid molasses and urea, which provide fermentable nitrogen, and are a good source of minerals, have been used for many years. Molasses in the liquid form is difficult to transport (requiring expensive tanker trucks), to store (requiring storage tanks), to handle (is highly viscous) and to distribute to animals (troughs or other receptacles needed). The "solidification" of molasses is a way of solving the difficulties encountered in distributing and feeding molasses and also allows for the incorporation of various other ingredients.

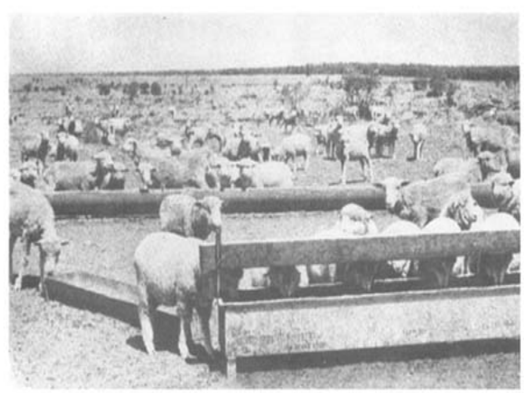


Figure 7.20. A lick-feeder for sheep that has a slatted wooden float on the surfaces of the liquid in a trough.

As the name suggests, these are lick blocks that contain urea, molasses, vitamins, minerals and perhaps other nutrients. The feeding of the blocks is a convenient and inexpensive method of providing a range of nutrients, which may be deficient in the diet, that are required by both the rumen microbes and the animal. The ingredients are designed to provide a wide rage of nutrients to cover all potential deficiencies.

Urea molasses blocks (UMB) have proven to be an excellent tool for the improvement of ruminant feeding. They are cheap, relatively safe and a practical means of supplying nutrients. They create an efficient rumen ecosystem which favors the growth of young animals and milk production. They also improve conception rates and the size of offspring. The urea molasses block technology should be encouraged in Ethiopia to make better use of available feed resources at the small farmer level.

The common ingredients used in making feed blocks are:

- Molasses
- Urea
- Fibrous feeds such as wheat bran
- Salt
- Cement (a binding agent).

Molasses is used to induce animals to eat the block drawn by its sweet taste. It also provides energy and some other nutrients such as minerals like sulphur. The block should not contain more than 40–50% molasses or it will break too easily and take too long to dry.

Urea, known to farmers as fertilizer for crop production, is used to make the blocks. It is advisable that the amount of urea be limited to 10% to avoid poisoning. Urea is essential in improving digestibility and providing protein. Cereal bran is the most common fibrous feed used. The bran provides protein and helps hold the block together. Finely chopped straw, bagasse, or finely ground leaves from leguminous shrubs (*leucaena*, *calliandra*, etc.) can substitute for cereal bran.


Urea


Molasses


Wheat bran

Figure 7.21. The major ingredients.

Salt in the range of 5–10% is added to the blocks to supply minerals and to control the rate of consumption. Calcium carbonate and dicalcium phosphate can be added to provide additional calcium and phosphorus.

Cement is used to make the block hard. About 10–15% is sufficient. Higher levels make the blocks too hard. Cement also provides calcium. Clay such as that used in brick-making can be mixed with cement to improve block hardness and reduce drying time. It can also reduce cost of making the block.

Other ingredients can be added to provide additional nutrients. Oilseed cakes or brewery by-products can be added to supply protein. Trace mineralized salt can be used to provide additional minerals that may be lacking. Use of trace mineralized salt is recommended in the Rift Valley area. Alternative ratios of combining ingredients to constitute various formulations of blocks are shown in Table 7.15.

Table 7.15. Practical examples of formulae for making urea molasses blocks (composition in %).

Ingredients	Alternative Formulae												
	A	B	C	D	E	F	G	H	I	J	K	L	M
Wheat bran	25	25	27	35	40	40	23	25	23	25	25	35	22
Molasses	40	50	10	20	10	5	50	45	50	31	34	39	50
Urea	10	10	8	8	10	10	5	15	10	10	10	10	9
Salt	4	5	5	8	5	5	5	5	5	3	3	5	5
Quick lime		5	5	5	7	7	5	0	10			6	
Cement	10	5	10	5	5	10	10	10	10	15	15	5	14
Triple phosphate							2	0	2				
Dicalcium phosphate	1		5		3	3				3			
Oilseed cake			15							13	13		
Clay				20	20	20							
Total	100	100	100	100	100	100	100	100	100	100	100	100	100

How to make urea molasses blocks

Urea molasses blocks (UMB) can be manufactured on the farm. Manufacture is easy and simple and different processes exist which may be used according to local conditions. The manufacturing can be divided into four stages:

1. Preparing the components
2. Mixing
3. Molding
4. Drying

Preparing the components

The amount of the different ingredients depends on the size of the block to be manufactured and the formula to be used. Table 7.16 shows the amount of ingredients to be mixed to make 1, 5, 15 or 25 kg of block based on formula alternative "A" in Table 7.15.

Table 7.16. Amounts of ingredients to mix to make different sizes of UMB.

No.	Ingredient	%	Size of block to be made			
			1 kg	5 kg	15 kg	25 kg
1	Molasses	40	400 g	2 kg	6 kg	10 kg
2	Urea	10	100 g	0.5 kg	1.5 kg	2.5 kg
3	Bran	25	250 g	1.25 kg	3.75 kg	6.25 kg
4	Cement	10	100 g	0.5 kg	1.5 kg	2.5 kg
5	Oil cake	10	100 g	0.5 kg	1.5 kg	2.5 kg
6	Mineral mix	1	10 g	0.05 kg	0.15 kg	0.25 kg
7	Salt	4	40 g	0.2 kg	0.6 kg	1 kg
	Total	100	1,000 g	5,000 g	15,000 g	25,000 g
8	Water (to mix the cement)		40 g	0.2 kg	0.6 kg	1 kg

Mixing

Good mixing is crucial for good block-making. Urea must be mixed thoroughly by breaking up lumps to avoid pockets of high concentration that could harm animals. Do the following to mix the ingredients.

- Weigh the amount of ingredients needed based on the formula of the block.
- Add urea to the molasses while continuously mixing.

- ♦ Mix the urea with molasses thoroughly by stirring for about 20 minutes.
- ♦ The molasses can be heated in the sun to improve handling and mixing.
- ♦ Never add water to molasses. It has to be thick.

- Add bran and any other fibrous material such as *nougseed* cake, if it is part of the formula, and mix thoroughly.
- Make the cement into a paste with water prior to adding to the rest of the ingredients.
- Mixing the salt with cement accelerates hardening.

High levels of molasses and urea tend to decrease block hardness. Check block hardness after drying and make the following adjustments to the formula.

If the block is too hard, reduce the proportion of cement or clay and slightly increase the proportion of molasses. If too soft, increase cement or clay and reduce molasses.

Figure 7.22. Mixing urea, molasses and bran.

Casting and molding

Once the ingredients are thoroughly mixed, place the mixture into molds. Any local container, such as tin cans or small buckets can be used as a mold. Using a plastic sheet to line the molds will make block removal from the mold easier.

Wooden mold – Debre Zeit Research Center

PVC tube mold – Debre Zeit Research Center

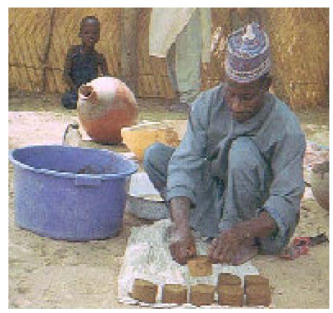
Mold made of metal sheets – Holeta Research Center

Machine for making solid construction blocks

Figure 7.23. Different types of molds.

Molding using wooden bars

Molding using small tin cans



Removing molded blocks for drying

Figure 7.24. Molding urea molasses blocks.

Example of steps of molding urea molasses blocks using sheet metal molds

The mold

Step 1. Filling the mold

Step 2. Compacting

Step 3. Opening the mold

Step 4. Removing block from the mold

Step 5. UMB ready for drying

Figure 7.25. Steps of molding urea molasses blocks using sheet metal molds.

Drying and storage of urea molasses blocks

Remove the blocks from the molds after 24 hours and place on racks to dry. Leave the blocks to dry for at least 5 days depending upon the weather condition.

Figure 7.26. Drying urea molasses blocks.

Characteristics of a good urea molasses block

A block is considered good when it fulfils the following:

- Ingredients are well-distributed throughout the block.
- It does not have lumps of urea and lime.
- It is hard enough to resist being squashed between fingers or breaking when a person steps on it.
- The sticky molasses can be felt when holding the block. The amount of molasses needs to be increased if the block doesn't feel sticky.

Feeding and intake of urea molasses blocks

Blocks should be fed as a lick so that only the top surface is accessible to animals. This prevents animals from pushing the blocks around, breaking them up and consuming large chunks that could cause urea toxicity.

Figure 7.27. Sheep licking urea molasses blocks (Technique being used by farmers after demonstration by ESGPIP trained *Kebele* Development Agents.

Blocks should be introduced to animals slowly and should be fed after animals have consumed adequate forage. This prevents animals from consuming too much at any one time. **Urea molasses blocks should never form the main diet.** They are meant to be a supplement to a basal diet of forage. Allow access by animals for one hour per day during the first week of adaptation, two hours during the second week and free access after the third week. Some animals may need to be forced to consume the blocks by preventing access to lush feed other than dry roughage during the adaptation period.

Block hardness will affect its rate of intake. If too soft, it is consumed too rapidly and there is the risk of toxicity. If too hard, intake may be too little. Urea at high levels is unpalatable. High levels of urea in urea molasses blocks may reduce intake of the block as well as of straw due to the bitter taste.

High levels or imbalances in minerals may result in excessive consumption in a short time, also leading to urea poisoning. Precautions should be taken to avoid this problem of over-consumption in drought-prone areas, particularly towards the end of the dry season when feed is scarce.

Precautions while supplementing with urea molasses blocks

It is essential to note the following while supplementing urea molasses blocks.

- Feed to **ruminants only** (sheep, goats, cattle, camels).
  - ♦ Do not feed to monogastrics, i.e., horses, donkeys, or pigs.
  - ♦ Do not feed to young ruminants less than six months of age (lambs, kids).
- Blocks should be used as a supplement and not as the basic ration.
  - ♦ A minimum of coarse forage in the rumen is essential.
  - ♦ Never give blocks to an emaciated animal with an empty stomach. There is the risk of poisoning

due to excessive consumption.

- The amount of blocks fed to sheep and goats should be limited to 100 g/day.
- Blocks should never be supplied in ground form or dissolved in water as this can result in over-consumption.
- Supply sufficient amount of water.

Transferable Messages

In *kebeles* where ingredients for making urea molasses blocks (UMB) are available, making and using UMB supplementation improves performance of sheep and goats.

1. Demonstrate to farmers on how to make and use UMB.
2. Demonstrate to small-farm urban/peri-urban youth on how to manufacture and supply UMB to farmers as a business venture.

7.10. Strategies for Sheep and Goat Feeding and Management during Drought

Many parts of Ethiopia experience extended periods of drought, leading to shortages of fodder and water. During these periods, sheep and goats are unable to meet their nutrient needs for maintenance and will begin to lose weight as body reserves are depleted. As this happens, the females do not come into heat and so do not breed. Those already pregnant will produce very weak lambs and kids. During very long dry spells animals will die, with the youngest, weakest and oldest dying first.

In most cases, no single strategy will be sufficient to solve this problem. Each situation will require a unique set of strategies. Some common options are discussed below. The options to employ and their degree of implementation depend on the prevailing circumstances.

7.10.1. Selling stock

This option should almost always be the first measure taken in the early period of drought. As the drought progresses, stock should be sold by class, starting with finished young stock, then replacement stock, aged stock and older breeders, until a nucleus of healthy, young, sound, breeding females — most valuable for restocking when the drought ends — remains.

The timing of selling stock and the condition of the stock at sale are important considerations. Prices received are likely to be better if stock is sold early in the drought before the market becomes congested with a high supply of animals. Stock should be in reasonable condition to fetch higher prices. This strategy is more effective for prolonged droughts.

Selling only a small percentage of stock may be necessary during short droughts. This will normally be compensated by increased performance per animal of the remaining stock as a result of reduced stocking rate.

7.10.2. Supplementation

Supplementary feed can be provided only if it is available in drought-stricken areas. This usually means that the transport of feed into these areas must be organized by the government or an aid program. Concentrates are preferred to roughages for drought feeding because of higher nutrient density.

7.10.3. Maintenance feeding

In a short drought, maintenance feeding is likely to be a low-cost strategy. However, maintenance feeding can be expensive if the drought is prolonged. This strategy is more successful if implemented in association with reduction of animal numbers before commencing feeding.

Protein-rich concentrates, enough to satisfy about half of the animals' maintenance requirements, should be given provided that there is still some poor quality vegetation available. If the drought worsens, the complete maintenance requirement will have to be fed by means of supplementary feed. If the protein content of the available concentrate is low, it may be necessary to feed a protein supplement such as urea at the rate of a few grams per day. Oilseed cake has been demonstrated to be especially useful for stimulating roughage consumption during a drought. When a limited quantity of supplement is available, it should be supplied to those members of the flock that are most needy.

7.10.4. Humane destruction

Humane destruction of livestock is another strategy which may be applicable at times of very low livestock prices, or when animals are unfit to be transported. Humane destruction should be carried out when animals are approaching a condition too poor to survive. Decreasing competition for feed will help the remaining animals to stay in better condition and be more productive following the drought.

7.10.5. Adjusting grazing strategies during drought

Below is a list of strategies to help producers avoid crisis in times of drought. It is best to assess options at the first sign of drought.

- Adjust stocking rate to the carrying capacity of dry years. Reduce stocking rate early. Increase stocking rate gradually after the drought, over a period of 1–3 years.
- Graze areas with limited water reserves first.
- Rest pastures or delay grazing in all pastures periodically. Lengthen pasture rest periods during slow or no growth times. Plants can withstand severe grazing if followed by proper rest periods. These rest periods allow plants time to replenish tissues above and below the ground.
- Maintain emergency pastures that can be used during emergencies.

7.10.6. Adjustment of animal management

The following changes in animal management are useful to improve utilization of feed resources during drought.

Parasite control: Animals under nutritional and heat stress are less resistant to parasites than under normal conditions. Strategic deworming during a drought will relieve some of the nutritional stress on the animal and "clean up" the herd for the next favorable season.

Herd segregation: Young animals are not able to compete with mature ones for pasture or supplemental feed. Drought feed is costly and it is important to feed only those animals that really need it. Vulnerable classes can be segregated and given preferential treatment. The older, dry animals can be moved to poorer pasture or range areas.

7.10.7. Early weaning and creep feeding

Creep feeding: Creep feeding is simply providing supplemental feed separately to young animals while they are still suckling. Creep rations should contain 12–13 MJ/kg of metabolisable energy with a protein content of between 13 and 16% depending on the protein levels in the forage.

Early weaning: Grazing forages decline rapidly in quality and quantity during droughts. Early weaning and disposal of weaned lambs/kids during drought periods will help reduce pasture requirements and help breeding animals maintain their body condition. This is critical in improving conception rates.

7.11. Cactus (*Opuntia* spp.) as an Emergency Feed Resource in Arid Areas

7.11.1. Characteristics of cactus

Getting appropriate plant species to grow in arid areas is a permanent concern. Cactus is such a plant that can play this role. Cacti are more efficient than grasses or legumes in converting water to dry matter due to their specialized photosynthetic mechanism. Cactus plantations create living fodder banks to feed animals during drought and to combat desertification. The increased importance of cacti in arid zones is because of their ability to:

- be relatively drought-resistant, survive and remain succulent during long droughts;
- produce large quantities of fodder during the rainy season, which can be utilized during the dry season;
- have a high carrying capacity;
- supply succulent fodder to animals during droughts;
- tolerate severe utilization and have high recovery ability;
- have low establishment and maintenance costs;
- tolerate a wide range of soil and climatic conditions, so that they can be planted where the production of ordinary fodder crops is uncertain;
- produce forage, fruit, and other useful products; and
- prevent long-term degradation of ecologically weak environments.

Figure 7.28. Spineless cactus varieties.

Cactus fruits are consumed by humans as an emergency food during food shortage periods. This is a widespread practice in many parts of Tigray and some parts of Hararghe. *Opuntia* cladodes (young leaves) behave like common forage crops and have the following characteristics:

- They have high contents of water (90%), ash (20%) and calcium (1.4%), soluble carbohydrates and vitamin A.
- They are poor in crude protein (4%), fiber (10%) and phosphorus (0.2%).
- Their digestibility is comparable to a good forage crop, with average digestibility ranging from 60 to 70% for organic matter, 35–70% for crude protein and 40–50% for crude fiber.
- Cactus cladodes are highly palatable, with average daily consumptions of 6–9 kg for sheep and goats. Cactus intake does not reduce intake of fibrous feed. Cactus consumption improves rumen conditions which enhances the intake of fibrous feed.
- The high moisture content of cactus cladodes helps mitigate the problem of animal watering in

dry areas. Research clearly shows that water intake is nil when daily cactus intake by sheep is about 300 g of dry matter.

- Feed values of spiny or spineless cactus are similar. Spines are not a limiting factor because they can be removed.
- Cactus, fed in any form during an emergency, will keep animals alive.

As a consequence of its composition and other characteristics, the following should be observed when feeding cactus:

- Cactus should be supplemented with an appropriate and cheap nitrogen source. Moreover, a special mineral supplement is required to provide sufficient sulphur and phosphorus to maintain an appropriate Calcium to Phosphorus ratio.
- Cactus is rich in soluble carbohydrates and Ca, but poor in P. Therefore, it is recommended to:
    - limit the amount of grain and molasses in the diet to avoid decreasing rumen cellulolytic activity, and
    - feed animals with fibrous feeds (straw, hay, etc.) before giving the cactus.

a. Manual chopping of cactus (Tunisia).

b. Small electrical chopper (Brazil)

Figure 7.29. Chopping *Opuntia* pads.

7.11.2. Some practical considerations

Spines: The spines from spiny varieties of cactus can be removed through burning individual pads or chopping large pads using tools and machines. In some countries like Mexico and the USA, the whole standing plant is burned before grazing.

Laxative effects: A laxative effect appears when the volume of cactus in the diet is high (more than 50–60% of the DM intake). This problem is easily solved by feeding small amounts of straw or hay prior to cactus distribution; this is sufficient for normal transit.

Different varieties are available for use. For best results, some cactus varieties, such as *Opuntia* pads, need to be chopped before feeding to animals.

7.12. Feeding Different Classes of Small Ruminants

Little information is available on the nutrient requirements of animals at various physiological states under tropical conditions. The amounts of energy and protein or amino acids supplied to the animal determine productivity. Both energy and protein must be supplied in sufficient quantities and balanced to meet requirements and optimize feed utilization. Energy in ruminants is largely supplied by volatile fatty acids (VFA) that arise from the rumen fermentation of all types of organic matter, though the majority comes from carbohydrates. The principal way of increasing VFA energy is to increase intake and/or the rumen degradability. This can be accomplished by supplementation with a nitrogen source or, in the case of poor quality roughages, urea treatment.

Table 7.17. The first limiting nutrients for different physiological functions of sheep and goats.

Physiological function	Limiting nutrients
Growth (lean tissue)	Amino acids
Growth (fattening)	Energy, amino acids
Puberty (egg and sperm production)	Energy, amino acids
Pregnancy	Energy, amino acids
Lactation	Energy, amino acids

7.12.1. Productive functions and the need for supplementary nutrients

Growth: Growing animals have a very high requirement for amino acids for tissue synthesis. High growth rates cannot be supported by the products of fermentative digestion alone. Bypass protein supplements are essential.

Reproduction: The growth of the fetus has little effect on the dam's protein and energy demand until the last third of gestation when most fetal tissues are formed. It appears that rumen function, even on diets of low digestibility, can support the birth of a viable offspring of normal weight. Urea supplementation can enhance milk production to a level that ensures survival of the offspring. But to allow the young animal to grow, milk yield must be further stimulated by feeding a bypass protein source.

Milk production: The major constraint to milk production from diets based on crop residues and agro-industrial by-products is the availability of nutrients to provide the glucose for lactose (milk sugar) synthesis. A dietary source of lipid can reduce any imbalance caused by relative deficiencies of glucogenic energy in the end-products of rumen digestion. For many feeding systems in the tropics, the level of fat in the diet could be a primary constraint to milk production.

7.12.2. Feeding different classes of animals

A balanced feeding program for sheep and goats should contain forages, hay, grains, browse and shrub plants and a source of bypass protein. Keep the following points in mind while feeding different classes of animals.

- Balance feed availability and number of animals kept.
  - ♦ Adjust the number of animals to the level of feed.
  - ♦ Produce more feed to meet requirements.
- A ration that is modified whenever necessary to meet the changing requirements of animals during different stages of the reproductive cycle is usually more economical.
- The amount of feed supplied should be accurately adjusted to the requirements of the animal so that feed is not wasted by feeding more than the animal needs.
- Feeds of similar nutritive values/properties can be interchanged based on prices in order to obtain each essential nutrient from the cheapest available source.

Experience and observation will show what feeds animals like and how much they will eat. Some guidelines for feeding different groups of animals are indicated below.

- **Adult breeding males:** Adult males used for breeding need to be well-fed to maintain their body condition for mating. Breeding males need to be supplemented beginning two weeks before start of breeding. They shouldn't, however, be allowed to become too fat. Breeding males need to be supplied with plenty of water and allowed to exercise. Supply of good pasture is enough when not being used for mating. Feed as follows starting two weeks before and during breeding season:

- ♦ Grass/crop residues, free choice (as much as they can consume).
- ♦ Supplement legumes, up to 1 part for every 4–6 parts of grass/residue consumed.
- ♦ Alternatively, supplement a handful (about 250 grams) of concentrate containing, for example, 49% bran, 49% *nougseed* cake, 1% limestone and 1% salt. The allowance should be higher (400–600 g) if the male is large and is serving a large number of females.

- **Dry breeding females:** A dry female that has recently been weaned from her lambs/kids can be maintained on good quality pasture or fed good quality hay depending on her physical condition at weaning. Very thin animals that are adversely affected by the stress of lactation (especially those that gave birth to twins or triplets) need supplementation in addition to forage for adequate preparation for the next breeding and conception. Thin breeding females should be flushed before breeding. Flushing is the practice of feeding the ewe/doe so that she starts to gain weight about two weeks before breeding. Flushing may increase lambing percentage and embryo survival. Flushing can also reduce mortality of offspring. Flushing works best on females in poor body condition.
- **Young, replacement females:** Young females selected for breeding need extra feed for growth so that they will be large enough and in good shape for breeding. They should be fed as follows:
  - ♦ Grass/crop residue, free choice.
  - ♦ Supplement legumes, up to 1 part for every 3 parts of grass/residue consumed.
  - ♦ Supplement a handful (250–300 g) of a mixed concentrate containing, for example, 49% bran, 49% *nougseed* cake, 1% limestone and 1% salt.
- **Pregnant females:** Pregnant females need feed to support the growth of the fetus. They shouldn't be fed to become too fat. Females that are too fat will have trouble lambing/kidding.
  - ♦ Females in early pregnancy should receive:
    - o Grass/crop residue, free choice.
    - o One part legume for every 3 parts grass/residue.
    - o A handful of concentrate, 200 g/head/day mixed concentrate containing, for example, 49% bran, 49% *nougseed* cake, 1% limestone and 1% salt or 500 g of wheat bran.
  - ♦ **Females in late pregnancy (2–3 weeks before the due date):** This is by far the most critical period during which correct feeding is important as the fetus grows fastest at this stage of development. They should receive:
    - o Free access to good pasture and other roughage.
    - o One part legume for every 3 parts grass/residue.
    - o Concentrate, 250–400 g/head/day mixed concentrate containing, for example, 49% bran, 49% *nougseed* cake, 1% limestone and 1% salt or 1 kg wheat bran depending on condition of the animal.
- **Lactating females:** The requirement of these classes of animals is similar to females in late pregnancy. Their rations should generally contain 14–16% crude protein. They have high requirements for milk production. They should receive:
  - ♦ Grass/crop residue, free choice.
  - ♦ One part legume for every 3 parts grass/residue.
  - ♦ Concentrate: 250–300 g/head/day mixed concentrate containing, for example, 49% bran, 49% *nougseed* cake, 1% limestone and 1% salt or 1 kg wheat bran. The level of concentrate should be higher for high milk producers. An allowance of concentrates at the rate of one third of the amount of milk produced is necessary.
- **Young lambs/kids before weaning:** Newborn lambs and kids should be supplied with colostrum within the first hour after birth. Colostrum helps protect them against diseases due to its content of

antibodies and high nutritional value. For the first few weeks of life, all a lamb/kid needs for nourishment is its mother's milk. Hay, water and protein supplements should be placed near the lambs/kids so that they start to eat and drink. Young ones can begin to consume other feeds at about six weeks of age. They should be fed the best quality feeds available to help them grow and get them accustomed to eating feeds other than milk. The feed needs to be of high quality because they can eat only small amounts. They should receive:

- ♦ High quality young forage, free choice.
- ♦ Supplementary legumes as much as are available.
- ♦ Free choice supply of concentrate. The concentrate should be fed in creep feeders so that only the lambs/kids can consume it. This prevents the adult animals from eating the feed intended for the young animals.


A simple creep feeder used by farmers around Ambo (on-farm trial supported by the ESGPIP)

Lambs eating a supplement in the creep while the dam is kept out

Figure 7.30. Creep feeding increases weaning weights and helps with early weaning.

- **Weaned lambs/kids:** Weaning involves removing young ones from the milk diet to other forms of feed. This separation can be stressful. Lambs/kids are very vulnerable to disease and growth depression at the time of weaning unless they are weaned on to high quality feeds. Weaning at two to three months of age depending upon management is possible. Abrupt weaning is unnatural and should be avoided. Ideally, weaned lambs/kids should receive:
- High quality young forage, free choice.
- Free choice supplementary legumes.
- Free choice concentrates. They can be started with 70 g/day of mixed concentrate or 150 g wheat bran, and the amount can be increased as they grow.

Transferable Messages

1. Feeding animals by separating them into groups with similar physiological requirements gives them the attention they need and substantially improves feed resource utilization.
2. Creep feeding as a management tool reduces lamb/kid mortality. It also improves growth at this stage of development when they have fast growth rates.

7.13. Intensive Feeding of Sheep and Goats before Slaughter

Intensive feeding of sheep and goats before slaughter under Ethiopian situations can be categorized into two systems:

Production of conditioned animals: This system is intended for the supply of animals of acceptable condition to the slaughterhouses for ultimate export. These animals may also go into a finishing operation targeted at supplying the local market.

Finishing: This is the process of feeding sheep and goats to slaughter weight with adequate finish (fat deposit). This targets the local market, which has high demand for fat animals.

The operation of large feedlots by export slaughterhouses is becoming feasible. The principal functions of such feedlot operations are to assemble large numbers of sheep and goats, often with different backgrounds, and produce a homogenous product. The following guidelines will serve these operations and also small farmers that want to fatten smaller numbers of sheep and goats.

7.13.1. Advantages of fattening

Fattening is one strategic feeding option that can have the following advantages under Ethiopian conditions:

- Technically, it is quite simple and within the capabilities of small farmers to implement; moreover, the results are highly visible. This helps ensure farmers' confidence in the technique. Other techniques such as feeding to boost reproductive performance are less convincing because the farmer may not be sure that the extra feed resulted in any benefit.
- Benefits can be realized within a short period unlike other animal production activities.
- Fattening generates cash income that is eagerly sought by farmers.
- Fattening is generally profitable because the value per kilogram of live weight increases as both weight and condition increase.

7.13.2. Fattening systems

Traditional systems: Farmers generally condition their animals and market them. This feeding operation takes a very long time because it is generally based on low quality feeds. It is also associated with huge fluctuations in the weights and conditions of the animals depending on feed availability. Several improved traditional systems are in use, but they are not widespread. For example, systems of sheep fattening exist in the Adillo area of the southern region where conditioned animals are fattened by feeding sweet potatoes and other high value ingredients. These fattened animals fetch very high prices.

Agro-industrial by-product-based fattening: Fattening of sheep based on agro-industrial by-products is also practiced around the Adama area. This system can be promoted to other similar areas that have agro-industrial by-products. Fattening using agro-industrial by-products, such as sugar-processing by-products, is feasible in places like Wellega where valuable feed resources such as molasses and corn (grain and residue) are widely available. Protein sources like oilseed cakes can be purchased from nearby processing plants, and/or forage legumes can be grown in the area. Brewery by-products are also available from the Bedele Brewery to serve as protein sources. The Horro sheep breed, one of the fast-growing breeds in Ethiopia, is also indigenous to this area. Table 7.18 shows examples of rations for areas where by-products are available. Local equivalents of the weights indicated can be used whenever scales are not available.

Table 7.18. Molasses-based rations.

Ingredient	Ration I	Ration II	Ration III
Straw	Ad lib	Ad lib	Ad lib
Molasses	350 g	250 g	200 g
Oilseed cake	125 g	100 g	–
Brewer's dried grain	–	–	200 g
Urea	10 g	–	–
Molasses urea block	–	Free choice	Free choice

7.13.3. Feeding management of finishing sheep and goats

- The fattening program should be started after the necessary feed supplies are secured. Underfeeding and incorrect timing are the most common causes of failures in fattening activities.
- The objective in a fattening operation is to convert as much of the feed to body tissue as possible. It is thus necessary to minimize the movement of animals during the fattening period. They should be allowed only limited exercise.
- The animals should have shelters that protect them from adverse environment. The shelter need not be expensive and can be made of locally available materials.
- The success of a finishing operation depends on the first two weeks after arrival of animals. They may have traveled long distances and will be stressed, hungry, and thirsty. It is recommended that the following guidelines be followed during this period.
    - ♦ Right after arrival, rest the animals for a few hours in a dry, clean, sheltered area with access to fresh water. Then offer grass hay or mixed grass–legume hay.
    - ♦ Hand-feed salt during the first two weeks, then provide trace mineral salt in a separate feeder. Afterwards, these supplements can be mixed in the complete diet, but salt should continue to be provided *ad libitum* (free choice).
- Animals should have feed available at all times including evenings. If there is no feed left in the morning, feed supply for the following day should be increased.
- Adjust the animals to the fattening concentrate diet over a two week period by feeding the concentrate after the animals consumed enough roughage to provide bulk. Gradually increase the intake of the diet every two days, while providing free access to the basal roughage diet.
- Drench for internal parasites and treat for external parasites before the start of the feeding operation. This will improve feed utilization and performance.
- Sort the animals by weight/size and feed in uniform weight groups.
- Cull non-performing animals.
- Feed for 90–120 days. The length of the feeding period depends upon the desired animal condition. What is desired for the export market may be just conditioning without the amount of fat desired by the local market. Thus, animals for export can be sold at a time when the desired condition is attained.
- Water should be available at all times. Inadequate water supply will affect performance.

7.13.4. Selection of sheep and goats for finishing

- Select animals that are healthy and have no visible physical defects. Avoid emaciated animals as their poor condition may not entirely be due to nutritional factors. Emaciated animals often take a long time to recover. Target animals with medium body condition.
- The animals should have a large skeletal frame (long legs, loin, etc.) capable of producing a heavy carcass.
- Avoid animals that are too old. Check that the teeth are sound. This has implications on feed utilization. It is advisable to select sheep/goats aged between 2 and 4 years for fattening.
- Castration influences the fattening process. Castrated animals deposit more fat while uncastrated animals have more muscular growth. The selection of castrated or uncastrated animals depends on the final product desired and market conditions.

7.13.5. Feedstuff for growing and finishing sheep and goats

Finishing can be accomplished with diets containing different proportions of roughages and concentrates. The proportion depends on the type of feeds available, the desired length of feeding and the types of animals to be finished.

- Concentrates:
    - Concentrates are fed for energy. Grains and grain products commonly fed are shelled corn, wheat, sorghum and oats. Liquid feedstuff, such as molasses, can also be used as a source of dietary energy. Alternative energy sources, such as beet and citrus pulp can be fed to growing and finishing sheep and goats, but in most situations performance will not equal that obtained from grains and grain by-products. The use of these feeds depends on the price differential in utilizing them for fattening compared to other alternative uses.
    - High-protein concentrate sources most commonly fed are *nougseed* cake, cottonseed cake, linseed cake, sunflower seed cake, brewer's grains, distiller's grains and other similar feeds.
- Roughages:
    - A wide variety of roughages can be fed to growing and finishing lambs. The amount of roughage to feed depends on the objective of feeding the roughage. The roughage may be added to simply add bulk or contribute to the feeding value. The role of roughage in short-term intensive feeding is generally to provide bulk.

7.13.6. Weight of animals

Weights of animals at the start of the feeding operation govern the duration of feeding and the types and amounts of feedstuff needed. Lightweight (15–20 kg) animals can use more roughage, whereas heavier lambs (>25 kg) require more concentrates and a shorter feeding period. Therefore, lightweight sheep and goats are more desirable for conditioning based on a larger proportion of roughage, whereas heavier animals perform best where high concentrate diets are used.

Finishing heavier animals (>30 kg initial weight) in dry lot allows for rapid turnover and more efficient use of facilities. There are many practical feeding programs based on available feedstuffs that will produce the most efficient gains at least cost (Table 7.19).

Table 7.19. Sample feeding programs for finishing in a dry lot.

Ingredient	Diet I (%)			Diet II (%)			Diet III (%)		
	Weight (kg)			Weight (kg)			Weight (kg)		
	To 30	30-40	40 to market	To 30	30-40	40 to market	To 30	30-40	40 to market
Ground corn	52	62	72	49	59	69	60.5	60.5	59.5
Ground cobs	20	10	–	–	–	–	–	–	–
Chopped grass hay				33	23	13	–	–	–
Oilseed cake	11	11	11	11	11	11	10	10	10
Dried legume hay	10	10	10	–	–	–	23	23	23
Liquid molasses	5	5	5	5	5	5	5	5	5
Dicalcium phosphate	1	1	1	1	1	1	1	1	1
Trace mineral salt	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

Transferable Message

Short term intensive feeding based on locally available feedstuffs is an economically more feasible activity than keeping animals for long periods of time on maintenance-level feeding.

1. Demonstrate to farmers the cost-benefit of short term fattening versus keeping animals for long periods of time;
2. Demonstrate to farmers that this can be a viable business venture.

7.14. Feeding Management

Feeding sheep and goats is both a science and an art. While diets are scientifically formulated, experience in the feeding and management of small ruminants is important in gaining optimum feed utilization. Feed should be stored and used as carefully and economically as possible. Proper care should be taken during storage and handling to avoid spoilage and loss; in feeding techniques and livestock management to avoid wastage; and in ensuring that different types of feeds are used in the context of a balanced feeding system. Some principles and applications of feeding management of sheep and goats are presented below.

7.14.1. Improving feed utilization and efficiency

- If livestock are to make the best use of feed, they must be healthy and correctly handled. Routine control of epizootic diseases and internal and external parasites are important to achieve efficient use of feedstuff.
- Feed animals based on their requirements. Both overfeeding and underfeeding result in feed wastage.

7.14.2. Proper storage of feed

- Stored feed must be kept dry and protected from animals, moisture and fire.
- Cover hay stacks with thatching or other material.
- Store feed in a well-ventilated area to avoid mold development and excessive heating.
- Feeds, especially concentrates, should be stored on pallets to avoid direct contact with the floor, which could cause spoilage.
- Buy concentrate feeds only in quantities required for one month.
- If possible, concentrate feeds should be stored as individual ingredients. Mixing should be in quantities that can be used in a one-week period. Mixed feeds spoil faster.
- Baled fodder is simpler to handle and requires less storage space compared with loose fodder. It is, therefore, advisable to bale roughages. Baling can be done on small farms using a box baler without requiring expensive equipment.

7.14.3. Adapting sheep and goats to new feeds and increasing consumption of less palatable feeds

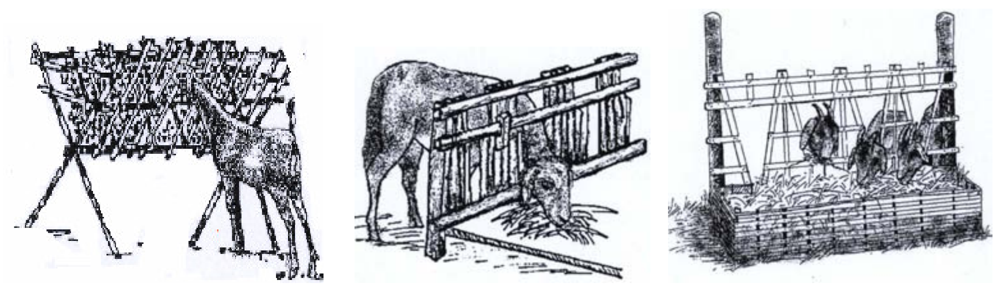
- Sudden diet changes, especially switching from a diet high in roughage to concentrate, should be avoided. Dietary changes should be gradual. The micro-organisms in the reticulo-rumen that help sheep and goats utilize feed require time for adaptation. The sudden introduction of a new feed can lead to scouring and loss of condition or even death in severe cases. A new feed or a feed that is not highly palatable should first be given in very small amounts with the quantity being increased progressively over a period of up to 15 days. There are, for example, observations that sheep and goats initially can refuse to consume some multipurpose trees and other feeds that have a strong smell. Some suggestions for use of new feeds are given below:
    - ♦ Always present the new feed when animals are hungry.
    - ♦ Mix new or less palatable feed with feeds the animals like to consume. The level of the new feed can be increased gradually. Mixing with feeds such as molasses or salt can shorten the adaptation period.
    - ♦ If the above strategies do not work, one can try forcing the animals to eat the new feed or go hungry. If they are persistent in their refusal, another approach or a different feedstuff may need to be used.

7.14.4. Separate feeding and/or grazing

- It is common for all classes of sheep and goats to graze together on communal land. This does not allow for feeding different classes of animals differently. For example, pregnant or lactating females should be fed differently than breeding males that should receive a maintenance diet.
- Individual animals within groups of sheep or goats differ in their nutritional needs. When feed resources are limited, animals with highest requirements should be targeted. For example, young stock and pregnant females have special needs and should be treated differently from other animals. Young lambs and kids need additional feed supplementation especially if they are born as twins or triplets. This can be done by using creep feeders that only allow access to the supplement by young animals.

7.14.5. Presentation of feed

- Little attention is given to the method of presentation of feed in improving feed intake and feed utilization. However, it has a crucial role in terms of its effect on the amount of feed eaten as well as the amount wasted. Sheep like to graze while goats like to browse. Raising the feed offered to goats high above the ground and simulating a browsing situation, by tying bundles of feed from a tree or barn roof, may stimulate feeding behavior. It will also help keep the feed clean and reduce wastage.



Hay rack for goats (adopted from Peacock, 1996) | Hay rack for sheep | Hay rack made of bamboo

Figure 7.31. Different types of hay racks.

7.14.6. Feeding based on palatability

- If a feed has high nutritive value, but low palatability, its dry matter intake will be low. Where farmers cut and carry forage of different species, it is important to know forage palatability ranking. Some farmers are aware of this fact and make use of forage ranking effectively. They do this by offering the forage of the lowest palatability first and that with highest palatability last.

A keyhole barrier made of wood

7.14.7. Provide fresh feed

- Supplying fresh feed in smaller quantities more often will help stimulate consumption compared with offering larger amounts at one time.

A “tombstone” barrier made of wood

Figure 7.32. Different types of barriers and racks that reduce wastage

7.14.8. Minimize wastage

- *Sanitation:* Under confined or tethered feeding situations, a clean and dry floor will mean less wastage. Feed that falls to a clean floor is more likely to be acceptable if offered again than feed contaminated by mud and feces. Sheep and goats are selective feeders and easily refuse to eat dirty or smelly feed. Feed that is refused by sheep and goats may, in most instances, be used for cattle, which are generally less selective. This is one way of effectively utilizing available feed resources
- Chopping: Feeding roughages in the chopped form reduces wastage and improves feed utilization. Chopping green feed and stover has the following advantages:
    - Reduces selectivity.
    - Permits thick-stemmed material to be easily eaten.
    - Can increase consumption of unpalatable feeds.
    - Allows for mixing with other ration components.
    - Uneaten, coarse bits of chopped fodder may be added to dung cakes and so are used as fuel.
- Poor feeding techniques:
    - When dry fodder is fed loose in the field, wastage will be less if distributed little by little so that the stock eat it all and wait for more.
    - Long hay and straw should be fed from racks or mangers; feeding on the ground, apart from being wasteful, is a health hazard.
- Provision of appropriate feeders:
    - Feeding on the ground results in considerable feed wastage and contributes greatly to the spread of disease, especially internal parasites. If sheep and goats are able to stand in their feed or in their feeders, they will inevitably defecate and urinate in the feed. Feeders need to be raised off the ground and constructed in such a way to keep the animals out as much as possible. Provision of appropriate feeders also reduces competition. There must be enough space at the feeder for all sheep and goats to be fed easily without fighting. Young animals should be fed separately from older ones to avoid competition and trampling.
    - Feed troughs for concentrate and hay racks for forage feeding are required. The size of racks and troughs is decided by the body size of the sheep and goats. Approximately 30–40 cm per animal is the minimum. Movable troughs are usually 2–4 m long. Fodder should not be put on the ground for sheep and goats. A feeding rack can be made from wood or other locally available material such as bamboo. The rack should be high enough to prevent adult sheep and goats from putting their heads in it and from jumping into the rack. The bottom should be above the normal head height.
    - It should be noted that the feeding behavior of goats is different from that of sheep and a barrier is needed to prevent animals from jumping into the trough. In a system called ‘tombstone or keyhole barrier’, each animal puts its head through an individual wooden barrier to eat without being able to push its body into the trough. Suggested dimensions for a concentrate trough is 30 cm wide with sides 15 cm high and standing on 15 cm legs.

In general, lowered troughs are not desirable because mud or soil can get into the trough and sheep and goats are tempted to put their feet in. When only a limited amount of supplementary feed is given, it is essential that the trough is long enough to allow all sheep to eat at once. Some troughs are fitted with a yoke to restrain animals during the short period of supplementary feeding. Such structures allow individual recording of the amount of concentrate consumed by an animal.

- **Feed racks:** Racks should be used wherever possible. Hay, crop residue, as well as cut green vegetation (if using cut-and-carry system), can most easily be fed in racks made with slatted sides and hung so that the feed is presented off the ground and at approximately head height. Galvanized metal racks are more durable than racks made of wood, but are more expensive. There should be enough feeder space for all animals to eat at the same time. Providing more than one feeder is a good option.

A hay rack made of wood | A different make of rack | Hay rack made of metal

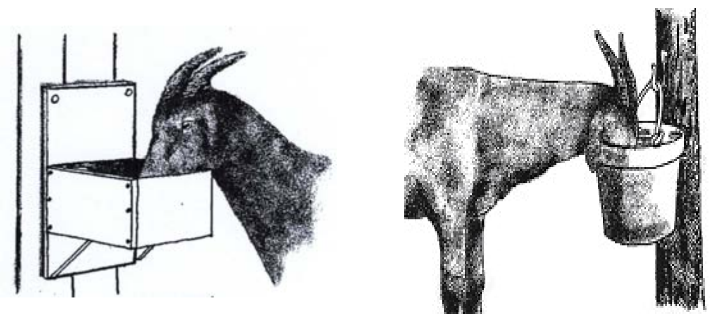
Figure 7.33. Different types of hay racks.

- The height of the rack will depend on the height of the animals. The rack should be high enough for the animals to reach up and pull the feed down. Do not place the racks too high. If animals are constantly reaching up to get at the hay, dust and particles from the hay will get into their eyes, and the irritation caused by the sharp particles can result in an unpleasant condition called "Red Eye". Racks can be constructed using materials available in the area; tree branches, bamboo, etc. The width between the bars depends on the type of feed offered. The rack can be constructed as a mobile free standing structure or attached to a wall for support. Placing a tray or another rack underneath will help to catch feed that falls through and so prevent contamination on the ground. A feeding space of 30 cm per animal is generally allowed. Feeding animals in smaller groups can serve to give adequate chance for all. Portable mobile racks can be used for field-feeding.

- **Feeding troughs:** Dry supplements and feeds that are chopped to small sizes should be fed on feeders that do not have gaps. Waterproof containers like a plastic bucket or a similar container can be used for wet feeds. Raising and providing support to such feeders will minimize spillage. There are various designs for feeding troughs. Round bottom or U-shaped feeders are easier to clean than feeders with square bottoms. Metal or hard plastic pans or containers are useful for hand feeding small numbers of animals. Old car tires cut in half can also be used.

A feeding trough made of burrowed wood | Trough made of metal sheet | Trough made of half-cut barrel | Trough made of PVC pipe used for feeding salt

Figure 7.34. Different types of feeding troughs.



a. Feeding trough fixed to a pole for goats

b. Watering trough fixed to a pole

Figure 7.35. Raised feeding trough and waterer for goats.

- Feeding racks and troughs placed on grazing areas should be:
  - Sited on hard-packed ground or on a well-drained part of the field, and
  - Shifted regularly to reduce damage to the sward.
- Housed stock should receive their feed and fodder in troughs and racks. Racks are often fitted above the trough or manger so that any feed which falls from the rack is held in the trough.

- Provision of shades:
  - ♦ Appetite of animals will be depressed if the place where they are fed is hot and exposed to the sun. They will eat more in a cool and shady place than in a place exposed to direct sunlight. It is, therefore, advisable to locate feeders under the shade.

Transferable Message

Proper storage by baling hay and crop residues saves storage space and reduces wastage.

Proper feeding management reduces wastage and improves feed utilization and performance of sheep and goats.

1. Chopping feedstuff.
2. Use of feeding troughs/racks to reduce wastage.
3. Feeding animals of similar nutritional requirements in groups.

7.15. Characteristics and Feeding Values of Some Common Feeds for Sheep and Goats

7.15.1. Cereals

Barley: Is easily digestible and therefore well suited for all kinds of animals. It contains more protein, lysine and fiber than corn.

Corn: Constitutes the basis for concentrate rations in many countries. It is the cereal with the highest metabolisable energy content which categorizes it among the best energy sources. It is low in protein and especially deficient in the amino acid, lysine. Its utilization is limited only by the need to limit the energy/protein balance. Utilization rates are commonly between 60 and 70%.

Millet: Millet is equivalent to sorghum as an energy source and higher in its lysine content. It may be used as feed for livestock and poultry. It should always be ground.

Oats: Has the lowest metabolisable energy content among the cereals. It is a bulky feed with high percentage of crude fiber. It is a palatable and digestible feed that also stimulates digestion. Oats has higher crude protein content than most grains and is the most balanced in terms of amino acids.

Sorghum: The composition of sorghum is close to that of corn. It is, however, richer in cellulose and less rich in fats. Sorghum may contain tannins, which have a depressing effect on the digestibility of feeds. The content varies considerably (0.2–3%) depending on the cultivars. Considerable variations in protein and starch contents also exist between varieties. Sorghum should be ground for efficient utilization.

Wheat: Wheat is usually not used extensively in animal rations due to its value as human food and the associated high cost. It is the best cereal grain for feeding animals next to corn. Wheat is usually best at levels not exceeding 50% of the concentrate mix in sheep and goat diets because of digestive upsets that may develop.

7.15.2. Cereal by-products

Brewer's Dried Grains (BDG): The dried and extracted residue of barley malt alone or in a mixture with other cereal grains or grain by-products resulting from the manufacture of beer. It has a high crude protein content of 16–24% of dry matter. It also has a high cellulose content of 9–20% of dry matter. BDG has about 80% of the energy content of barley grain but is not as palatable as the original grain. It is chiefly used interchangeably with other feeds of similar bulk in finishing rations.

Brewer's Dried Yeast (BDY): Is the dried, non-fermentative, non-extracted yeast of the botanical classification *Saccharomyces* resulting as a by-product from the brewing of beer. BDY must not contain less than 35% crude protein. It is an excellent source of highly digestible, good quality protein.

Grain Screenings: Consists of 70% or more of light and broken grains along with weed seeds and other foreign material that is separated with a screen in the cleaning of grain. Quality varies according to the percentage of weed seeds and other foreign material. Most grain screenings are incorporated in ruminant rations. Screenings are normally limited to 15–20% of feedlot rations.

Wheat Bran: Is the coarse outer covering of the wheat kernel separated from wheat in commercial milling. It is rich in niacin, Vitamin B1, phosphorus and iron. A large part of the phosphorus is phytin phosphorus. Wheat bran is widely used in horse rations because of its bulky nature and laxative effects. It is also a favored supplement in sheep rations.

Wheat Middlings: Is a by-product of the milling industry. Consists of the fine particles of bran, shorts, germ and flour. Wheat Middlings should not contain more than 9.5% fiber. It is deficient in calcium, carotene, and Vitamin D, but is widely used as a potential grain replacement in rations for all animal species.

Wheat Shorts: A similar product to wheat bran and middlings but lower in its crude fiber content (max. 7%) and richer in its energy composition because it contains the finer wheat milling by-products including a larger proportion of flour.

7.15.3. By-products of oil mills

Cottonseed meal: Is the finely flaked residue that remains after most of the oil from cottonseed has been extracted. The nutritive value of this meal varies a great deal according to the manufacturing technique used. The crude protein content of the decorticated meal can range between 40 and 50%. Cottonseed meal is low in lysine, methionine and tryptophan and deficient in Vitamin D, carotene and calcium but rich in phosphorus. It is an excellent protein supplement for ruminants, since they can tolerate gossypol and do not require lysine and tryptophan in the diet.

Groundnut meal (Peanut meal): Can contain 45–50% crude protein depending on the method of oil extraction. It is low in methionine, lysine and tryptophan. It is also low in calcium; carotene and Vitamin D. Groundnut meal is palatable and contains high quality protein. The meal can be contaminated with molds, especially *Asperigillus flavus* that excretes a toxin known as aflatoxin. It shouldn't be stored for more than six weeks since this product tends to spoil when held too long, especially in warm moist climates.

Linseed meal (Flax meal): Is low in the amino acids lysine and tryptophan. It is also lacking in carotene and Vitamin D, and only fair in the content of calcium and B-vitamins.

***Nougseed* meal:** Is a product comparable in feeding value to undecorticated peanut meal. It is very palatable and can be included in concentrate mixtures for all classes of livestock.

Rapeseed meal: May be used as a protein supplement for all classes of livestock. It may be used at maximum levels of 20% in rations.

Sesame seed meal: Has analytical characteristic similar to groundnut meal. It is a little oilier, richer in cellulose and a little poorer in total crude protein content. It has high methionine content and, thus, an excellent quality plant protein supplement suitable for all animal species. No toxic factor is known in this meal. The color of the expeller meal varies with the variable color of sesame seed varieties.

Soybean meal: Is a product obtained by grinding the flakes that remain after extracting most of the oil from soybeans. It has the highest nutritive value of any plant protein source. The preponderance of soybean meal is explained by its richness in the "indispensable" amino acids, notably lysine. The heat treatment of soybean meal improves its digestibility and destroys the toxic anti-trypsin factor (ATF), of which small amounts are present in crude soya. It contains 40–50% crude protein, is very palatable and, thus, suitable for all animal species.

Sunflower meal: The variation in feeding value is considerable due to differences in crude fiber and the method of extraction. It is a suitable protein supplement for all animal species. Crude protein content ranges from 35 to 40%.

7.15.4. Sugar refinery by-products

Cane molasses: Is a by-product of the manufacture of table sugar from sugarcane. It is a good energy source but low in protein. It is very palatable and an excellent appetizer. It may be fed to any animal species. Molasses is used mostly as a binder to mixed feeds to be pelleted. It also helps to reduce dustiness of mixed concentrate.

7.15.5. Feeds of animal origin

Dehydrated poultry litter: Is poultry manure mixed with litter material from poultry managed under the litter system of management. It is dried immediately after removal from the poultry house and preferably milled and run over a magnet to remove stray metal scraps. Is a low-cost palatable feed that is fair in energy but high in protein and minerals. Quality varies with the type of litter material used.

Poultry Manure: Is produced in cage systems of poultry husbandry. Fresh manure is about 30% crude protein on a dry matter basis. The digestibility of crude protein and organic matter for ruminants is about 80 and 65%, respectively. Initially, the rumen organisms require an adaptation period of about three weeks to fully utilize uric acid, which is the main nitrogenous compound in the manure. Poultry manure intended for feeding must be dried immediately as fresh manure ferments very quickly.

7.15.6. Roughage sources

Bagasse, sugarcane: Is the fibrous residue of sugarcane that remains after the juice is pressed out. It is one of the principal by-products of the sugar-making process. It may be used as low quality roughage.

Barley straw: Is usually superior to wheat straw but inferior to oat straw in feeding value. May be fed to sheep and goats as a maintenance ration.

Bean straw: Varies widely in quality. It is satisfactory as a roughage source.

Corncobs: Are low quality roughage. May be fed to cattle or sheep except for feedlot animals in which case they should be limited to very small quantities.

Corn husks: Are the most digestible of the corn residues that rank as follows: husks, leaf, cob and stalks.

Corn stover: Is the mature corn plant from which the ears have been removed.

Oat straw: Is the most nutritious and palatable of the cereal straws. It may constitute up to half the roughage of breeding and stocker cattle, provided the other half consists of good legume hay.

Peanut hulls: The outer covering of peanut seeds. Are high in fiber, but have 8% protein on a moisture-free basis. These may constitute up to 10% of lamb finishing rations.

Pea straw: Is the residue remaining after separation of the seeds by threshing mature peas. It is worth about 2/3 of legume hays.

Sorghum stover: Consists of the stalks and leaves left after removing the mature sorghum heads. It may be grazed in the field, stored as dry roughage or ensiled. It is commonly fed to beef cattle. After harvest, sorghum will send up new shoots if the moisture is favorable. The prussic acid content of these shoots may be toxic to grazing animals.

Soybean hulls: Are the outer covering of soybean seeds. They are high in fiber and fair in protein content. The hull constitutes some 8% of the seed weight. Soybean hulls are incorporated in commercial feeds primarily because of their high fiber. They are best suited for use by growing sheep.

Soybean straw: Is the residue remaining after separation of the seeds by threshing mature soybeans. It is a high-fiber, low-protein and high-lignin product. It should be fed with good quality hay at about a 1:1 ratio.

Wheat chaff: Includes the husks, hulls, joints and small fragments of straw that are separated from the seeds in threshing of wheat. It is bulky, high in fiber and low in protein.

Wheat straw: Is the residue remaining after separation of the seeds by threshing of wheat. It is best fed with good quality legume hay at about a 1:1 ratio.

Glossary of Nutrition Technical Terms

Ad libitum: A feeding system where animals are given unlimited access to feed. Synonymous terms include full feeding, free choice, self-feeding.

Air-dry basis: Expression of the composition of a feedstuff. This may be actual, i.e., referring to feed that is dried by means of natural air movement in the open or assumed dry matter content. Assumed to be 90% dry matter.

Animal protein: Protein of animal origin derived from slaughterhouses and animal product processing plants that can be used as ingredients in feed mixtures.

Anti-nutrients: Some feed ingredients and potential feeds contain factors that inhibit the digestive process, causing reduced growth, diarrhea or pasting. They limit the amount of some feed ingredients that can be added to the final feed. The anti-nutritional factors in some feed materials such as beans can be destroyed by heat treatment (cooking).

Anti-oxidant: A chemical compound that prevents oxidative rancidity of polyunsaturated fats; added to feed ingredients or feed mixtures for protection against oxidation.

Appetite: Desire to eat; could also be used to refer to the weight of feed dry matter consumed as a percentage of live weight.

As fed: Refers to feed as normally fed to animals.

Available nutrient: A nutrient that can be digested, absorbed and used in the body for some useful purpose.

Average daily gain (ADG): The mean daily increase in the live weight of an animal.

Balanced daily ration: A combination of feeds fed at one time or in portions at intervals, that will provide the essential nutrients in such amounts as will properly nourish an animal for a 24-hour period.

Balanced ration: A combination of feeds that provides the essential nutrients in the proper amounts and proportions to adequately nourish a particular animal.

Biological value: The usable proportion of the protein of a feed or feed mixture by an animal. It is a measure of protein quality. A protein that has a high biological value is said to be of good quality.

Blend: A mixture, such that the constituent parts are rendered indistinguishable from one another.

By-product feeds: Secondary products from plant and animal processing and industrial manufacturing that may be used for animal feeding.

Cake (press cake): Material resulting as a by-product from the processing of oilseeds to remove oil using the mechanical or expeller method.

Calorie: amount of heat energy required to raise the temperature of one gram of water from 14.5 to 15.5°C used as a measure of feed energy.

Chaff: Glumes, husks, or other feed covering together with other plant parts, separated from seed in threshing or processing.

Commercial feeds: Feeds mixed by commercial feed manufacturers that specialize in the business, as opposed to home-mixing.

Compaction: A condition when feed in the stomach and intestines of an animal becomes closely packed causing constipation and/or digestive disturbances.

Complete ration: All feedstuffs (forages, grains, processed feeds etc.) combined in one feed mixture that is nutritionally adequate for a specific animal in a specific physiological state, sometimes referred to as a total mixed ration.

Concentrate: A class of feedstuff low in fiber (<18% crude fiber).

Creep: An enclosure or feeder used for supplemental feeding of nursing young that excludes their dams.

Crop residue: Portion of plant growth that remains after harvesting a grain or seed crop, e.g., straw, stalks, husks, cobs, etc.

Deficiency: Lack or shortage of one or more basic nutrients.

Diet: A feed or mixture of feed ingredients including water regularly offered to or consumed by an animal.

Digestibility: The proportion of feed that is not excreted in the feces and, thus, assumed to be absorbed.

Digestion: Process of changing food to a form that can be absorbed from the digestive tract by the body tissues (mainly the intestines).

Diluent: An edible substance used for mixing with and reducing the concentration of nutrients and/or additives to make them more acceptable to animals, safer to use and more capable of being mixed uniformly in a feed mixture.

Dry-matter basis: An expression of the level of a nutrient contained in a feed on the basis that the material contains no moisture. Synonymous with 100% dry-matter basis, moisture free, oven dry.

Energy feeds: Feeds high in energy and low in fiber (<18% crude fiber), e.g., grains.

Expeller process: A process for the mechanical extraction of oil from oilseeds involving the use of a screw press.

Feed (feedstuff): Any naturally occurring material suitable for feeding animals.

Feed additives: Non-nutritive products that improve animal performance or preserve feeds.

Feed conversion efficiency: Measure of the efficiency of feed utilization. It is expressed as units of feed per unit of animal product — meat, milk or eggs.

Feeder's margin: Difference between the cost per unit weight of feeder animals and the selling price per unit weight of the same animals when finished.

Feeding standards: Estimates of nutrient requirements for a specific function in a given environment.

Feedlot: A lot or plot of land on which animals are fed or finished for marketing.

Fibrous feed: Feed high in cellulose and/or lignin.

Finish: To fatten a slaughter animal. The term may also refer to the degree of fatness of such an animal.

Flushing: The practice of supplementing breeding animals two weeks prior and for one or two weeks after breeding to improve fertility.

Fodder: Coarse feeds such as corn or sorghum stover.

Forage: Vegetative parts of plants fed to livestock in the fresh, dried or ensiled form.

Formula feed: Feed mixture consisting of ingredients mixed and processed in specific proportions.

Free choice: A feeding system by which animals are given unlimited access to the separate components or groups of components constituting the diet.

Full feed: A situation where animals are being offered as much feed as they will consume safely without going off-feed.

Gestation ration: Ration given to pregnant animals during the last trimester to provide the additional nutrients needed for proper growth of the fetus and to keep the mother fit for optimum milk production.

Grits: Coarsely ground grain from which the bran and germ have been removed. Usually screened to uniform particle size.

Hulls: Outer covering of dry grain or other seed, especially when dry.

Ingredient: Constituent feed of a feed mixture.

Joule: A measure of energy. It is the work done when a force of one Newton is applied through a distance of one meter. 4.184 Joules = 1calorie.

Laxative: Feed that induces bowel movement and relieves constipation.

Limiting amino acid: An essential amino acid of a protein that shows the greatest percentage deficit in comparison to the amino acids contained in the same quantity of another protein selected as a standard.

Maintenance ration: The minimum amount of feed required to maintain the essential body processes at their optimum rate without gain or loss in body weight or change in body composition.

Mash: An expression of the physical form of a mixture of ingredients in the form of a meal.

Meal: An expression of the physical form of an ingredient that has been ground or otherwise reduced to a particle size somewhat larger than flour.

Mechanically extracted: Fat extraction procedure from oilseeds by the application of heat and mechanical pressure.

Medicated feed: Any feed that contains drugs for prophylactic or therapeutic purposes.

Metabolic body weight: Measure of body size expressed as the body weight of the animal raised to the three-fourths power ($W^{0.75}$).

Micro-ingredient: Any ration component normally measured in milligrams or micrograms per kilogram or in parts per million (ppm), e.g., trace minerals, vitamins.

Non-protein nitrogen (NPN): Nitrogen that comes from sources other than protein but may be used by ruminants and can, thus, form part of ruminant rations, e.g., urea.

Nutrient: Any chemical substance in feed that has specific functions in the nutritive support of animal life.

Nutrition: The process of digesting, absorbing and converting feed into tissue and energy. It can also refer to the study of this process.

Nutrient requirements: Minimum nutrient needs of animals without margins of safety for maintenance, growth, reproduction, lactation and work. Nutrient requirements plus a safety margin is called "nutrient allowance."

Off-feed: Not eating with normal healthy appetite.

Palatable feed: Feed that is well-liked and is eaten with relish.

Pellets: Agglomerated feed formed by compacting and forcing the material through openings by a mechanical process.

Plant proteins: A category of feeds of plant origin high in their protein content, e.g., cottonseed meal, peanut meal, etc.

Production ration: Additional allowance of ration for production over and above maintenance requirements.

Protein supplements: Feedstuff that contain more than 20% protein or protein equivalent.

Protein quality: A term used to describe the amino acid balance of a protein. A protein is said to be of good quality if it contains all of the essential amino acids in proper proportions and amounts needed by a specific animal.

Ration: The total amount of feed or a mixture of feeds allotted to an animal for a 24-hour period with no reference to quantity or quality.

Roughage: Feedstuff of plant origin that is high in crude fiber but low in digestibility and protein.

Scalping: Removing larger material by screening.

Solvent extraction: A method of extracting oil from oilseeds using solvents.

Supplement: A semi-concentrated source of one or more nutrients used to improve the nutritional value of a balanced ration, e.g., protein supplement, mineral supplement.

True protein: A compound that will completely hydrolyze to amino acids.

Zero-grazing: Feeding of green fodder as green chop in a lot or stall.

References

Banerjee, G.C. 1982. A Textbook of Animal Husbandry. Oxford and IBH publishing Co.

Close W and Menke, K.H. 1986. Selected Topics in Animal Nutrition. DSE. pp. 170.

Devendra, C and Burns, M. 1983. Goat Production in the Tropics. Commonwealth Agricultural Bureau. Pp. 183.

Devendra, C. 1986. Feeding systems and nutrition of goats and sheep in the tropics. In Adeniji, K.O., and Kategeli, J.A. Proceedings of the Workshop on the Improvement of Small Ruminants in eastern and southern Africa. 18–22 August 1986. Nairobi Kenya. pp.91–110.

Gatenby, R.M. 2002. Sheep. The tropical Agriculturalist Series. McMillan publishers. pp.178.

Gipson, T. A., Merkel, R. C., Hart, S., Williams, K. and Sahlu, T. 2005. Meat Goat Production Handbook. American Institute for Goat Research, Langston University, USA.

Nelson, R.H. 1979. An Introduction to the Feeding of Farm Livestock. 2nd ed. Pergamon press. pp 156.

Peacock C. 1996. Improving Goat Production in the Tropics. A manual for development workers. OXFAM (UK and Ireland) and FARM_Africa, United Kingdom.

Roger C. Merkel and Subandriyo. 1997. Sheep and Goat Production Handbook for Southeast Asia. viii +214 pp.

Steel, M. 1996. Goats. The Tropical Agriculturalist Series. McMillan publishers, UK. Pp.152.

Chapter Eight

Forage Development for Sheep and Goats

Solomon Mengistu

Objectives

1. To discuss alternative strategies and techniques for feed resource development and improvement available for the smallholder farmer.
2. To explain important activities which integrate the various sub-sectors, namely food crops, forage crops, ruminant livestock and environment conservation especially soil and vegetation.
3. To discuss promising forage and pasture species, their establishment techniques and their suitability to different agro-ecological zones.
4. To explain practical procedures of forage seed production.
5. To explain improved forage conservation and storage techniques.
6. To list methods of improving the productivity of natural pasture in both highland and pastoral grazing areas.

Expected Outputs

Knowledge of alternative forage development strategies for different agro-ecological zones.

8.1. Forage Development Strategy Options

There are two important factors that should be considered in forage development strategies for sheep and goats. First, their ecological distribution in the country is closely associated with either of climatic extremes — sheep mostly concentrated in the highlands while goats in the arid and semi-arid lowlands. Second, the feeding habit of sheep is grazing herbage close to the ground while goats predominantly browse diverse flora. Therefore, the type of forage to be introduced and its favored climate and soil, system of development and utilization at the farmer level, need to be viewed in relation to the ecological situations and feeding behavior of sheep and goats.

There are several strategies of forage development introduced with widely varied results into Ethiopian farming systems, especially in the highlands. Permanent pasture technologies have had limited success in spite of three decades of research and development endeavors. The lack of success is due to several constraints including low farmer resources, causing a low adoption rate of high-input technologies that take long periods of time for realization of benefits, and fragmented land with continually decreasing land holdings. Promising strategies that have shown some initial successes of improved forage development in the country are briefly discussed below.

8.1.1. Improving forage productivity of grazing lands on marginal areas

In the mixed crop–livestock (the central highland) and cash crop (the south-western highland) areas, the natural pasture from marginal lands is an important source of livestock feed. Natural pastures provide about 50% of the total annual feed supply depending on availability of alternative feed resources such as crop residues. These marginal-land grazing areas are located mostly on both extremes of topography — steep slopes and bottomland not suited for normal crop production. These grazing lands can be improved in yield and quality through methods like over-sowing. They can alternatively be made more productive through replacement of the sward with adaptable improved forage species.

Waterlogged areas

These consist of poorly drained or flooded areas dominated by black clays (*Vertisols*) or riverbed deposits eroded from various land-forms (alluvial*)*. The *Vertisols* cover a huge area of land (12.6 million ha) estimated to cover about 12% of the country. These waterlogged areas are not suited for normal crop production due to poor drainage, so in most highland areas they are mainly utilized as bottomland communal grazing lands or for pasture deferred as standing hay for use in the driest part of the year.

Currently, the only species identified for over-sowing highland pastures are vetches (*Vicia* species), which unfortunately do not perform well under poor drainage. Some native grass species that showed considerable promise as water logging tolerant at Debre Zeit are listed in Table 8.1. Other commercial forage species recognized for their tolerance to excess moisture are listed in Table 8.2. Such aquatic and semi-aquatic grasses and legumes available commercially may be considered for salvaging marshy areas located on the peripheries of major rivers and lakes.

Table 8.1. Herbage yield and quality of native grass species grown under rain-fed conditions for three months on bottom lands at Debre Zeit.

Species	Herbage yield (DM t/ha $^{-1}$)	Nutritional analysis		Tolerance to water logging
		CP%	IVOMD%	
Pennisetum sphaceletum	10.5	10.1	53.6	Excellent
Pennisetum trachyphyllum	10.3	7.5	64.5	Excellent
Panicum maximum	14.4	11.5	59.3	Good
Chloris gayana	8.7	9.5	57.5	Fair
Pennisetum unisetum	8.1	9.3	50.2	Fair

Table 8.2. Selected commercial grass and legume forage species with potential adaptability to water-logged areas.

Potential species	Common name	Excess water tolerance
	GRASS SPECIES	
*Brachiaria mutica**	Para grass	Excellent
Echnochloa polystachea	Aleman	Very good
Hymenache amplexicaulis	Hymenachne	Good
*Paspalum dilatatum**	Paspalum	Good
Phalaris aquatica	Phalaris	Good
	LEGUME SPECIES	
*Macroptilium lathyroides**	Phasey bean	Excellent
Aeschynomene americana	Joint vetch	Very good
*Desmodium intortum**	Green leaf	Good
*Desmodium heterophyllum**	Hetero	Good
	BROWSE TREES/SHRUBS	
Sesbania sesban	Sesbania	Excellent
Salix subserata	Willow tree	Excellent

*Also well-adapted to black-cracking heavy clay soils (Vertisols) (*Koticha, Merere, Walka*)

Steep slopes

Sloping land features like gullies, escarpments and peaks are unsuitable for cultivation and are thus generally utilized as communal grazing lands. They serve as the sole source of feed when all cultivable lands are cropped, and waterlogged areas become inaccessible due to flooding during the rainy season. Various forage-development strategies potentially applicable in these areas are discussed below.

Agroforestry

Agroforestry involves a close association of trees or shrubs with crops, animals and/or pasture. Specifically, it is the deliberate combination of trees with crop plantation or pastures, or both, in an effort to optimize the use of accessible resources to satisfy the objectives of the producer in a sustainable way.

Alley cropping

Alley cropping is an agroforestry practice in which leguminous browse trees or shrubs are planted widely apart so that grain crops are sown in the alleys between rows of trees. The trees are pruned heavily during the cropping season in order to reduce shading, and the pruning is used for fodder, green manure and mulch. Unlike the case with other herbaceous intercrops, competition between the trees and cereal crop for moisture and nutrients is minimal since the deep roots of the tree utilize nutrients from deep layers of the soil that the cereal plant roots do not reach. In this system, the legume trees provide feed to stock, improve the nitrogen status of the soil through biological nitrogen fixation, and make available nutrients from the subsoil to the surface.

In soil conservation programs, steep slopes are planted with narrow lines of forage intercropped with arable crops. This system is referred to as *forage strip* or *strip cropping*. Herbaceous forages such as elephant grass, vetiver grass, *Panicum*, stylos, desmodium, siratro as grass/legume mixtures or pure stands are established on soil conservation terrace lines (Figure 8.1) for multiple uses, including:

- providing both bulk and quality feed for a cut-and-carry feeding system;
- preventing soil erosion;
- providing fuel wood;
- providing shelter and green manure for crops; and
- improving soil fertility.

Species suitable for the alley cropping system are listed in Table 8.3.

Table 8.3. Forage species suited for planting on sloping areas.

Herbaceous species	Tree and shrub species
Stylosanthes guyanensis	*Chaemacytisus palmensis* (tagasaste, tree lucerne)
Stylosanthes scabra	*Leucaena pallida*
Stylosanthes hamata	*Sesbania sesban*
Stylosanthes humilis	*Calliandra calothyrsus*
Stylosanthes fruitcosa (native)	*Cajanus cajan*
Desmodium intortum	*Gliricidia sepium*
Desmodium uncinatum	
Pennisetum purpureum	
Panicum maximum	
Phalaris tuberosa	

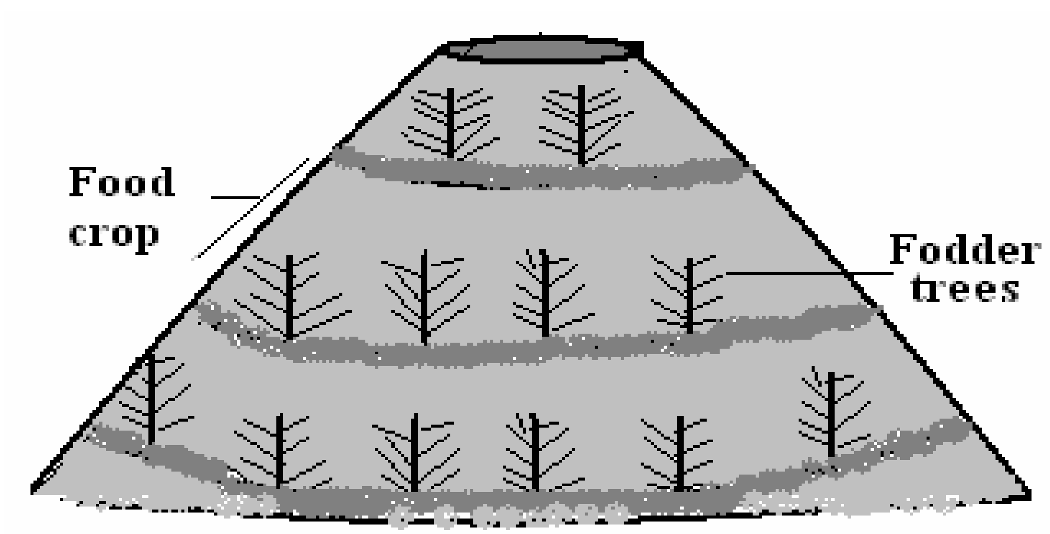


Figure 8.1. Alley cropping.

8.1.2. Integration of forages with food and cash crops

Forage legumes and grasses can be integrated into cropping systems through a number of methods such as intercropping, relay or sequential crops, fodder banks and alley farming. There are better chances for these technologies to be acceptable to the smallholder farmers than the more expensive conventional pastures. This is because, in all of the above-mentioned methods, the land is tilled for the sake of the food crop and so there is no need for special input for pasture establishment. The farmer is often reluctant to sacrifice arable land for sole pasture production. In this system, however, the farmer is likely to accept production of food and forage crops together. This will increase the net production per unit area of land.

Intercropping

Intercropping is a method in which two fairly compatible crops, often a leguminous forage species and a cereal crop, are grown together at a given planting pattern during a season. Competition between the cereal and the intercrop is minimized through selection of lines with different growth rate, rooting pattern and adaptation to light intensity. The intercrop, being leguminous, fixes nitrogen and thus avoids competition with the cereal for nitrogen, which is often scarce in tropical soils. Different forage legumes have different intensity of reaction with cereal crops. ***Relay cropping*** is the practice of intercropping a cereal planted within or between the rows of forage by offsetting the planting time of the cereal crop and the intercrop by two to three weeks to reduce competition.

The advantages of such an intercropping system are:

- the possibility of nitrogen accretion from the legume to the cereal;
- maintenance of continuity of feed supply during the dry season;
- more efficient utilization of low-quality cereals through the addition of high-protein forages;
- possibility of returning manure from livestock to the field; and
- increasing crop productivity.

Cereal/forage crop rotation

This system involves introducing annual forage legumes into the traditional cropping pattern. In the central highlands, to which the system is more applicable, the cropping sequence is cereal-cereal-pulse. In between any two cereal crop phases, annual fodder crops like clovers, medics or lablab may be sown, harvested and conserved as hay for strategic feeding during the dry season.

The advantages of this system are primarily to provide high-quality fodder and maintain soil fertility. Interspersing a legume in the crop rotation enhances soil fertility, prolongs the cropping period and reduces the normal fallow time traditionally used to replenish soil fertility. Legume crops also reduce the use of high amounts of chemical fertilizers. Thus, the method minimizes expenses for commercial fertilizers, especially nitrogen, which is fixed from atmospheric sources through *Rhizobial* fixation (Figure 8.2).

Sequential cropping

Sequential cropping is practiced when two crops (forage and pulse) are grown during a season, one after the other. The essential feature of this system, known as sequential or double cropping, is that the two crops do not overlap, the second being sown only after the first crop is harvested. This cropping is incorporated between any two cereal crop phases according to the traditional crop rotation.

For example, at the Debre Zeit Agricultural Research Center (DZARC), short-duration native clovers were successfully grown in sequence with chickpea on a *Vertisol* to exploit the advantages of:

1. producing a double crop of food grain (chickpea or grasspea) and high quality fodder, and
2. improving the nitrogen content of the soil through *Rhizobial* nitrogen fixation by both crops (Figure 8.3).

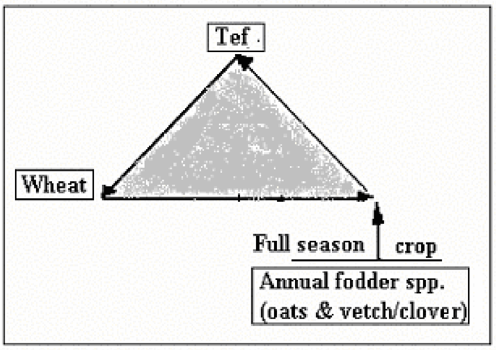


Figure 8.2. Modified cropping cycle with a replacement of the pulse phase with annual fodder legumes grown as full-season crop in the Ethiopian-highland cereal-based farming system.

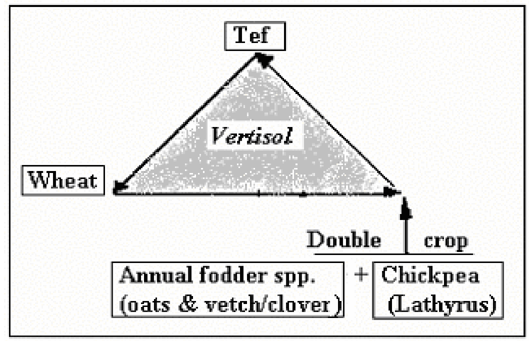


Figure 8.3. Modified cropping cycle without affecting the traditional crop rotation practice on the Ethiopian highland *Vertisols* through sequentially growing annual fodder crops with off-season pulses (chickpea/grasspea).

Fodder bank/lay pastures

This is a system whereby fallow land is sown to leguminous perennial forages or self-seeding annuals for production of high quality dry-season fodder and at the same time rebuilding the nitrogen content of the soil through biological nitrogen fixation. The system is like forage/crop rotation except that the forage phase may last for three or more years until the desired soil fertility level is attained.

Backyard forage crops

Backyard forage/fodder crops include highly productive species grown around a farmer's homestead under intensive management conditions. The objective is to produce high-quality fodder as supplementary feed to highly productive dairy cows and young animals. The system has gained popularity among smallholder farmers since it does not compete with food crops for arable land.

Recent forage innovation surveys undertaken nationwide indicate that most forage technologies successfully introduced to the farming community are based on this strategy. The quantity of produced fodder can be increased through the use of irrigation (from wells or surface water ponds), making multiple harvests possible. For instance, where water is abundant multiple harvests of high quality alfalfa fodder are possible every 3 to 4 weeks (12 cuts per year) (e.g., Debre Zeit Research Center Dairy Farm). Highly productive fodder species recommended for this system are listed in Table 8.4.

Table 8.4. Forage species suited for backyard forage production system.

Herbaceous species	Tree and shrub species
Pennisetum purpureum (Elephant grass)	*Chaemacytisus palmensis* (tagasaste)
Medicago sativa (Alfalfa)	*Leucaena pallida*
Desmodium intortum (Green leaf desmodium)	*Leucaena leucocephala*
Desmodium uncinatum (Silver leaf desmodium)	*Sesbania sesban* (Sesbania)
Beta vulgaris (Fodder beet)	*Calliandra calothyrsus*
	Gliricidia sepium
	Desmanthus virgatus
	Cajanus cajan (Pigeon pea)

Transferable Messages

- Determine the ecology and terrain of your *kebele* and take the choice of alternative approaches appropriate for the area.
- Make the appropriate choice of forage species.
- Select progressive farmers to demonstrate your choice of interventions.
- Organize demonstration visits by other farmers and encourage discussions on the practice and advantages of the introduced forage species and the approach.

8.2. Establishment and Management of Sown Pastures

8.2.1. Important considerations

Permanent pasture establishment can be an expensive venture so one has to take certain fundamental considerations before attempting such a venture.

Adequate soil moisture: For most productive pasture species, there is better chance of success where annual rainfall is about 600 mm or more.

Soil fertility: Improved forages can behave as food crops in soil-fertility requirements.

Topography: Must be convenient for easy farm operation (cultivation, fertilizing, spraying, harvesting, etc), and convenience for grazing animals (if grazed pasture).

Cost-effectiveness of undertaking ecological changes

- Consider whether clearing, cultivation, fertilizing and drainage operations are all justified and cost-effective.
- Check for the possibility of controlling the established pasture to implement management measures, including: better stock distribution, better systems of grazing, reduced stocking, and closing to stock until recovery.

8.2.2. Procedures of establishing sown pastures

Selection of pasture mixtures

Mixed pastures composed of grasses and legumes are preferred to solid stands for the following agronomic and nutritional advantages:

Agronomically

- More rapid establishment of the sward and better land use.
- Better seasonal distribution of growth by the inclusion of both early- and late-maturing species.
- Increased production with greater palatability.
- Leguminous components increase the nutritive value of the sward.
- Legumes play an important role through symbiotic N fixation, and the cycling of this nitrogen into the pasture system.

Nutritionally

- Legumes have high protein content. They improve the palatability of a mixed grass–legume pasture by keeping the crude protein level above the critical level of 7%, below which voluntary intake declines.
- Dry-matter digestibility and voluntary intake of legumes is generally higher than that of grasses. The fiber content increases at a later stage of maturity as compared to grasses, thus ensuring quality feed supply over the dry season.
- Legumes have high contents of the minerals: calcium, sulphur and phosphorus; therefore, they provide stock with more balanced diets.

Number of components

Pastures can be established as a mixture composed of up to five grass-plus-legume species depending upon specific situations.

Examples of some recommended mixtures and seeding rates are outlined as follows.

(a) Two components

Mixture options	Component A	Component B
Option 1	Rhodes grass	Lucerne
Seed rate	11 kg/ha	2 kg/ha
Option 2	Guinea grass	Centrosema
Seed rate	4–6 kg/ha	2–3 kg/ha
Option 3	Rhodes grass	Siratro
Seed rate	3–4 kg /ha	1 kg/ha

(b) Three components

OPTION 1:		
Component A	Component B	Component C
Para grass	Centro	Tropical kudzu
Root splits 60–90 × 90–120cm	4–5 kg/ha	1 kg/ha
OPTION 2:		
Component A	Component B	Component C
Guinea grass	Molasses grass	Stylo
3 kg/ha	1–2 kg/ha	1–2 kg/ha

Seedbed preparation

It should be realized that grass seeds are very small in size (most grass seeds are equal to or less than teff seeds), and thus one has to prepare a seedbed favorable for seed germination, seedling emergence, and growth.

Procedures

- **Clearing trees:** Consider ecological impacts, i.e., hazards of soil erosion and watershed destruction. Methods of clearing are:
  - Mechanical: Manually, using axe or slashers ('gejera').
  - Ring-barking: Removing a strip of surface bark 10 cm wide around the trunk.
- **Ploughing:** First deep-ploughing, then shallow-ploughing to a fine, firm, even, and level seedbed.
- **Rolling:** Done after sowing to consolidate the soil and provide better soil–seed contact.

Fertilizing and manure application

Improved pastures require fertile soils for optimal herbage production. Basal applications of the macronutrients, especially nitrogen (100–150 kg/ha urea) and phosphorus (50 kg/ha triple superphosphate) are helpful for successful establishment. However, considering the economic status of farmers, use of farmyard manure, as much as possible, is advisable at the rate of 5–10 tons/ha (t/ha). If the pasture to be established contains a good proportion of adapted and readily nodulating legumes, the nitrogen application may be ignored or reduced to a starter dose (10–25 kg urea/ha) in anticipation of atmospheric nitrogen fixation after some weeks by the legume component.

Propagation by seed

Seed considerations

True variety: Check that the seed is the right variety recommended for the target area. The best way to do this is to obtain seed from a reliable source.

Seed quality: There is a need to use high quality seed to establish the pasture. Quality is measured in terms of purity and germination. If commercial seed is considered, it is fair to request for a recent seed analysis statement for the seed to be sown, since this will show the quality details. Purity is expressed in terms of the percentages of seed of the sown variety, other crops and weeds, of inert matter (including pieces of straw, soil etc.), and of broken seed. Special attention must be given to the weed seed in the sample so as not to introduce new, potentially serious weeds into the pastureland.

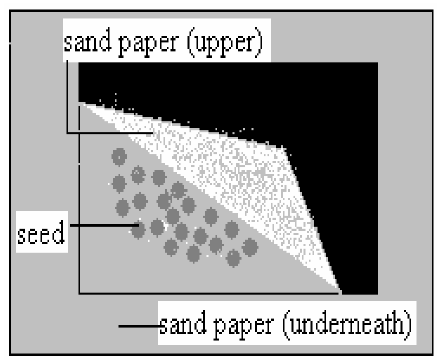


Figure 8.4. Seed scarification by rubbing the seed in between two pieces of sandpaper.

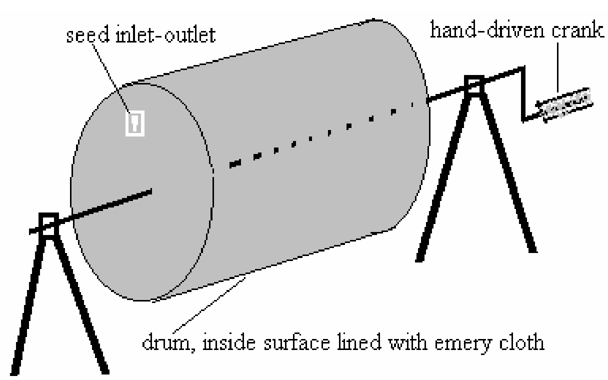


Figure 8.5. Scarifying seed by using a drum scarifier.

Seed dormancy

Seed dormancy is a natural protective phenomenon which prevents premature germination of seed to ensure long-term survival of species.

Two types of seed dormancy

1. **Embryo dormancy:** The embryos are physiologically inactive due to intrinsic germination inhibitors, inactive enzyme systems. These need a period of dormancy after ripening.

2. **Dormancy due to seed coat characters:** Occurs due to a) seed coat mechanisms constricting the expansion and growth of the embryo, b) prevention of the entry of gases and moisture, or c) chemicals in seed coats which inhibit germination.

Methods of breaking seed dormancy

Storage: Holding freshly harvested seed in storage will overcome dormancy problems since dormancy declines with time. Storage is often applied to grass seeds.

Scarification: Scarification treatments are employed prior to sowing to abrade the seed coat and improve permeability, e.g., most legume and some grass seeds such as *Cenchrus, Melinis,* and *Paspalum notatum* require scarification.

Methods of Scarification

Mechanical scarification: The seed coat is abraded by passing over abrasive surfaces or rubbing with sandpaper if sowing small quantities (Figure 8.4). For large quantities, use drum scarifiers. These are seed-mixer drums with an inner surface lined with abrasive material (Figure 8.5).

Hot-water treatment: Immersion of seed in hot water, the temperature and duration of treatment depending on species (Figure 8.6). For example:

- *Chaemacytisus palmensis* at 100 °C for 9 minutes.
- *Leucaena leucocephala* at 75°C for 6 minutes.
- *Phaseolus atropurpreus* at 55°C for 20 minutes.
- *Stylosanthes guyanensis* at 55°C for 20 minutes.

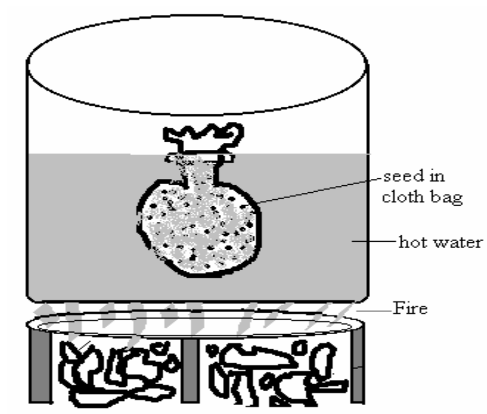


Figure 8.6. Scarifying seed by immersing in hot water.

Inoculation

Inoculation is treating legume seeds with *Rhizobium* bacteria carried in peat medium. The inoculum is usually sold along with the seed. Inoculation is recommended, particularly when introducing new forage species into new areas, to ensure that the species are nodulated by the most effective and efficient *Rhizobium* bacteria strains.

Most native legume species do not require inoculation since they can be infected by bacteria strains living in the soil. An effective nodule is pink on the inside while ineffective nodules are either white or green.

A simple method of inoculation:

- Make slurry of inoculant in water and mix the seed thoroughly to make all seeds wet.

- Add a small quantity of sugar solution (10%) to the slurry to make it sticky. For inoculating 1 kg of seed, a half teacup full of sugar is sufficient.
- Inoculation and drying should be done in the shade.
- Inoculated seeds should be sown within 24 hours of inoculation.

Seed rate

Seed rate depends primarily on the viability and purity of the seed. Furthermore, seed rate depends on seed size, pure stand or mixture, amount of rainfall and soil fertility. As a general guideline, for row planting, sow grasses at 6–8 kg/ha, legumes at 3–4 kg/ha, and fodder shrubs at 10–15 kg/ha. When broadcasting seed, sow at double the rate recommended for row planting.

Sowing practice

Timing: The most desirable time to seed non-irrigated areas is immediately before the season of the most reliable rainfall, and when temperature is favorable. Sow perennial species at the onset of the longest wet season when the soil has received sufficient moisture to support germination and establishment.

Spacing: Generally, spacing between rows should not exceed 25–45 cm and within-row plant spacing should be 5–15 cm.

Depth: Generally, the smaller the seed the shallower the depth of planting. Usually, grasses are sown at the depth of 1–1.5 cm, while medium-sized legume seeds are sown at a 2.5 cm depth.

Method of sowing

Two ways:

1. **Row-sowing**
2. **Broadcasting**

Row-sowing is preferred because it offers the following advantages:

- Low seed rate is required, which is important in view of seed scarcity and cost.
- Better establishment than by broadcasting in case of poor weather conditions.
- Easy weeding and fertilizer application.
- Better exposure of plants to sunlight.

When planting in rows manually, mark the rows with a stick or a row marker that has adjustable spikes. Sow the seeds in the row and cover with a thin layer of soil pressed down by feet (men or animals) to ensure good soil–seed contact.

When row-planting is not possible, broadcasting should be done, in which case the sowing rate should be doubled to compensate for poor seedling survival. To cover surface-sown seeds, drive animals back and forth, or drag a spiny tree branch devoid of leaves. Both methods give good results (Figure 8.7).

Propagation by vegetative parts

Vegetative propagation is necessary for establishing sterile plants, erratic-seeders and for plants giving seed of low genetic stability (hybrid varieties; segregating populations). Some examples:

- Sterile: *Digitaria decumbens (pangola grass).*
- Erratic-seeder: *Pennisetum purpureum* (elephant grass).
- Low genetic stability (bred variety): *Pennisetum clandestinum* (kikuyu grass).

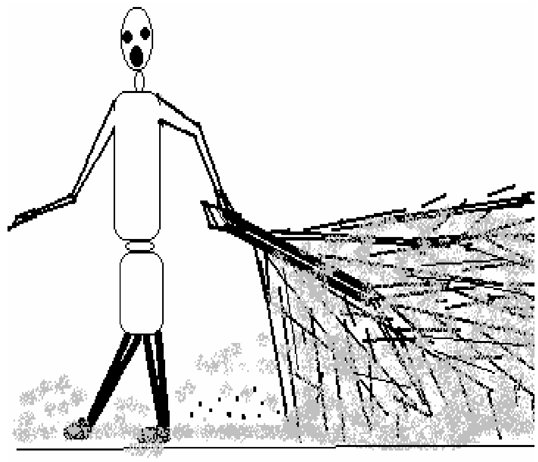


Figure 8.7. Seed covering by dragging a leafless tree branch.

Methods

Tuft division: Tuft splits may be dug out by hand and taken to the establishment area and planted in furrows.

Stem cuttings: Dependent upon favorable moisture conditions. A well-grown stand of mature stems bearing three nodes are cut and planted in furrows or surface broadcast and covered with soil. Two nodes are buried and one is left above ground. The spacing for most grass species is 0.7 × 0.3 m within and between rows. For runner grasses, 2 × 2 m spacing is recommended if weed control is adequate and early season grazing avoided (Figure 8.8).

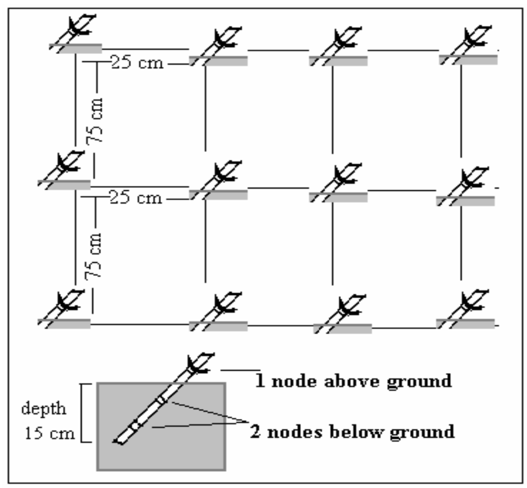


Figure 8.8. Vegetative (stem cutting) propagation.

Propagation by seedlings

Browse trees and shrubs have a better chance of survival if planted as seedlings. It is advisable to raise seedlings two months ahead of the rainy season using plastic bags in a seedling nursery.

The procedures are as follows:

- Prepare a mixture of fine sand, forest soil and farmyard manure.
- Mix well and moisten by sprinkling with water and fill small plastic bags/pots.
- Arrange the bags/pots under a nursery shed and plant viable seeds (two seeds per hole if seed is not limiting).
- Supply adequate water daily. Monitor germination and remove any weeds.
- Thin seedlings to one strong plant per pot.
- At the start of the rainy season, dig planting holes in the target field a week or so before planting to allow adequate water infiltration.
- Preferably on a cloudy day, plant the seedlings in the prepared holes. Fill the hole first with the topsoil followed by the subsoil and press firmly.

8.2.3. Management after sowing

Weed management

The newly established pasture has to be kept free of coarse weeds, especially broadleaf weeds, which are usually a threat to sward consolidation. Remove weeds by hand or by spraying herbicides before weeds flower. This reduces competition when grasses are weak while minimizing further perpetuation of weeds by seed.

Fertility management

Fertilizers should be applied according to the fertility status of the soil. To determine what nutrients are needed:

- Observe characteristic symptoms, e.g., leaf yellowing is likely a nitrogen deficiency.
- Undertake soil and plant tissue analysis.
- Know the characteristics of the plant, e.g., tall and rank-growing grasses such as elephant grass and *Panicum* species are heavy feeders and require more frequent fertilizer applications than thinner and shorter stature grasses.

Generally, legumes have a high requirement for phosphorus (P), sulphur (S) and Molybdenum (Mo); grasses have a high requirement for nitrogen (N), P, and Potassium (K). Levels of nutrients used will depend on soil type, species used, level of production required, and production system (cut-and-carry systems require greater maintenance inputs than grazing systems). Typical levels of nutrients required for annual maintenance (Cook *et al*, 2005) are 50–300 kg/ha N; 10–20 kg/ha P; 25–50 kg/ha K; 30 kg/ha S; and 100–200 kg/ha Mo. Nitrogen is often applied at each grazing or cutting. Phosphorus should also be applied especially if the legume component loses vigor due to grass dominance. Manipulating the ratio of application of nitrogen and phosphorus is a useful management technique to maintain a desirable balance between the grass and legume components.

Grazing/defoliation management

- The newly established pasture can be utilized within 2–8 months after sowing. This is only possible if proper grazing or cutting is ensured.
- Rotational or periodic grazing is usually recommended. However, some species may not respond to rotational grazing and this situation has to be treated cautiously. As a precaution, stocking rate should be highly reduced or grazing totally stopped when no more than 50% of the weight of herbage has been consumed.
- If sown pastures are well utilized and maintained with fertilizers, they will continue to provide high herbage yield for up to about five years and start to decline thereafter.

Transferable Message

- Select progressive farmers to demonstrate your choice of interventions. Usually, cultivated pastures should go with maintaining improved breeds. It is, therefore, advisable to promote cultivated pasture production among farmers that keep improved breeds.
- Organize a training session and show farmers the different methods of pasture establishment.
- Organize demonstration visits by other farmers and encourage discussions on the practice.

8.3. Agronomic Characteristics of More Important Forage Species

8.3.1. Annual fodder crops

Oats (*Avena sativa* L.)

Figure 8.9. Oats (*Avena sativa*).

- ***Botanical description:*** Erect annual grass up to 1.5 m tall (Figure 8.9).
- ***Adaptation*:** Commonly grown annual crop in cool areas for fodder or grain.
  - Altitude range: 1700–3000 m.a.s.l.
  - Climatic requirement: 500–800 mm mean annual rainfall, cold- and frost-tolerant.
  - Soil requirement: Fairly tolerant to water logging.
- ***Cultivation:*** Requires a well-prepared seedbed.
  - Propagation: By seed; sowing rate 70–80 kg/ha in pure stand. In mixtures: with vetch: 60 kg/ha + vetch 15–20 kg/ha; with pea: 60 kg/ha + pea 20 kg/ha.
  - Fertilizer requirement: Gives better yield when fertilized with nitrogen and phosphorus fertilizers.
  - Companion species: *Trifolium alexandrinum, Vicia dasycarpa, Vicia villosa, Lathyrus sativus.*
- ***Utilization:*** Fodder crop as green feed or conserved as hay.
- ***Productivity:*** Yields of up to 10–52 t/ha of fresh herbage have been reported.
- ***Reproduction:*** Seed yield up to 10 quintals/ha or more (1 quintal = 100 kg).
- ***Special merits:*** It is the best annual fodder grass for the highland areas, often conserved as hay for dry-season feeding.

Figure 8.10. Vetch (*Vicia dasycarpa*).

Vetch (*Vicia dasycarpa* L.)

- ***Botanical description:*** Climbing, sprawling annual legume (Figure 8.10).
- ***Adaptation:*** Medium- to high-altitude highlands.
  - Altitude range: 1500–3000 m.a.s.l.
  - Climatic requirement: Wide rainfall range, can survive as low as 400 mm.
  - Soil requirement: Versatile.
- ***Cultivation:*** Can be established on a rough seedbed.
  - Propagation: By seed at the rate of: 20 kg/ha (pure stand); 12 kg/ha (undersown); 5–12 kg/ha (pioneer component of pasture mix); 12–20 kg/ha (sown with oats).

- ♦ Fertilizer requirement: Apply 20–40 kg P/ha at planting.
- ♦ Companion species: Oats (*Avena sativa*).

- ***Utilization:*** As conserved fodder (hay) crop in mixture with oats; good for under-sowing maize and sorghum; excellent as pioneer crop.
- ***Productivity:*** Up to 6 t/ha DM as pure stand.
- ***Reproduction:*** Cross-pollinated. Seed yield 400–1000 kg/ha.
- ***Special merits:*** Excellent as pioneer crop and as fodder crop for haymaking.

8.3.2. Temperate perennial forage crops

Cocks foot (Orchard grass) (*Dactylis glomerata* L.)

Figure 8.11. Cocks foot (*Dactylis glomerata*).

Figure 8.12. White clover *(Trifolium repens L.).*

- ***Botanical description:*** Tufted perennial (Figure 8.11).
- ***Adaptation:*** Highland adaptive, cold- and frost-tolerant.
  - ♦ Altitude range: Highlands 2000–3000 m.a.s.l.
  - ♦ Climatic requirement: Mean annual rainfall 400–1500 mm, cold- and frost-tolerant.
  - ♦ Soil requirement: Versatile in its soil requirement provided drainage is adequate.
- ***Cultivation:*** Requires a well-prepared seedbed.
  - ♦ Propagation: By seed, sown at the rate of 2 kg/ha.
  - ♦ Fertilizer requirement: Responds well to N and P application.
  - ♦ Companion species: *Trifolium alexandrinum, Vicia dasycarpa, Vicia villosa, Lathyrus sativus.*

- ***Utilization:*** Grazing or cutting should be moderate, sensitive to both under-use and over-use. Mainly utilized for mixed pastures.
- ***Productivity:*** Up to 5–9 t/ha DM.
- ***Reproduction:*** Seed production up to 200 kg/ha.
- ***Special merits:*** Cold- and frost-tolerant; good for grazing pastures for dairy industries.

White clover (*Trifolium repens* L.)

- ***Botanical description:*** Trailing perennial legume up to 30 cm high (Figure 8.12).

- ***Adaptation:*** Cool tropical highlands.
  - Altitude range: 1800–3000 m.a.s.l.
  - Climatic requirement: Mean annual rainfall 800–1500 mm.
  - Soil requirement: Versatile.
- ***Cultivation***: Well-prepared seedbed
  - Propagation: By seed at 3–6 kg/ha.
  - Fertilizer requirement: Responds well to P and S application.
  - Companion species: *Bracharia humidicola, Digitaria decumbens, Pennisetum clandestinum, Setaria anceps.*
- ***Utilization:*** Most suited for grazing.
- ***Productivity:*** About 1.5–2.5 t/ha DM.
- ***Reproduction:*** Cross-pollinated.
- ***Special merits:*** Good as grazing pasture for high-altitude highlands.

Figure 8. 13. Buffel grass *(Cenchrus ciliaris L.*).

8.3.3. Tropical perennial grasses

Buffel grass (*Cenchrus ciliaris* L.)

Figure 8.14. Colored Guinea grass *(Panicum coloratum* L.).

- ***Botanical description:*** Tufted or spreading perennial grass 12–120 cm tall; has a large strong root system (Figure 8.13).
- ***Adaptation:*** Adapted to semi-arid conditions.
  - Altitude range: Sea level to 2000 m.a.s.l.
  - Climatic requirement: Mean annual rainfall 375–750 mm (does not do well in high rainfall areas, but its rainfall requirement ranges widely: 300–1000 mm); temperature 20–30^{o}C; less cold-tolerant than green panic.
  - Soil requirement: Prefers light-textured soils of high P status, but still performs well on self-mulching soils; has only moderate salt tolerance.
- ***Cultivation:*** Light cultivation.
  - Propagation: By seed at the rate of 6-8 kg/ha for drilling in rows and 12 kg/ha for broadcasting. Sowing depth is 1–2 cm; rolling or cattle trampling after sowing improves establishment.
  - Fertilizer requirement: Responds to N application up to 160 kg/ha. Buffel grass has a reputation as a phosphorus-loving grass.
  - Companion species: *Stylosanthes humilis, Neonotonia wightii, Macroptilium atropurpureum, Medicago sativa.*
- ***Utilization:*** Good for grazing and haying.
- ***Productivity:*** Buffel grass is not a heavy producer and herbage yields usually range between 2 and

8 t/ha DM.

- ***Reproduction:*** Apomictic; seed yield 10–60 kg/ha.
- ***Special merits:*** Excellent in drought and firing tolerance; recovers rapidly after drought-breaking rains.

Colored Guinea grass *(Panicum coloratum* L.*)*

- ***Botanical description:*** Tufted perennial with variable habit, up to 150 cm high (Figure 8.14).
- ***Adaptation:*** Adapted to drier (400 mm) lowland alluvial flood plains of southern Africa (Makarikari, Botswana)
    - ♦ Altitude range: 500–2000 m.a.s.l.
    - ♦ Climatic requirement: Rainfall 600–1200 mm; optimum temperature 17–21^{o}C; susceptible to frost.
    - ♦ Soil requirement: Adapted to red and black clay soils. It makes its best expression on black clay soils.
- ***Cultivation:*** Requires a well-prepared seedbed. Propagation is by seed at the rate of 5–7 kg/ha for broadcasting and 2–3 kg/ha for row planting; sowing depth 2 cm. Planting by rooted cuttings can also be done.
    - ♦ Fertilizer requirement: Responds well to N application; reported to fix N (23 Kg/ha in 100 days).
    - ♦ Companion species: *Desmodium uncinatum, Neonotonia wightii, Macroptilium atropurpureum.*
- ***Utilization:*** Good for grazing and haying.
- ***Productivity:*** Yields are usually around 12 t/ha DM but ranges of 5.8–18 t/ha DM have been reported.
- ***Reproduction:*** Cross-pollinated sexual, with some apomixis; seed yields 45–400 kg/ha.
- ***Special attributes:*** Drought-resistant; tolerates seasonal waterlogging.

Elephant grass (Napier grass, English or *Zihone sar*, Amharic) (*Pennisetum purpureum*)

- ***Botanical description:*** Robust perennial with a vigorous root system, sometimes stoloniferous with a creeping rhizome, culms 180–360 cm high (Figure 8.15).
- ***Adaptation:*** Best-adapted to high-rainfall areas.
    - ♦ Altitude range: Sea level to 2000 m.a.s.l.
    - ♦ Climatic requirement: Rainfall 1480–1620 mm/y; optimum temperature 25–40^{o}C; resists drought if successfully established. Susceptible to frost.
    - ♦ Soil requirement: Prefers deep, friable fertile soils.
- ***Cultivation:*** Full land preparation.
    - ♦ Propagation: Usually by stem cuttings buried in 15 cm furrows, 2 nodes in soil and one exposed. One ha of grass provides planting material for 15–20 ha.
    - ♦ Fertilizer requirement: Responds well to fertilizers applied after every cut.
    - ♦ Companion species: *C. pubescens, N. wightii, P. phaseoloides.*
- ***Utilization:*** Commonly used in a cut-and-carry system; also made into silage. For grazing, it should be heavily stocked to maintain it in a lush vegetative form; best grazed when the new growth consists of 5 new leaves. Slash coarse leafless stems. Makes good hay if cut when young; usually made into silage of high quality without additives.
- ***Productivity:*** Highest DM yield recorded is 84.8 t/ha when it was fertilized with 987 kg N/ha/yr

and cut every 90 days under rain-fed conditions (2000 mm/yr) (Puerto Rico). In Hawaii, it produced 336 t green forage/ha/yr. In Colombia, a 2.5 ha plot of elephant grass forage maintained 35 milking cows producing an average of 15 liters of milk/day supplemented with 1 kg concentrate per 4 kg milk.

- ***Reproduction:*** Cross-pollinated; erratic seeder.
- ***Special attributes:*** High DM yield; deep roots can forage widely for moisture and N.

Figure 8.15. Elephant grass, (Napier grass), (English) *Zihone sar* (Amharic) (*Pennisetum purpureum*).

Figure 8.16. Rhodes grass (*Chloris gayana*).

Rhodes grass *(Chloris gayana* Kunth)

- ***Botanical description:*** Stoloniferous perennial grass with the erect leafy stems up to 1.5 m bearing at the top 10–12 radiating brownish-green seed spikes (Figure 8.16).
- ***Adaptation:*** Wide range of adaptation; moderate frost tolerance.
  - ♦ Altitude range*:* 600–2000 m.a.s.l.
  - ♦ Climatic requirement: Rainfall 650–1200 mm.
  - ♦ Soil requirement: Versatile.
- ***Cultivation:*** Well-prepared seedbed. Propagation is by seed at the rate of 0.5–7 kg/ha depending upon amount of rainfall. Seeding depth should not exceed 0.6–1.3 cm.
  - ♦ Fertilizer requirement: Responds well to increasing levels of N application if in balance with P.
  - ♦ Companion species: *Stylosanthes guyanensis, Neonotonia wightii, Macroptilium lathyroides, M. atropurpureum, Medicago sativa, Centrocema pubescens.*
- ***Utilization:*** Good for grazing and haymaking. If underutilized, it becomes stemmy especially if soil fertility declines.
- ***Productivity:*** Under farm conditions, 5–8 t/ha DM; with high N application and variable cutting frequency yields up to 25 t/ha DM have been reported.
- ***Reproduction:*** Cross-pollinated; isolation distance of 200 m is recommended in seed production. Seed yields 65–650 kg/ha, often two crops per year.

- ***Special merits:*** It is the best perennial grass adapted to most medium- to high-altitude highlands of Ethiopia with moderate amount of rainfall. Good seeder so it can be established from home-grown seed. Its vigorous root system confers appreciable drought tolerance, although not as much as buffel grass, green panic or blue panic. It has special value in its salt tolerance. It is also tolerant to fire; withstands heavy grazing; is suitable for erosion control, being one of the best species for sowing on earthwork.

Figure 8.17 Para grass (*Brachiaria mutica*).

Para grass (*Brachiaria mutica* (Forsk.) Stapf)

- ***Botanical description:*** A short-culmed stoloniferous perennial grass up to 2 m high (Figure 8.17).
- ***Adaptation:*** Semi-aquatic high-rainfall/moisture area adaptive.
  - Altitude range: Sea level to 1000 m.a.s.l.
  - Climatic requirement: Minimum of 900 mm mean annual rainfall; 15–21°C mean annual temperature; frost sensitive.
  - Soil requirement: Alluvial and waterlogged soils.
- ***Cultivation:*** Light cultivation for vegetative and fine seedbed for seed propagation.
  - Propagation: Usually by cuttings of 25 cm or 3 node-sized stem spaced 1 m. apart. Also by seed at the rate of 2.5–4.5 kg/ha, no deeper than 1cm, roll after sowing.
  - Fertilizer requirement: Responds well to N and P application.
  - Companion species: *Desmodium heterophyllum, Pueraria phasioloides, Centrocema pubescens, Calopogonium mucunoides.*
- ***Utilization:*** Suitable for deffered grazing, start grazing after full establishment, avoid grazing/cutting close to ground level, makes good hay or silage with a DM loss of only 10%.
- ***Productivity:*** Two- to four-cuttings per season each, 2.5–7.5 t/ha DM, with irrigation, 84.3 t/ha fresh (24 t/ha DM).
- ***Reproduction:*** Usually by vegetative means.

Figure 8.18. Guinea grass (*Panicum maximum*).

Guinea grass (*Panicum maximum* Jacq.)

- ***Botanical description:*** Tufted perennial with a shortly creeping rhizome; variable habit 60–200 cm high (Figure 8.18).
- ***Adaptation:***
  - Altitude range: Sea level to 2500 m.a.s.l.
  - Climatic requirement: 780–1797 mm mean annual rainfall (usually in excess of 1000 mm); optimum temperature 19–23°C; does not tolerate heavy frosts.
  - Soil requirement: Versatile; more productive on fertile soils; tolerates acidity; does not tolerate drought or waterlogging.
- ***Cultivation:*** Full seedbed preparation is required.
  - Propagation: By seed at 3–6 kg/ha; by sods spaced 0.6 × 1.25 m; cuttings 15 × 45 cm spacing.
  - Fertilizer requirement: Responds well to N and P application.
  - Companion species: *Centrocema pubescens, Stylosanthes guyanenesis, Macroptilium atropurpurium, Neonotonia wightii.*
- ***Utilization:*** Stands defoliation if grazed or cut below 30 cm, graze only after the first seeding period. Makes good hay and silage. With optimum fertilization, stocking rate of 4.2 beasts/ha with annual live weight gains of 377 kg/ha for pure Guinea grass and 601 kg/ha in mixture with *C. pubescens* reported.
- ***Productivity:*** Up to 60 t/ha DM when 300 kg N/ha was applied (cv. Makueni) (Queensland); up to 26.8 kg/ha DM with 440 kg N/ha, cut at 40 days intervals (Puerto Rico).
- ***Reproduction:*** Facultative apomict, with 1–5% sexual reproduction. Seed yield 45–156 kg/ha; harvest seed after 12–24 days from panicle emergence.
- ***Special attributes:*** Wide adaptation, quick growth, easy to establish from seed, good response to fertilizers.

Figure 8.19. Green leaf desmodium (*Desmodium intortum*).

Figure 8.20. Common stylo (*Stylosanthes guianensis*).

8.3.4. Tropical perennial forage legumes

Green leaf (*Desmodium intortum*)

- ***Botanical characteristic:*** Vigorous perennial herb with ascending or scandent, branched reddish-brown stems (Figure 8.19).
- ***Adaptation:*** Best adapted to high rainfall areas exceeding 900 mm, with altitude range 800–2500 m.a.s.l.
- ***Herbage yield potential:*** Varies widely from 3–20 t/ha DM in pure stands.
- ***Cultivation:***
  - Propagation: by seed at the rate of 1–2 kg/ha in rows 45 cm wide. Green leaf is highly specific in its Rhizobium requirement.
  - Fertilizer: Reported to respond well to P and K application.

- ♦ Companion species: Combines well with *Panicum maximum, Melinis minutiflora,Paspalum plicatulum, Digitaria decumbens Bracharia mutica, Pennisetum clandestinum.*
- ***Reproduction:*** Self- and cross-pollinated. Sensitive to photoperiod; it is a short-day plant. Seed yields 100–120 kg/ha.

Common stylo (*Stylosanthes guianensis* (Aublet) Swartz)

- ***Botanical characteristics:*** Erect or sub-erect perennial herb 30–120 cm high (Figure 8.20).
- ***Adaptation:*** Grows best under warm climate; wide range of rainfall 600–2500 mm; survives long dry periods; tolerates low pH or low P status due to endotrophic mycorhiza found in the roots.
- ***Herbage yield potential:*** Varies widely from 2.5–10–15 t/ha DM (as pure). Good for over-sowing natural pasture.

- ***Cultivation:***
  - ♦ Propagation: By seed sown at the rate of 2–3 kg/ha. Seed treatment essential by using one of the following methods:
    - Mechanical scarification of seed using drum scarifiers.
    - Boiling for 10 seconds.
    - Freezing to 17°C for 7 days.
  - ♦ Inoculation is necessary for some cultivars.
  - ♦ Fertilizer: P is needed on poor soils, normal rates are in the order of 50–100–150 kg super-phosphate/ha.
  - ♦ Companion grasses: *Digitaria decumbens. D. smutsii, Chloris gayana, Cenchrus ciliaris, Melinis minutiflora, Setaria anceps Andropogon gayanus, Heteropogon contortus, Hyparrhenia rufa, Panicum maximum, Pennisetum polystachion.*
- ***Reproduction:*** Self-pollination, but cross-pollination can occur. Seed yield ranges 75–200 kg/ha.

Figure 8.21. Axillaris *(Macrotyloma axillare)*;.

Figure 8.22. Lucerne (Alfalfa), (*Medicago sativa*).

Axillaris (*Macrotyloma axillare* (E. Meyer) Verde.)

- ***Botanical description:*** Climbing perennial legume (Figure 8.21).
- ***Adaptation:***
  - ♦ Climatic requirement: Best adapted to areas where rainfall exceeds 1000 mm; tolerant of drought but susceptible to frosting and water logging.
  - ♦ Soil requirement: Prefers light soil; tolerates soil acidity.
- ***Cultivation:*** Light cultivation.
  - ♦ Propagation: By seed at the rate of 3–5 kg/ha.
  - ♦ Fertilizer requirement: Responds well to N and

P application.

- ♦ Companion species: *Panicum maximum, P. coloratum, Chloris gayana, Sorghum sudanense.*

- ***Utilization:*** Mixed pastures utilized for grazing and hay making.
- ***Productivity:*** Variable.
- ***Reproduction:*** Self fertilized; seed yield 200 kg/ha.

Lucerne (alfalfa) (*Medicago sativa* L.)

- ***Botanical description:*** Erect perennial herb with deep-growing taproot (Figure 8.22).
- ***Adaptation:***
  - ♦ Altitude range: Wide range of adaptation from 500–3000 m.a.s.l. altitude and above.
  - ♦ Climatic requirement: Best adapted to warm, temperate climate. Because of its deep-rooted habit, it can be grown in areas receiving as little as 550 mm of annual rainfall.
  - ♦ Soil requirement: It is quite intolerant of water logging and requires fertile, well-drained soils. It prefers neutral or alkaline (lime-rich) soils. It is susceptible to acid soils unless top-dressed with lime.
- ***Cultivation:*** Well-prepared fine, firm seedbed is required for best result. Propagation is by seed sown at a rate varying with soil moisture: generally 6 kg/ha for rain-fed; 2 kg/ha for areas receiving 600–750 mm of annual rainfall. The rate suggested when sowing in mixtures with grasses is 0.5–2 kg/ha. [Other reports suggest 8–10 kg for pure stand, 5–6 kg/ha for mixtures.] For irrigated pastures, the recommended rate is 14–15 kg/ha so as to obtain fine stems for best hay quality and to control weeds. Sowing depth of 0.5–1.0 cm for heavy soils. Seed inoculation may be necessary if native pastures do not contain medics.
  - ♦ Fertilizer requirement: Lucerne has high demand for nutrients. Phosphorus may be required for establishment.
  - ♦ Companion species: Combines with *Panicum maximum, Chloris gayana, Cenchrus ciliaris, Sorghum almum.*
- ***Utilization:*** Utilized as grazed mixed pasture, as hay or as green fodder. Cut or graze at 30–40 days interval or at 10% flowering.
- ***Productivity:*** Variable according to moisture supply. Yields of 7–9 t/ha/yr are expected and 11 t /ha/yr is quite often achieved.
- ***Reproduction:*** Cross-fertilized; bees necessary for pollination. Seed yields 100–300 kg/ha.
- ***Special merits:*** Lucerne is the most successful conserved fodder in the tropics and has special application in the dairy business. It is ideal for irrigated pasture. Under irrigated conditions at Debre Zeit, harvests every 3–4 weeks (12 times a year) have been possible.

8.3.5. Fodder trees and shrubs

Leucaena (*Leucaena leucocephala*)

- ***Botanical description:*** A long-lived shrub or tree up to 20 m high (Figure 8.23).
- ***Adaptation:*** Performs best under warm

Figure 8.23. Leucaena (*Leucaena leucocephala*).

climate at low altitudes less than 2000 m, sensitive to frost, drought-tolerant, can grow at 400 mm annual mean rainfall.

- ♦ Altitude range: less than 2000 m.a.s.l.
- ♦ Soil requirement: Well-drained soils; not tolerant to acid soils; favors a range of soils neutral to alkaline (pH 6.0).

- ***Cultivation:*** Light cultivation for direct sowing; dug holes for transplanting.
  - ♦ Propagation: Propagation by seed sown at 4–7 kg/ha, but different rate or spacing can be used depending on utilization; sowing depth: 2–3 cm. Spacing when sown 2–2.5 m between rows to up to 4.0 m between rows/alleys. Usually planted by seedlings.
  - ♦ Treatments: Seed treatment necessary. Hot-water treatment 60–80^{o}C; H_2SO_4 for 10 minutes.
  - ♦ Inoculation with appropriate rhizobium strain is helpful.
  - ♦ Fertilizer requirement: On acid soils, liming may be necessary.
  - ♦ Companion species: May be planted to pasture grasses in inter-row spaces.
- ***Utilization:*** Cut at 80–100 cm height every 6–8 weeks; use as supplementary ration 25–30%; beyond this level, animals develop enlarged thyroid gland or goiters because of mimosine (an alkaloid) preventing animals from using iodine efficiently.
- ***Productivity:*** Considered the best fodder tree in the world. Multipurpose (for fodder, fuel, pulp, immature shoots and seeds for human consumption, shade and hedge). Yields of 50 t/ha (cut at ground level) and 40 t/ha (at 75cm) have been reported. Despite inconsistent figures 10–20 t/ha DM can be expected.
- ***Reproduction:*** Self-pollination prevails, although cross-pollination is possible; prolific seeder.
- ***Special merits:*** Vigorous plant of high yield and high-quality protein; leaves and thin twigs well-accepted by livestock.

Figure 8.24. Sesbania (*Sesbania sesban*).

Sesbania (*Sesbania sesban* Scopoli)

- ***Botanical characteristics:*** Relatively short-lived (6–7 years) shrub or small tree up to 6 m high (Figure 8.24).
- ***Adaptation:*** A wide range of adaptation, 200–2400 m.a.s.l. Grows best under moisture-stress free conditions, versatile in its requirement.
- ***Herbage yield potential:*** The best fodder tree second only to Leucaena.
- ***Cultivation:***
  - ♦ Propagation: By seed; seed must be scarified by immersing the seed in concentrated sulphuric acid for 30 minutes; also mechanically by using drum scarifiers. Plant seedlings at the onset of first rains. Spacing: variable according to uses:
    - Continuous hedges: 50 seeds/m or 2–3 seeds/hole at 0.5 spacing.
    - Alley cropping: up to 4 m or more between alleys.
- ***Utilization:*** Cut at 0.5–1.0 m height at 6–8 week intervals; use as supplement (20–30%) with crop residues. There is no toxicity if higher levels are fed.

- ***Reproduction:*** Cross-pollinated; prolific seeder.

Pigeon pea (*Cajanus cajan*)

Figure 8.25. Pigeon pea (*Cajanus cajan*).

Botanical description: Erect shrub or short-lived perennial herb (2–3 years) up to 1–4 m high (Figure 8.25).

- ***Adaptation:*** Adapted to arid and semi-arid environments. Favors warm climate, drought-resistant but susceptible to frost; can grow at 500–800 m annual rainfall; tolerates acid soils.
- ***Cultivation:***
  - Propagation: Established from seed sown at the rate of 4–6 kg/ ha or 1–20 kg/ha broadcast. Spacing: about 1 m apart between rows.
  - Treatments: Seed scarification and inoculation are not necessary.
  - Fertilizer requirement: Responds favorably to P fertilizer but negatively to N.
- ***Utilization:*** Dual-purpose crop for food and forage. For forage: cut when the first pods begin to ripen at 50–25 cm height.
- ***Productivity:*** Up to 12 t/ha DM
- ***Reproduction:*** Essentially self-pollinated and self-fertilized, but cross-fertilization by bees can occur.
- ***Special merits:*** Dual purpose crop; tolerant to soil acidity. Can be used as a semi-permanent, perennial component in alley cropping systems. Grown as hedgerow for windbreaks, and as ground cover or shade cover for establishing plantation crops, e.g., coffee. Good nitrogen fixation makes it a useful green manure.

Figure 8.26. Tree lucerne (tagasaste) (*Chamaecytisus prolifer*).

Tree Lucerne (Tagasaste) (*Chamaecytisus prolifer*)

- ***Botanical characters:*** Shrub or small tree (Figure 8.26).
- ***Adaptation:*** Wide range of adaptation from low to 3200 m.a.s.l. altitude, the only browse legume adapted to higher altitude highlands of Ethiopia. Tolerates infertile and acid soils and droughts once established. Needs good drainage.
- ***Cultivation:***
  - Propagation is by seed sown directly or by transplanting. Spacing 30–50 cm between plants.
  - Seed treatment necessary. Dip in boiling water for 5–10 minutes.
  - Inoculate if possible.
- ***Utilization:*** Establishment is slow. Commence cutting in the second year. Cut at 1 m height every 6–8 weeks. Use as a supplement to crop residues.

- ***Reproduction:*** Seed yield up to 0.5 kg/tree.
- ***Special merits:*** Useful as a multipurpose fodder tree for cut-and-carry fodder, ornamental, windbreak and for bee forage, fuel wood and biogas. Tagasaste can be planted as a hedge and also has potential for alley-cropping systems. Grows well on light, well-drained sandy soils on slopes and hillsides. It has a wide range of adaptability to soil pH (4.0–8.5). Tagasaste grows well up to altitudes approaching 3,000 m in the tropics and is one of the few fodder trees that can withstand frost as low as -9ºC in the tropical highlands (Cook *et al*, 2005).

Figure 8.27. Fodder beet grown under supplementary irrigation and farmyard manure application at Debre Zeit Research Center.

8.3.6. Root fodder crops

Fodder beet (*Beta vulgaris*)

- ***Botanical characteristics:*** Biennial tuberous herb (Figure 8.27).
- ***Adaptation:*** Highland crop (1800–3000 m.a.s.l.). Needs long growing season, 5–7 months of 750 mm rain or over.
- **Soil***:* fertile sandy soil, avoid water logging.
- ***Yield potential:*** Under well-fertilized and irrigated conditions at Debre Zeit Research Center, each tuber had a fresh weight of 37.5 kg in about 5–7 months growth period.
- ***Cultivation:***
  - Propagation:
    - Direct seeding 5 kg/ha; sowing depth, 2 cm; plant in rows 40 cm apart and thin to 20–25 cm between plants when two real leaves have been developed.
    - Transplanting from nurseries planted 1–2 months ahead of planting time gives it a competitive advantage over weeds.
  - Seed production is stimulated by cold: Altitude of 2500–2750 m.a.s.l. is suitable.
  - Fertilizer: Fodder beet is a heavy feeder and thus it should be planted near an animal corral for easy application of manure.
- ***Utilization:*** Used in intensive management systems in dairy or fattening enterprises. Beets must be chopped before feeding.
- ***Reproduction:*** Seed production is stimulated by frost. In Ethiopia, areas with altitudes of 2500–2700 m are suited for fodder beet seed production. Seed yield is about 400–500 kg/ha.

8.4. Forage Seed Production

The major impediments to the progress of improved forage development include:

- Poor availability of planting material both in amount and diversity.
- Imported seed is expensive and at times difficult to obtain on time. For example, a kilo of alfalfa seed costs more than Birr 100.00 (1 US$ = 9.2 Birr), a price that a subsistence farmer cannot afford.
- Certain forage legumes cannot be successfully grown without specific inoculum, which is not readily available and difficult to handle.

8.4.1. Suggested institutional arrangement to promote forage seed production

Establishment of a non-profit forage seed project

The demand and supply of forage seed has never been predictable. Sometimes, there is a demand for thousands of quintals, while at other times, thousands of quintals of seed are stored for long periods for lack of market. Therefore, until improved forage utilization is well-adopted and the demand becomes predictable, regional forage seed enterprises similar to the Ethiopian Seed Enterprise (but neither profit-making nor obligatory expense-retrieving) must be established. The enterprises can gradually pull out as demand increases and private investors get interested.

Promotion of seed producer cooperatives

In selected areas where demand for improved forage seed is high and the environment is convenient for seed production, farmers may be organized into cooperatives where they pool their land to produce seeds of elite forage crops to sell to users elsewhere. Assistance should be sought from regional governments for technical backstopping and providing facilities: foundation seed, farm inputs, irrigation and access to markets.

Site selection

Forage seed production sites must be accessible and as much as possible located in lands suitable for cultivation, irrigation, and fertilizing. Other ecological requirements for a suitable site include:

- A climate and soil suitable to most elite forage species or at least the target species.
- The area must be free of noxious weeds, pest and diseases.
- Adequate space to make isolation possible for multiplying cross-pollinated species.
- Adequate growing season with ample rainfall.
- Access to irrigation to make multiple harvests possible and guarantee against fluctuating rain distribution.
- Free from frost: ensure the site is not located in a frost-pocket in the landscape.
- Sunny weather during flowering to initiate reproductive development, flower opening, pollination and facilitate seed harvesting.

Seedbed preparation

A clean and firm seedbed is necessary to ensure a strong and dense plant population that will compete successfully with weeds and produce high quantity and quality seed.

Seed quality and treatment

Follow suggested procedures in the section under forage establishment.

Sowing operation

Small-seeded forages are usually broadcast on a fine and firm seedbed and then trampled by sheep and goats to ensure better soil–seed contact. If collection of shattered seed is expected for very small-seeded species, the seedbed has to be rolled lightly and leveled. Larger seeds are drilled in rows or buried by driving sheep and goats back and forth. Forage seed crops are usually drilled in rows wide enough (60–122 cm apart) to make weeding and harvesting operations easy, and seeding rates are often low (2–7 kg/ha).

Fertilization

For grass-seed crops, nitrogen is the most limiting soil nutrient. Generous amounts of nitrogen, often in combination with phosphorus, substantially increase seed yield of grasses (100–150 kg/ha diammonium phosphate). Nitrogen application varies with soil fertility, moisture level and the type of species sown. Legume seed crops are independent of soil N levels as long as they effectively fix atmospheric nitrogen.

Weed, pest and disease control

- Weeds affect seed yields and quality. Efficient weed control reduces contamination with weed seeds during harvesting.
- Thorough and repeated cultivation, hand weeding, use of herbicides, crop rotations, etc., offer a reasonable degree of weed eradication.
- Pests like mole rats, porcupines, wild herbivores and insect pests can be a threat to pasture seed crops.
- Insect larvae of the Sesbania beetle (*Mesoplatis orchoptera*), for example, can devastate plots of stands overnight.
- Control measures against such serious insect pests could be expensive at an advanced level of infestation and thus prompt spot-spraying at the earliest detection with recommended chemicals is necessary.
- Diseases, especially fungal, are more serious in grasses than in legume seed crops.
- Disease-control measures in forage crops are based on the use of resistant crop varieties and employing pre-emptive cultural practices such as:
  - crop rotations
  - burning of infected plants
  - solar treatment of soil
  - use of clean and treated seed

Harvesting

- Efficient timing and harvesting techniques result in high quality and quantity of seed production.
- Species in the genera *Panicum* and *Brachiaria* are the most difficult in this regard where there is premature shattering or seeds are harvested by birds while still green.
- Techniques of determining optimum harvest time vary with the species. One has to closely watch the change in color, ease of removal from the rachis (or pod in legumes), and seed hardness.
- Grass species such as *Brachiaria* require sweating — a procedure whereby the upper portion of the crop, along with the inflorescence, is mowed at the right stage of seed development and heaped immediately after harvest and left under a shed to 'sweat' to assist the final maturation of the caryopsis. Thereafter, the material is gently beaten to separate the seed from the sheaves and cleaned.

Harvesting implements

At the smallholder level, the available simple and practical techniques are:

- Hand-picking of the inflorescence or pod.

- Shaking the sheaves and collecting the seeds falling on a sheet of canvas placed underneath the crop.

Cleaning and drying

The drying process must be done under a shed to protect the seed from direct sunlight. Grass seeds are more sensitive to drying processes than legume seeds and should be dried slowly under a shed to maintain high viability. Legume pods and grass inflorescence heaps should be turned regularly once a day to ensure uniformity of drying.

After drying, the material could be threshed by trampling with feet, lightly pounding with local wooden mortar (*mukecha*) or beating with sticks. Final cleaning can be done traditionally using a grass plate (*sefeid*) and sieve (*wonfeet*).

Storage

Cleaned and properly dried seed must be stored in a cool, dry place. Seeds may be stored in cloth bags which provide good aeration. For both grass and legume seeds storage in plastic bags should be avoided. Seed storehouses should have high roofs for efficient ventilation and to keep the temperature as low as possible. Vent holes around the wall above the ceiling will provide movement of hot air out of the space in between the ceiling and iron roof. The seed storeroom should be clean and free from insects and rodents. Generally, seed must be kept at a room temperature not exceeding 15^{o}C with a relative humidity below 45% for short-term (2–3 years) storage.

8.4.2. Suggested sources of foundation seed

Foundation seed for initiating forage seed multiplication may be found at/through one of the following:

- National and international research institutes
  - ♦ Ethiopian Institute of Agricultural Research
    - Holetta Research Centre
    - Debre Zeit Research Centre
    - Kuklumsa Research Centre
    - Bako Research Centre
  - ♦ International Livestock Research Institute
  - ♦ Farmer-to-farmer seed exchange
    - The most reliable and sustainable source for the smallholder farmer.
    - Organize and create awareness among farmers to raise and exchange forage seeds the same way they exchange food crop seeds.
  - ♦ Cost-retrieving projects at the *woreda* level.

Seed producers' cooperatives organized at the *woreda* level may operate seed production nurseries for elite forage species and varieties and sell the seed at a reasonable price just to cover the cost of production The *woreda* Ministry of Agriculture offices, besides organizing and monitoring the cooperatives, may offer technical training and guidance as to where foundation seed and other farm supplies can be obtained.

Transferable Message

1. Select progressive farmers to demonstrate your choice of interventions.
2. Organize a training session and show them the different methods of forage seed production.
3. Organize demonstration visits by other farmers and encourage discussions on the practice.
4. Organize forage-seed producers' cooperatives and seed supply chains, including exchange schemes for sustainable forage seed production.

8.5. Range Management

8.5.1. General characteristics of rangelands

Rangelands are areas where both wild and domestic animals graze on uncultivated vegetation. Rangelands do not support normal crop production due to one or more of the following environmental limitations.

- Unfavorable climate: particularly erratic rainfall. Most rangelands receive below 500 mm total annual rainfall, or sometimes as low as 200 to 350 mm.
- Poor soil:
  - Ruggedness, stone outcrop
  - Very thin soil horizon
  - Poor fertility
  - Excessive mineral accumulation, e.g., carbonates, sulfates, fluorides
- Topographic/landscape limitations:
  - Gully
  - Sloping
  - Waterlogged.

Such lands are typically referred to as marginal lands. The best use of such wastelands in agriculture is usually as rangelands for multiple benefits of:

- livestock production,
- game animal sanctuary, recreation, tourism,
- watershed, and
- conservation of biodiversity.

8.5.2. Objectives of range management

Range management is the science and art of maintaining maximum range forage production without affecting other resources or uses of the land. The central objective of range management is sustainable production of domestic and wild animals in a manner that protects the land.
The specific objectives of range management are listed below.

- Protect, improve and promote the continued welfare of the range soils, vegetation and animals.

- Optimum production of animal products (meat, milk, hides, wool/hair), wildlife and water (from watershed).
- Provide recreational sites.
- Conserve biodiversity of plant and animal genetic resources.

8.5.3. Distribution and features of the Ethiopian rangelands

Ethiopian rangelands are located around the periphery of the country and mostly found below 1500 m.a.s.l. They cover 61–65% of the total area of the country, are generally arid and semi-arid and are home to 12–15% of the human and 26% of the livestock population. There are three recognized rangelands that have been subjected to rangeland development programs.

- The Southern Rangeland (Borana Rangelands)
- The Southeast Rangeland (Jijiga and Bale Rangeland)
- The Northeast Rangeland (Lower Awash / Afar Rangeland)

There are humid and sub-humid rangelands in Benishangul-Gumuz (Metekel), and Gambella, along the frontier with the Sudan that have relatively abundant forage resources for a major part of the year. The major constraint in these rangelands is disease and parasite prevalence, especially Trypanosomiasis.

8.5.4. Common features of the Ethiopian rangelands

- Most rangelands are located in drier parts of the country, i.e., the Rift Valley and adjoining lowlands.
- They are arid or semi-arid lands, generally receiving below 600 mm annual rainfall.
- They share the same vegetation zone: the Somali-Massai Acacia/Commiphora woodland and bush land, which is an extensive vegetation zone covering East and Southeast Africa.
- They consist of arid soils (Aridosols), which are generally poor in fertility and usually contain excessive salts (saline-sodic soils).
- Topographically, they are usually low-lying plains below 1000 m altitude, with hot weather conditions.
- Pastoral and agro-pastoral modes of animal production predominate.

8.5.5. Constraints related to effective use of rangeland resources

- Keeping excessive numbers of animals for prestige and security against losses due to epidemic diseases.
- Lack of alternative feed resources such as crop residues, predisposing rangelands to overgrazing.
- Diseases and parasites.
- Lack of permanent water supply.

8.5.6. Livestock development prospects

There are several strategies for developing rangelands to increase livestock production. A few are listed below.

- Limit livestock numbers to match the available feed resources.
- Develop efficient grazing systems to maintain plant composition in favor of useful plants for grazing.

- Eliminate undesirable plants to give a competitive advantage to herbaceous grass and legume species and browse trees and shrubs.
- Reseed/over-sow range units that have favorable amount and distribution of rainfall with desirable forage species.
- Ensure fair distribution of watering facilities to ensure more equitable grazing pressure over the grazing resource.
- Develop efficient extension and veterinary services.
- Establish feedlots to increase offtake.
- Develop water-harvesting techniques, e.g., introduce earthen-pond construction and other techniques.
- Develop infrastructure: roads, veterinary clinics, marketing facilities, farmer training centres, etc.

8.5.7. Monitoring and proper utilization of rangelands

Primary indicators and the theory of proper use

The first indicator is too heavy grazing, beyond the growth capability of plants. When the best plants are overgrazed, the manager should take this as a sign for need of precaution and take appropriate measures. Improvements can be made by not grazing primary choice plants in excess of the permissive 50% of production for the season.

The ***theory of proper use*** states ***'never graze more than 50% by weight of those better plants by the end of the grazing season'***.

The following need to be known to implement this theory:

- The primary choice plants.
- What makes up 50% of current production, usually done by field sampling.

Monitoring of range forage using key site and key species

Key site is a grazing area which livestock instinctively prefer to graze first, and from where they consume the most forage throughout the grazing period. Key range site serves as a standard measure of the current use and management requirement of the entire range.

Key species are plant species that are more attractive to livestock than any other species in a range. They are high quality forage of a climax decreaser category (components of the climax vegetation that decrease in abundance with increasing grazing intensity). Key species serve as a unit of measure as to how to use the entire range.

Judging range sites using key site and key species

Key range site and key species can be used as a unit of measure in the utilization and management of a range. The principle is that if the most favored range site, along with the best forage species in the range, has not deteriorated neither will any other site in the range.

Selecting a key range site

A key range site is a site which is grazed the hardest and deteriorates rapidly if not properly managed.

It contains one or possibly two forage species that are a first-choice for grazing. A key site should be at least 25% of the total area of the range unit and must be far from high livestock concentration points, e.g., watering place, homestead, travel-ways. It must be accessible and grazed by choice through most of the grazing season or year, plus able to provide quality forage over most of the grazing period.

Once recognized, the key range site, with the 1 or 2 key species, provides a unit of measure for ‘‘the true grazing value’’ of a range unit.

Selecting a key species

As much as possible, the key species must be:

- a climax-decreaser type of high forage quality;
- able to respond to better management;
- relatively abundant, accounting for at least 20% of the forage;
- accessible to alleviate pressure grazing; and
- must be vigorous enough to insure normal development.

Judging the range site

Once the key site and the key species are determined, they then serve as a standard unit of measure for the entire range, and the subsequent measures to be taken. The manager (or group of livestock producers using the range) concentrates his observations on the key site and the degree of use that is made of the key species. Based on the response to use of the key site, the necessary adjustment in the management system is undertaken.

8.5.8. Over-sowing natural pastures

Over-sowing or partial reseeding is a technique of improving range forage, whereby adapted and productive pasture species are sown into the existing vegetation. The objective is to improve the yield, quality and palatability of the native pasture.

General considerations

Reseeding can be an expensive and risky undertaking in the sense that rangelands are vast areas of land, meaning that the operation will require high expenditure in terms of labor and planting material. In addition, it requires a change in grazing management, which is usually difficult to achieve. Therefore, the following should be considered before over-sowing is undertaken.

- Ensure that there are no cheaper techniques and reseeding is absolutely essential.
- Investigate all other options, viz.:
  - better livestock distribution
  - better system of grazing
  - reduced stocking
- Ensure that the grazing land can be controlled; otherwise reseeding should not be started until proper grazing management can be assured.
- Ensure that the grazing land meets the minimum growth requirement. Lack of success has been recorded in East Africa in reseeding areas receiving <375 mm of annual rainfall, but a high success rate in areas receiving a minimum of 625 mm.

- If reseeding is necessary, select the most suitable sites (better soil fertility and soil moisture) for reseeding first; inappropriate site conditions may increase the risk of failure. Deep fertile soils on level-to-gently slopping land are preferred. Shallow or rocky soils rarely justify expensive seeding.

Selection of species

Native species found on sites similar to those being reseeded are preferred to exotic ones in a reseeding program. A grass species for reseeding must be:

- Sufficiently drought-tolerant to survive and perpetuate itself and provide good quality herbage of fair or good grazing value.
- Easy to establish.
- Able to produce an adequate amount of viable seed which can be easily harvested.

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Sowing procedures

Seedbed: Make some form of simple seedbed preparation. The more complete the cultivation, the better the stand. Consider one or more of the following techniques:

- burning
- heavy grazing
- light cultivation

Timing: The most desirable time to seed non-irrigated areas is immediately before the season of the most reliable rainfall, and when temperature is favorable.

Plant diversity: A mixture of grasses, forbs, and shrubs will better meet the multiple needs of the farmer user (feed, fuel wood, erosion control, etc.). A pure stand has a risk of failure due to insect and disease infestation.

Seed rate and plant density

- Plant at double the usual seed rate.
- Aim at achieving one established plant of each species in each 0.9 m^2. As a general rule, at least one shrub and 10 desirable herbaceous plants per 9 m^2 should be present following revegetation.
- Ensure a good cover of soil or chaff after sowing.

Grazing control after reseeding

Reseeding of rangelands is useless unless stock numbers can be controlled. It is especially important to protect young seedlings from grazing for one or more years to allow grasses to become fully established and to reseed, thickening the stand.

Subsequent grazing should also be controlled, where the recommended procedure is to remove livestock from reseeded areas when no more than 50% of the weight of the herbage has been consumed. (The 50% use level can be determined by clipping an intact and grazed plant of the 'key-species' category, taking the weight difference and expressing as percent of intact plant weight).

Recommended species for reseeding tropical ranges

Species closely related to the native ones will have high chance of survival. A mixture of grasses, herbaceous legumes and trees is preferred to a single species (Table 8.5.). For details of species characteristics and their specific applications, please refer to Appendix Table 8.1.

Table 8.5. Recommended species for reseeding degraded grazing lands.

Grasses	Herbaceous legumes	Trees
Bothriochloa insculpta	*Clitoria ternatea*	*Acacia decurrens*
Bothriochloa pertusa	*Desmodium intortum*	*Acacia siberiana*
Cenchrus ciliaris *	*Desmodium uncinatum*	*Calliandra calothyrsus*
Cenchrus setigerus	*Lotononis bainesii*	*Leucaena leucocephala*
*Chloris gayana**	*Macrotyloma axillare*	*Gliricidia sepium*
*Chloris roxburghiana**	*Neonotonia wightii*	*Sesbania sesban*
Echnochloa haploclada	*Stylosanthes guyanensis*	*Atriplex numularia*
Eragrostis curvula	*Stylosanthes scabra*	*Atriplex halimus*
*Eragrostis superba**	*Stylosanthes humilis*	
*Leptochloa obtusiflora**	*Stylosanthes hamata*	
Panicum coloratum	*Stylosanthes fruticosa**	

* Indigenous species

8.5.9. Grazing management and efficient use of rangeland resources

Grazing management is the manipulation of grazing animals to accomplish desired results in terms of animal, plant, land, or economic responses.

Aims

- To provide a supply of nutritious herbage over the growing season at a low cost.
- To avoid wasting herbage and inefficient utilization by the animal.
- To maintain the productive capacity of the sward.

Distributional control of animals

Distributional control aims to reduce animal movements and thus avoid destruction of the range by excessive grazing and trampling. The following methods can be employed to achieve uniform distribution of animals.

- Fair distribution of watering areas.
- Development of boreholes (wells) at several sites in the range.
- Use of fences to help control animal movements.
- Provision of salts (mineral licks) at different sites.
- Employing controlled grazing system (described under grazing systems) appropriate for the more intensively managed rangelands (ranches).

Basic principles of controlled grazing for natural pastures

- Provide rest or recovery period between grazing cycles.
    - During recovery, plants build up nutrient reserves that ensure continued vigor.
    - There is a need to take care of palatable species by controlling scrub and brush growth to avoid competition.
- Avoid heavy defoliation of key species during their active growing period.

- ♦ Plants use up to ¾ of root food reserve (when rate of carbohydrate production is greater than the rate of demand) to produce new vegetative growth until the plant nears flowering.
- ♦ Heavy defoliation during active growth will result in the valuable perennials to be replaced first by increasers, then by invaders and finally by bare ground.

As a precaution, stocking rate should be highly reduced or grazing totally stopped when no more than 50% of the weight of herbage has been consumed.

Grazing systems

The objectives of proper grazing systems are to:

- maintain a favorable balance between herbage species;
- maintain high production of good quality forage for the longest possible period;
- achieve efficient utilization of the forage produced; and
- achieve high rates of animal production.

Continuous grazing is an extensive system of grazing in which animals remain on the same pasture area for prolonged periods. Continuous grazing is a normal practice on rangelands and tropical savannahs where, in most cases, the low carrying capacity of the grazing resource may not allow employment of other intensive systems of grazing.

In continuous grazing systems, pasture areas are generally undergrazed during the rainy season and overgrazed during the dry season, with a consequent deterioration of the sward. A low stocking rate should be maintained to maintain the grazing system. Major disadvantages of the system include a build up of tick and nematode infestation and a lack of grazing distribution.

Rotational grazing is an intensive system of grassland management practiced on improved permanent or lay pastures. The grazing area is subdivided into a number of paddocks, usually at least six, and the animals are moved systematically from one to another of these in rotation. Each paddock is grazed for a period of 3–7 days, the length of the grazing period depending on stocking rate (often high, up to 25 cow equivalents/ha) and herbage growth rate.

The aim of this system is to use the pasture when it is young and highly nutritious and then to allow an adequate recovery period (See Figure 8.28).

1 →	**2 →**	**3 →**	**4 →**	**5 →**	**6**
3–7 days					**18–42 days rest↓**
↑ ←	←	←	←		← ←

Figure 8.28. An alfalfa pasture divided into 6 paddocks.

Strip grazing is a more intensive method of rotational grazing based on the use of electric fence, which is moved forward once or twice a day.

Advantage

- Selective grazing is minimized, resulting in more uniform consumption.

Applicability

- Highly productive and nutritious pasture.
- High-producing animals.

Deferred grazing is the setting aside of certain pasture paddocks for use at a later stage, e.g., standing hay.

Advantages

- Enhanced plant vigor.
    - Improved self-regeneration from fallen seed.

Soiling or zero grazing is the feeding of cut crops to housed stock.

Advantages

- Efficient herbage utilization.
    - No loss due to trampling.
    - Uniform herbage intake.
    - Control of bloat by wilting lush pasture.

Disadvantages

- High cost for labor or machinery.
- Bedding required for housed stock.
- Manure disposal is laborious.

Strategies during drought

There are a number of drought-mitigation strategies that pastoralists need to consider in anticipation of catastrophic droughts, which, nowadays are reported to recur every 2–3 years.

- Adjust stocking rate to the carrying capacity of dry years. Reduce stocking rate early.
- After drought, increase stocking rate gradually over a 1–3 year period.
- Plan for water availability; graze areas with limited water reserves first.
- Periodically rest pastures or delay grazing. Lengthen pasture rest periods during slow or no-growth times. Plants can withstand severe grazing if followed by proper rest periods. These rest periods allow plants time to replenish tissues above and below the ground.
- Cull more heavily before the market becomes flooded with animals.

Transferable Message

- Understand the traditional grazing management practices of the community.
- Build upon the traditional practices and convince the community to strengthen the practices of efficient utilization of communal grazing resources.
- Use community leaders to implement grazing land improvement practices.

8.6. Systems of Forage Utilization and Conservation

Systems of forage utilization fall into two major categories:

- Immediate use
  - grazing
  - green chop

- Conserved forage
  - standing hay
  - hay
  - silage

The objective is to maximize the utilizable yield of the forage crop. In deciding the usage system, one has to consider the following:

- Type and persistence of the forage: Species with persistent and strong root systems are preferred for grazing while fast-regenerating and erect-growing ones are suitable for haying.
- Type of the farm enterprise: e.g., green chop/cut-and-carry systems are suitable for dairying and fattening.
- Potential maximum forage yield versus expected loss in the type of usage: If low herbage yield is expected for some reason, wastage due to conservation must be avoided, e.g., silage has the disadvantage of wastage compared with hay.

8.6.1. Grazing

Grazing is the most common and the cheapest utilization method for both natural and sown pastures. In the case of sown pastures, prior to establishment, species have to be selected for palatability, accessibility, nutritive value and their ability to tiller profusely, resist defoliation and trampling, and respond to fertilization,.

Advantages

- Effective recycling of nutrients.
- Possible manipulation of transfer of nutrients from day grazed paddocks to night corrals via manure.
- Requires less labor and is less time-consuming.

- Animals can select their diet in both quality and quantity.

Limitations

- Loss of material due to trampling, fecal contamination.
- Selective grazing.
- Early maturity, leading to stemmy stands.
- Difficulty in clay soils, i.e., excessive plant damage and crusting.
- In some forage species, reduced content of soluble carbohydrates and subsequent production of toxicity of prussic acid (HCN), nitrite, and magnesium tetany is observed on cloudy days.
- Requires controlled grazing — fencing or shepherding.

Grazing capacity of native pastures

Grazing studies on native pastures at Holetta Research Center indicate that well-managed natural pastures could be stocked at 2 Tropical Livestock Units (TLU)/ha from July to end of December and 10 sheep/ha for year-round grazing with hay supplementation during the dry season. Cutting or grazing at 2-week intervals reduced total dry matter to about 50% of that obtained from a 4-week grazing interval, indicating that a rest period of at least 4 weeks was important.

8.6.2. Green chop/cut-and-carry system

Green chop is cutting green forage in the field and transporting it to the livestock (also called cut-and-carry system). It is a common practice in areas where grazing land is limited, e.g., traditional feeding of tethered beef cattle in Hararghe (Eastern Ethiopia); thinned maize plants; garden weeds; chat (*Catha edulis*) leftover (‘*geraba*’), etc.

A cut-and-carry system involving improved forages is more economical for commercial dairy farms and feedlot cattle finishers, and holds advantages for small ruminant feeding as well. When the green chop feeding operation aims to collect animal excreta in a confined space and return it to the land to build soil fertility, it is called *soilage*.

Advantages of cut-and-carry system

- High recovery of plant material as it is not lost by trampling and contamination.
- Little selectivity because the system allows for rationing of animal intake.
- Feeding can be arranged at a convenient site.
- The excreta can be utilized as farm yard manure and applied where it is most required or composted.

Limitations of cut-and-carry system

- The continued removal of plant material could lead to deficiencies of soil nutrients, particularly potash.
- Requires high labor for cutting, chopping and transporting.

8.6.3. Standing hay (deferred feed)

Deferred feed is the cheapest and easiest way of conserving forage, as it does not require machinery or physical handling. It is a common traditional practice in rural areas of Ethiopian highlands where certain village communities by common consent defer the bottomland communal grazing lands for use during the dry season. It is also practiced by large ranch holders and pastoralists in the drier areas. On bottomlands, aquatic and semi-aquatic grasses such as *Paspalum scrobiculatum, Urochloa colona, Echnochloa pyramidalis, Pennisetum reparium, Pennisetum glabrum, Pennisetum salifex* and others can maintain a reasonably high level of nutrient content at maturity.

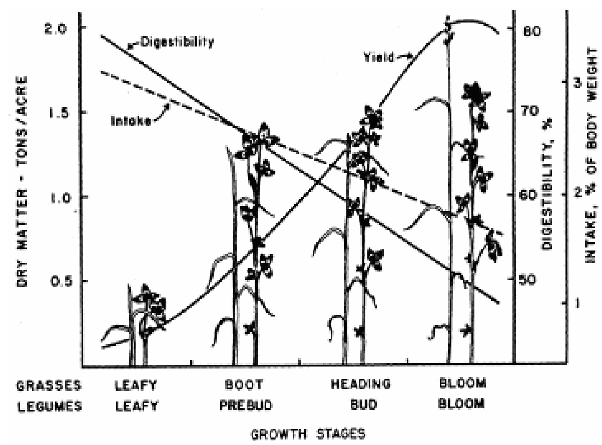


Figure 8.29. The relationship between the growth stage of the plant and yield, digestibility and intake

Limitations

- High risk of fire hazard.
- Possible occurrence of light rainfall where the culms and leaves become moldy, called "blackening", making the standing hay useless as forage.

8.6.4. Stored fodder

Storing fodder is an important operation in livestock farming to bridge the gap in feed supply during dry seasons, recurrent drought hazards, and during the cropping season when grazing land becomes scarce. The aim of conserving fodder is to harvest the crop at its maximum nutrient content and minimize losses while at the same time maintaining its acceptability to the animal. The time of harvest may be earlier if higher protein content is required or later if maximum dry matter is desired. Therefore, time of cutting is a compromise between quality and quantity of the harvested forage. Fodder is usually conserved as hay and sometimes as silage especially for dairy business.

Hay

Hay is feed produced by drying green forage to a moisture content of 15% or less. It is the most commonly stored fodder on the farm and used to level-out the feed supply throughout the year. Hay is generally the most convenient processed form of storage and an appropriate forage conservation method for small-scale farming. Well-processed hay is the cheapest form of feed during the non-grazing season.

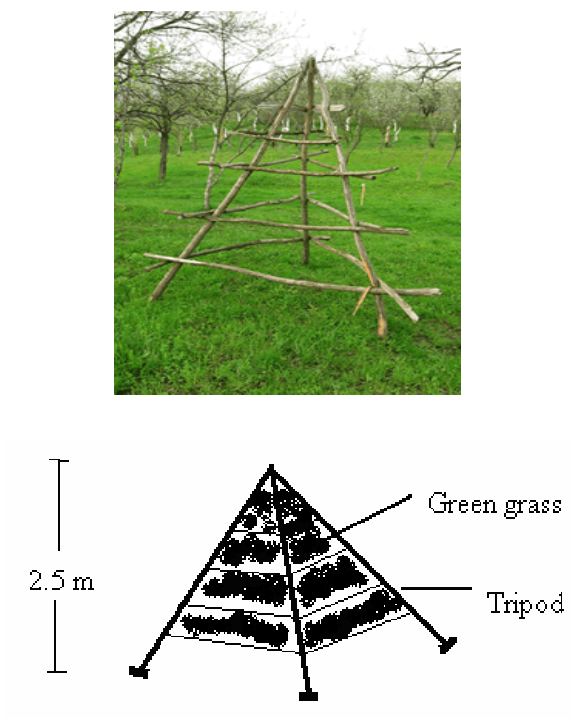


Figure 8.30. Hay making tripod.

Hay should be made at the optimum date to maximize yield and still fulfill the nutrient needs of the livestock. It is best cut early in the flowering stage. When cut earlier, the nutritive value is higher but yield is lower and the moisture content is too high for easy curing. If cut after flowering, the increased yield does not compensate for decreased palatability and nutritive value. The first cut of hay from a crop is usually of better quality than subsequent cuttings. The relationship between the growth stage of the plant and yield, digestibility and intake is shown in Figure 8.29.

Problems in haymaking vary according to the crop, climate and prevailing weather at harvest:

- Sub-humid and humid conditions:
  - Slowness of drying (the aim is to dry the crop as quickly as conditions will allow to avoid loss by spoilage).
- Hot, dry conditions:
  - Too rapid drying.
  - Shattering of the finer parts of the plant.
  - Bleaching, with consequent loss of carotene and vitamins.

Curing of hay

The grass should be dried quickly and not unduly exposed to the sun. Rain can cause leaf losses and leaching of nutrients. The loss of nutrients in haymaking is about 25% for temperate pasture grasses and 22–25% for tropical pasture grasses. Tropical pasture grasses generally take 50–55 hours of drying in good weather and 70–75 hours in poor weather.

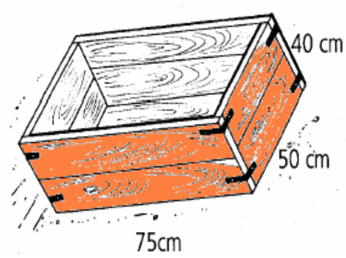
Hay-making steps for the smallholder

- Harvest the plant at the optimum stage of maturity to maximize nutrient yield per unit of land. Most forages should be cut just after reaching an early bloom stage of maturity.
- Start harvesting after the dew has evaporated from the green material in late morning.
- Cut and place the material into small heaps about 20–30 cm high and turn the heap frequently in the sun to encourage quick drying. Raking (turning) should be completed before it is completely dry to avoid excessive shattering of leaves and overexposure to the sun. It is better if raking is done when the dew is on, especially when high leaf-shattering is expected. If the weather is humid or rainy, place the cut material off the ground using a home-made tripod with three poles to facilitate drying (Figure 8.30).
- The optimum permissible moisture content for storing hay is around 18–22%.
- When the initial moisture has evaporated, the material can then be placed under the roof of any shed, and allowed to dry completely away from the sun. Where a hay shed is not available, collect the cured hay as soon as it is sufficiently dry and store as stacks, which should be fairly compressed and loaf-shaped or conical shaped to shed rainwater (Figure 8.31).

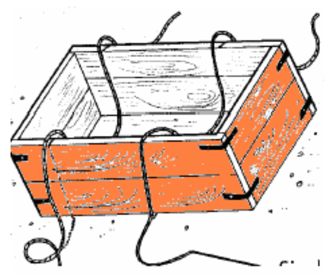
Figure 8.31. Hay in carefully built and thatched stacks.

- Alternatively, a "baling box" can be used to make a tightly packed bale, tied with string. This will reduce wastage from shattering and make storage easier. Figure 8.32 shows the steps of baling roughages using a baling-box at a small-farm level. This is a procedure even the smallest farmer can use.

- In places with a long and severe dry season, tree legumes may lose their leaves during the driest period. Instead of 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. Legumes should be cut and carried to the place of storage when green to avoid losses from the shattering of leaves. Tree legume branches should be cut and the leaves allowed to dry on the branch. They can then be easily stripped off the branch and stored in a sack for later feeding.



Step 1. Make a box


Step 2. Put twine in


Step 3. Put in roughage and compact


Step 4. Tie up the compacted roughage


Step 5. Remove the bale

Figure 8.32. Steps in baling roughages using a hay-box (Adapted from Massawe et al.).

Harvesting implements

Machinery

Specialized dairy or beef industries use mechanical harvesters, which are tractor-mounted and driven by a power-take-off shaft. There are two types of such harvesters: the reciprocating blade mower (line mower), and the rotary slasher blade mower. The latter seems durable and efficient, especially for harvesting natural pasture from rough surface.

Hand tools

Machinery, even small-scale, is generally beyond the economic capacity of the subsistence farmer. The most widely (almost universally) used hand tool for harvesting grain and pasture is the sickle. While the sickle is more commonly used, the scythe is a more efficient hand tool for harvesting forage, cereal crops, and slashing weeds (Figure 8.33).

The scythe can mow at about five times the speed of the sickle. However, it requires:

- a sward that is reasonably free from obstacles
- to be kept very sharp by regular whetting throughout the day,

- some skill to use the scythe, and
- both hands for usage.

Forage crops are mown with wide cuts, advancing in a straight line and cutting away from the standing crop. A scythe cuts about 2½ times the length of the blade, so a 75 cm blade will mow a swath 175 cm wide if the crop is not too heavy, with the width reduced in a denser crop. On good, level, stone-free ground, about 500 m^2 can be mown per hour.

The scythe is not widely known or used in Ethiopia except in some areas near Addis Ababa, including Sululta and Holetta. In these areas, the scythe (locally known as *falch*) is widely used to harvest natural pasture for making hay. Hay is a source of cash income (commodity) in these areas and it is common to see a number of donkeys transporting haystacks to Addis Ababa, where they are sold to small-scale animal farms.

a. Parts of a scythe | b. How to use a scythe | c. Field mowed using a scythe

Figure 8.33. Mowing forage using a scythe.

Common losses of haymaking

- Leaf shattering
  - Leaves contain 2 to 3 times as much protein as stems.
  - Leaves are also richer in carotene, B-vitamins, minerals, and energy.
- Heat damage
  - Hay stored with excess moisture (25–35%) may tend to mold, and contain bacterial growth and heat.
  - Hay stored dry reaches a maximum of about 29°C.
  - Above about 49 °C, nutrient destruction or binding occurs. Proteins are most vulnerable to heat damage.
  - When temperature of stored hay reaches 71–73°C, there is a danger of spontaneous combustion.
- Fermentation/plant cell respiration
  - Converts sugars and starch to CO_2 and H_2O representing a loss of nutrients.
  - Reduces energy value.
  - Destroys carotene.
  - Under good condition, accounts for 5–7% of loss in total dry matter.
  - Rapid drying is the key to low fermentation losses.
- Bleaching
  - Color loss due to destruction of chlorophyll by sunlight.
  - Reduces carotene (related to greenness) or Vitamin A.

- Leaching
  - Washing of nutrients out of the hay by rainfall.

Factors influencing hay quality

- **Maturity:** Affects both yield and composition of hay.
  - Young plants are more digestible because they have less structural fiber and lignin, which are difficult to digest.
  - Young plants are higher in protein, minerals and carotene than older plants.
  - Young plants are more palatable, tender and less fibrous.
- **Leafiness:** Applies mainly to legume hay.
  - The percentage of leaves is the best index of actual feed value of alfalfa, clover and other legume hays.
  - Leaves are higher than stems in protein, fat, ash, nitrogen-free extract, calcium and phosphorus.
  - Leaves have a higher digestibility than stems.
- **Color:** Is an indication of maturity, the care exercised in curing, and the amount of weather to which the hay has been exposed.
  - A high percentage of natural green color (pea-green color) in hay indicates early cutting, good curing, high palatability, freedom from must or mold and high carotene content.
- **Foreign matter:** Indicates hay of low feeding value.
  - Injurious foreign matter, such as wire, stones, etc.
  - Poisonous plants, hard, bearded grasses etc.
- **Condition:** Refers to soundness of hay. Unsound hay is an indicator of poor quality and low nutrient content.
  - Contains excess moisture (under-cured).
  - Heated or hot hay, perhaps a burnt-brown appearance.
  - Has a musty or sour, rotten odor, generally due to heating.
  - Moldy.
  - Lacks the aroma of well-cured hay.
- **Texture**: Refers to the size of the stems. Texture is influenced by the thickness of the stand, maturity, percent leaves and the rainfall, soil fertility and other environmental conditions affecting the rankness of growth.
- **Variety**: Refers to kind or variety. Legume hay is more valuable than grass hay of the same maturity condition and foreign-matter content.

Standards of hay

Hays from sown pasture

Standards or grades of hay are generally based upon the percent of leafiness (in legumes), percent green color, percent foreign material, maturity or ripeness when cut, size and pliability of the stems, and general condition.

Hays from natural pasture

Three broad standards (grades) of hay are recognized based upon legume composition and quality of processing (curing) the hay.

Excellent hay

Excellent hay is cured forage, which includes a mixture containing a large amount of legumes and some grasses which are cut at an early, immature stage shortly after the legumes begin to bloom (1/8–1/4 of the plants in bloom) or shortly after the grasses form a head. For hay to be excellent quality, it must not be exposed to weather damage of any type, including sunlight for more than one or two days.

Good hay

Good hay would be cured forage which contains smaller amounts of legumes and more grasses than an excellent forage and is cut at a slightly later stage of maturity (about ½ of the plants in bloom). For hay to be rated as good quality, it must have little or no weather damage.

Fair-to-poor hay

Fair-to-poor hay is that which is mature at harvest (most of the plants in bloom); contains little or no legumes, and is exposed to some but not excessive, weather damage.

Silage

Silage is moist forage that is the product of acid fermentation of green forage crops that have been compressed and stored under anaerobic conditions in a container called a silo. A point of precaution in silage making is that it is not economically justified nor is there a special advantage to be gained in terms of animal nutrition by ensiling forages as long as the weather allows making good quality hay. However, there are certain advantages of silage which still do not rule out other cheap methods of forage conservation:

Advantages

- Where the production of high quality hay is not possible due to weather conditions.
- Silage saves feed that would be inedible in the dry state or would be damaged by rains.
- It is quite palatable and has a high content of carotene.
- It clears the ground early and completely for another crop.
- Storing a crop as silage instead of hay eliminates the hazard of fire.

Limitations

- It requires additional outlay for structures, equipment and power.
- It concentrates the labor of harvesting into a few days since the silo has to be filled quickly (in 1–3 days).
- Most silage has a low content of minerals and protein and is not suitable for use as the sole ration.
- If it is fed in place of legume hay in the ration, more expense must be incurred for high-protein feed.

Kinds of silos

Generally, there are four types of silos: stacks, trench silos, bunker silos and tower silos. The common ones applicable to the smallholder are stacks and trench silos.

Stacks

- Heaps of herbage (above ground) that are covered by plastic to exclude air.
- Used for ensiling grass and cannery refuse (by-product from food/vegetable processing and canning industries).
- Require adequate moisture in the crop.
- Need thorough packing to exclude oxygen.

Trench silos (clamp silo)

- Have three walls, which are sloped and built strongly to sustain the lateral pressure from the silage.
- For safety and prevention of waste, the walls should always be higher than the surface of the silage at the time of filling the silo.
- The silage should be packed tightly against airtight walls; otherwise wastage will occur.

Crops suitable for silage

Any green forage crop can be made into silage that will keep in good condition without an excessive loss of feed nutrients. Few feeds are improved either in palatability or in nutritive value by undergoing fermentation in the silo. On the other hand, none appear to be affected detrimentally to any marked extent. Very coarse or weedy crops and spiny plants become completely edible when made into silage.

Maize (Corn)

Corn is the common silage crop wherever it can be grown successfully. Silage made from corn is very palatable and will keep in good condition for 12 years or more. Yields range between 4 and 20 tons of silage from 9–45 tons of maize that may be harvested per hectare.

Sorghum

Various varieties of sorghum, including the forage sorghum (*S. sudanense*) are suitable for silage. They are dependable and yield more than maize in light rainfall areas. However, sorghum has a higher content of water and less grain and thus has less feeding value than maize.

Legumes

All legumes, including alfalfa, clovers, vetches, cowpeas, etc., can be made into silage successfully. If a crop is too mature to make leafy hay that will be eaten without waste, the legume crop can usually be made into silage that conserves more of the leaves and will be consumed with practically no waste. However, there is no special value in making legume silage if the crop can be hayed successfully.

The low, fermentable sugar content and the high protein and calcium content of legumes favor the development of undesirable types of bacteria during the fermentation process. Thus, special precautions must be taken in making legume silage or it will have low palatability and feeding value. When making legume silage fine chopping, tight packing, adequate covering and suitable drainage is essential.

- It is important to harvest the legumes at the correct moisture content, between 60 and 70%. In legumes, this is attained when cut at a growth stage from pre-bloom to 1/10 bloom stage.
- Fill the silo in shallow layers, each layer being allowed to heat to about 60°C before the next layer is added.
- Add molasses (18 kg of molasses per ton (1000 kg)) to provide fermentable sugar to favor development of desirable types of bacteria and facilitate the fermentation process. Molasses also improves palatability and odor of silages, especially those with high moisture content.

Grasses

Very good silage can be made from the grasses or mixtures of grasses and clovers that are ordinarily used for pasturage or hay.

- The crop grass should be low enough in moisture either naturally or by wilting so there will be little or no leakage of juices from the silo.
- The silo should have an open drain to let any free juice flow away from the silo in case the material is too wet. It is advisable to use about 18 kg of molasses per ton of grass if the moisture content is high.
- No molasses is necessary if the moisture content of immature grasses is below 70% (low enough to avoid leakage from the silo).

Harvesting the crop and filling the silo

- The fodder may be cut by hand and chopped by homemade, manually-operated rotary choppers that are more efficient than chopping by sickles.
- Hay and pasture crops may be cut using sickles or scythe and transported by animal-drawn carts to be dumped directly into the silo.
- In packing trench silage, livestock can be driven back and forth over the chopped material.
- Grasses and legumes need more uniform packing; such silages shrink away from the sides so special attention should be given to packing the top.
- It is advisable to fill the upper part of the silo higher than the sides.
- After filling, the silo should be covered with straw or unchopped maize and then covered with a polythene sheet.
- Trench silos must be filled high above the ground and then covered with straw and dirt. This will help to prevent spoilage by rain.

The fermentation process in the silo

When a green crop is put together in a heap, it continues to respire and in the process oxygen is consumed, CO_2 produced, and heat is developed. Several aerobic bacteria continue to increase in number until the oxygen is used up in 1–4 hours. The desirable temperature of silage after respiration stops is 27–38°C. If the temperature is lower, lactic acid-forming bacteria cannot compete with butyric acid-forming bacteria. On the other hand, temperature above 38–49°C result in sweet, tobacco-smelling, dark brown silage being formed; this is palatable but nutrients are lost (especially protein). The amount of fermentation products, lactic and acetic acids depends highly on the amount of sugar in the material from which these acids are derived by fermentation. A sugar content of about 6% is necessary for successful silage.

The normal fermentation process lasts about 21 days. Silage (maize) has been known to keep well for 12 years or more.

Transferable Message

- Select progressive farmers to demonstrate the choice of fodder conservation methods.
- Organize a training session and show farmers the advantages and the different methods of fodder conservation.
- Organize demonstration visits by other farmers and encourage discussions on the practice.

Glossary of Technical Terms

Browse: The part of leaf and current twig growth of shrubs, woody vines, and trees available for animal consumption.

Concentrate: All feed low in fiber and high in total digestible nutrients (TDN) that supply primary nutrients (protein, carbohydrate, and fat).

Carrying capacity: The optimum combination of products that can be derived from the land without degradation of the range.

Feed: Any non-injurious, edible material, including forage, having nutritive value for animals when ingested.

Forage: The part of the vegetation that is available and acceptable for animal consumption, whether considered for grazing or mechanical harvesting; includes herbaceous plants in mostly whole plant form, and browse.

Fodder: Any bulky green or dry plant material, which is used for stock feed.

Forage crop: Forage plants harvested before being fed to animals, e.g., hay, silage, green chop.

Grassland: Any land on which grasses predominate.

Green chop: Harvested forage fed to animals while still fresh.

Pasture: Grazing lands under relatively intensive management, usually supporting introduced forage species and receiving periodic cultural treatments, such as tillage, fertilization, mowing, and irrigation.

Pasture crop: Crops grown primarily for grazing.

Proper use: Grazing a range to a degree that will permit the best forage plants to make full use of the environment for maximum development during the current production season.

Permanent pasture (Conventional pasture): Medium-term grazing area on which the forage stand is principally perennial grasses and legumes and/or self-seeding annuals, and on which grazing tenure is indefinite but expected to exceed ten years.

Proper stocking rate: Limiting the number of animals which can be grazed in a given area of a pasture or range to match available feed resources.

Rangeland (Range): Uncultivated grasslands, shrub lands or forested lands with an herbaceous and/or shrubby under-story producing forage for grazing or browsing; may be native or seeded.

Range management: The science of maintaining maximum-range forage production without jeopardy to other resources or uses of the land. Grazing land management as applied to native and seeded rangelands.

Ranch: An economic unit of range or pastureland having defined boundaries together with its internal construction and improvement.

Roughage: Plant materials and other feedstuffs high in fiber and low in total digestible nutrients, usually bulky and coarse.

Supplemental pasture: A pasture of different kinds of forage grazed simultaneously and in conjunction with a base pasture; while the base pasture provides the primary source of grazing capacity, the supplemental pasture of enhanced nutritive quality serves to correct nutrient deficiencies in the total animal diet.

References

Alemayehu Mengistu. 2005. Rangelands: biodiversity conservation and management and inventory and monitoring. SG 2000. Addis Ababa, Ethiopia.

Berhanu Debele. 1985. The vertisols of Ethiopia; their properties, classification and management. In: The 5th Meeting of the Eastern African Subcommittee for Soil Correlation and Land Evaluation. Wad Medani, the Sudan, WSRR No 56. FAO, Rome, pp. 31–54.

Bogdan, A.V. 1977. Tropical Pasture and Fodder Plants. Longman N.Y. 475p.

Cook, B.G., Pengelly, B.C., Brown, S.D., Donnelly, J.L., Eagles, D.A., Franco, M.A., Hanson, J., Mullen, B.F., Partridge, I.J., Peters, M. and Schultze-Kraft, R. 2005. Tropical forages: an interactive selection tool. [CD-ROM], CSIRO, DPI&F (Qld), CIAT and ILRI, Brisbane, Australia.

Skerman, P.J. and Reveros, F. 1989. Tropical Grasses. FAO-UN. FAO Plant production and Protection Series No 23. Rome, Italy.

Skerman, P.J. Cameron, D.G. and Reveros, F. 1989. Tropical Forage Legumes. FAO-UN. FAO Plant Production and Protection Series No 2. Rome, Italy 832p.

Stoddart, L.A., Smith A.D. and Box, T.W. 1975. Range Management. 3rd ed. McGraw-Hill, N.Y. 532p.

Whiteman, P.C. 1980. Tropical Pasture Science. Oxford University Press. New York, USA. 217p.

Additional Reading

Alemayehu Mengistu. 2004. Rangeland biodiversity — concepts, approaches and the way forward. Addis Ababa, Ethiopia.

Alemayehu Mengistu. 2004. Pasture and forage resource profiles of Ethiopia. Addis Ababa, Ethiopia.

Humphreys, L.R. 1994. Tropical Forages: Their Role in Sustainable agriculture. Longman Scientific & Technical, Essex, England 414p ISBN 0-582-07868-7.

Ministry of Agriculture (undated). Forage extension manual. Animal and Fishery Resources Development Main Department.

Pandy, D.N. 1980. Animal nutrition and biochemistry. Kitab Mahal, Allahabad, India.

Partridge, I. 2003. Better pastures for tropics and subtropics.
< http://www.tropicalgrasslands.asn.au/pastures/default.htm>.

Appendix Table 8.1. Characteristics of common forage crops.

Species	Rainfall (mm/yr)	Seed rate (kg/ha)	Tolerance to				Propagation	Nutritive value	Agro-ecology
			Drought	Waterlogging	Acidity	Frost			
HERBACEOUS LEGUMES									
Centrocema pubescens	900	3–5	fair	fair	good	poor	seed	very good	kola & w. dega
Desmanthus virgatus	500	1–2	good	fair	good	poor	seed	good	kola & w. dega
Desmodium intortum	700	1–2	fair	good	very good	fair	seed	very good	kola & w. dega
Desmodium uncinatum	700	1–3	good	fair	very good	fair	seed	very good	kola & w. dega
Neonotonia wightii	600	2–5	good	poor	very good	fair	seed	very good	kola & w. dega
Lablab purpureus	400	10–30	good	poor	good	fair	seed	very good	kola & w. dega
Lotononis bainesii	800	0.5–1	fair	very good	very good	good	seed	good	kola & w. dega
Lotus corniculatus	900	10–15	poor	fair	fair	very good	seed	very good	w. dega & dega
Macroptilium atropurpureum	500	1–3	good	fair	good	fair	seed	very good	kola & w. dega
Macroptyloma axillare	500	3–5	good	fair	very good	poor	seed	very good	kola & w. dega
Medicago scutellata	800	10–20	fair	very good	poor	good	seed	very good	kola, w. dega & dega
Medicago sativa	600	2–15	very good	poor	poor	very good	seed	very good	kola, w. dega & dega
Pueraria phaseoloides	1000	3 – 4	fair	good	very good	poor	seed	good	kola & w. dega
Stylosathes guyanensis	600	3–6	fair	fair	very good	poor	seed	good	kola & w. dega
Stylosanthes hamata	500	3–6	very good	poor	very good	poor	seed	good	kola & w. dega
Stylosanthes scabra	500	3–6	very good	poor	very good	poor	seed	fair	kola & w. dega
Trifolium repens	600	1–4	fair	fair	fair	very good	seed	very good	kola, w. dega & dega
Vicia dasycarpa	400	20	fair	poor	fair	good	seed	very good	kola, w. dega & dega
Vicia villosa	400	20	fair	poor	fair	very good	seed	very good	kola, w. dega & dega
Vigna unguiculata	300	20	good	poor	good	fair	seed	good	kola & w. dega
TREE LEGUMES									
Cajanus cajan	300	20–25	very good	poor	very good	poor	seed	very good	kola & w. dega
Calliandra calothyrus	1000	20–50 seed/m	fair	good	good	poor	seed/seedling	good	kola & w. dega

Species	Rainfall (mm/yr)	Seed rate (kg/ha)	Tolerance to				Propagation	Nutritive value	Agro-ecology
			Drought	Waterlogging	Acidity	Frost			
Gliricidia sepium	900	cutting	fair	fair	good	poor	cutting/seed	good	kola & w. dega
Leucaena leucocephala	400	20–50 seeds/m	very good	poor	poor	fair	seed/seedling	good	kola & w. dega
Leucaena pallida	400	20–50 seeds/m	very good	poor	poor	fair	seed/seedling	good	kola & w. dega
Sesbania sesban	500	20–50 seeds/m	good	good	fair	poor	seed	good	kola & w. dega
Chamaecytisus prolifer	500	20–50 seeds/m	good	poor	good	very good	seed/seedling	good	kola, w. dega & dega
GRASSES									
Andropogon gayanus	900	4–6	good	fair	very good	poor	seed	good	kola & w. dega
Brachiaria decumbens	1000	3–6	fair	good	good	poor	seed/split	fair	kola & w. dega
Brachiaria mutica	1000	2–6	fair	very good	poor	poor	seed/split	fair	kola & w. dega
Cenchrus ciliaris	250	1–4	fair	very good	fair	poor	seed	good	kola & w. dega
Chloris gayana	600	1–6	very god	poor	good	fair	seed	good	kola & w. dega
Dactylis glomerata	500	3–6	good	fair	fair	very god	seed	good	kola, w. dega & dega
Festuca arundinaccea	600	4–6	good	fair	fair	very good	seed	good	kola, w. dega & dega
Lolium perene	500	5–20	fair	poor	fair	very good	seed	good	kola, w. dega & dega
Melinis minutiflora	1000	1–4	fair	Poor	good	poor	seed/split	fair	kola & w. dega
Pennisetum purpureum	600	splits	good	Poor	good	fair	seed/split	good	kola & w. dega
Panicum coloratum	400	1–6	very good	very good	good	good	seed	good	kola & w. dega
Panicum maximum, var. Gatton	750	2–6	fair	Fair	good	fair	seed	good	kola & w. dega
Panicum maximum, var. Green	550	1–6	good	Poor	very good	good	seed	good	kola & w. dega
Panicum maximum, var. Guinea	900	2–6	fair	Fair	very good	fair	seed	good	kola & w. dega
Panicum maximum, var. Hamil	900	1–4	good	good	very good	fair	seed	fair	kola & w. dega
Paspalum plicatulum	900	6–10	fair	good	fair	fair	seed	fair	kola & w. dega

Species	Rainfall (mm/yr)	Seed rate (kg/ha)	Tolerance to				Propagation	Nutritive value	Agro-ecology
			Drought	Waterlogging	Acidity	Frost			
Phalaris aquatica	400	2–4	very good	very good	fair	very good	seed/split	good	kola & w. dega
Setaria sphaceleta	800	2–5	fair	good	good	good	seed/split	good	kola & w. dega
FODDER CROPS									
Avena sativa	600	70–80	fair	good	fair	good	seed	good	kola, w. dega & dega
Beta vulgaris	750	5	very good	poor	fair	very good	seed	good	kola, w. dega & dega

Designation: Traditional Ethiopian agro-ecological zones clustered into three major zones: *kola, weinadega* and *dega*. 1. *Kola* (including: *Bereha* (dry-hot), *Erteb Kola* (sub-moist warm) 2. *Weina-dega* (dry-warm, sub-moist warm) and Erteb Weina-dega (moist-cool) and 3. *Dega* (including Dega (cold); *Erteb dega* (moist cold) and *Wurch* (very cold or alpine). See the following description for the traditional agro-ecological sub zones.

Appendix Table 8.2. Description of traditional agro-ecological zones.

		Traditional Ethiopian Agro-ecological Zones			
Major zones Code No.	Major zone	Zone	Altitude (m)	Mean Rainfall (mm)	Temperature (^{o}C)
1	Kola	*Bereha* (dry-hot)	500–1500	<900	>22
		Erteb Kola (sub-moist warm)	500–1500	900–1000	18–24
2	Weina-dega	*Weina-dega* (dry-warm)	1500–2500	<900	18–20
		Weina-dega (sub-moist cool)	1500–2500	900–1000	18–20
		Erteb Weina-dega (moist- cool)	1500–2500	>1000	18–20
3	Dega	*Dega* (cold)	2500–3500	900–1000	14–18
		Erteb dega (moist cold)	2500–3500	>1000	10–14
		Wurch (very cold or alpine)	>3500	>1000	<10

Source: Ministry of Agriculture (MoA) 2000. Agroecological Zonations of Ethiopia. Addis Ababa, Ethiopia.

CHAPTER NINE

Sheep and Goat Flock Health

Sileshi Zewde and Desalegn Lidetu

Objectives

1. To describe the symptoms of economically important diseases of small ruminants.
2. To describe some important internal parasites that affect small ruminants.
3. To introduce control strategies for major diseases of small ruminants.

Expected Outputs

1. Ability to identify important diseases of small ruminants.
2. Knowledge of the symptoms of major diseases of small ruminants.
3. Ability to assist the animal health assistant in the design and implementation of disease control strategies.
4. Know and advise farmers when deworming is needed.
5. Know when to organize vaccination campaigns for important infectious diseases.

Introduction

Many important livestock diseases that inflict major socio-economic losses in Ethiopia occur every year. Annual disease losses amount to 8–10%, 14–16%, and 11–13% of the cattle, sheep and goat populations, respectively. It is estimated that some 700 million Birr (1US$ = 9.2 Birr) is lost annually due to helminth (internal parasite) infestation of domestic animals. Besides affecting the quantity and quality of livestock products, the prevalence of infectious and economically important animal diseases in Ethiopia excludes the country from profitable international markets, thereby greatly reducing the country's foreign exchange earnings. Poor husbandry practices and inadequate veterinary services are the major factors favoring the expansion of livestock diseases.

Brief introductions on the control and eradication of diseases, major internal and external parasites, and infectious diseases of sheep and goats are presented in this chapter of the handbook. *Kebele* Development Agents (KDAs) and other development workers must familiarize themselves with the nature of disease problems, symptoms of diseases and their prevention and control, and the life cycle of parasites. This knowledge is necessary to assist sheep and goat owners in taking appropriate disease prevention and control measures and to assist animal health assistants in organizing producers for necessary animal health interventions. The more detailed sections on the treatment of animals are generally meant for animal health assistants who have the authority to treat animals.

9.1. Biosecurity

Biosecurity is the prevention of disease-causing agents from entering or leaving any place where animals are present. It involves a number of measures and protocols designed to safeguard producers, animals and the livestock industry from disease outbreaks. A biosecurity program includes the following measures:

- Isolate new animals from the flock or stock returning from the market or other places.
- Do not bring infection onto your farm, or spread it around your farm through clothes, footwear or hands.
- Where possible, limit and control farm visitors.
- Do not allow contact with neighboring animals, such as through fences.
- Do not share injecting and dosing equipment with other producers. If necessary, cleanse and disinfect all equipment thoroughly.
- Dispose of dead animals properly.
- Use separate equipment and personnel for isolated animals.
- Keep the isolation barn as near as possible to the farm entrance and separate it from other pens or barns by at least 3 meters.
- Dispose of bedding properly so that other livestock do not have access to it.

9.1.1. Importance of disease control, prevention and monitoring

Disease control

- Disease control is the reduction in the incidence of disease and the number of deaths in a flock.
- Disease control can be achieved by treating diseased animals and by preventing disease through proper herd management practices.

Strategies of disease control

Quarantine

- Quarantine is the isolation of animals that are either infected or suspected of being infected with a disease or diseases. Non-infected animals that are at risk of getting a disease may also be quarantined.
- A quarantine period is also used to isolate new animals before allowing them to mix with a flock.
- A quarantine period is a minimum of 3 weeks.

Slaughter

- If a disease is infectious, affected animals can be a source of infection to others. In such circumstances, it may be economically and technically advantageous to slaughter the infected animals to prevent further spread of the disease.

Vaccination

- Vaccines are used routinely to prevent disease.
- A vaccine is a suspension prepared in a laboratory from the cause of the disease. When injected into an animal, the animal produces immunity to that disease, which protects the animal from that specific disease.
- Vaccines are of two types, dead and living vaccines.
- Vaccines need to be kept in a cold chain, meaning kept cold at all times from production through transport and storage, and before injecting into an animal. Hence, vaccines must be kept:
    - in an ice box with sufficient amount of ice during transport,
    - at 4^0C or -20^0C while in the clinic, and
    - out of direct sunlight.
- Vaccines are easily damaged if handled improperly.
- Always exactly follow the instructions given for the storage and use of vaccines.
- Most vaccines are injected under the skin.
- Always use sterile syringes and needles for vaccination.
- Always give the correct dose by the correct route.

Movement of susceptible animals

- Susceptible animals can be removed form high risk areas where infections are endemic.

Control of biological vectors

- Infectious diseases transmitted by biological vectors (insects, birds, rodents, etc.) can be controlled by eliminating the vectors.

- As examples, insect vectors can be killed with insecticide; snail habitat can be destroyed to prevent liver flukes.

Disinfection of fomites

- Fomites include farm equipment, surgical instruments, etc., used with animals.
- Fomites can be disinfected to prevent the transmission of infectious agents.

Disease prevention

- Preventing disease is much more effective than trying to cure sick animals.
- Through good husbandry practices, livestock owners can reduce the risk of diseases entering a flock.
- Understanding the main disease threats to a herd can assist a producer in taking appropriate disease prevention measures, and thus lower the impact of disease problems.

Good management practices are vital to preventing diseases

- These include provision of clean water and proper nutrition, maintaining clean housing with adequate ventilation, and clean pastures that reduce parasite and disease build-up, and the strategic treatment of stock with anthelmintics. All of these measures will reduce disease challenges.

Housing and feeding

- Housing that provides protection from wind and rain, is easily cleaned and is well ventilated is preferred to warm, wet and airless conditions.
- Feed racks should be used to avoid contamination of feed with feces and urine.

Drenching and spraying

- The build-up of parasites is likely to occur where sheep and goats are kept in intensive conditions. Regular practice of sanitation measures such as manure removal or rotation of grazing areas or paddocks can assist in disease control.
- Sheep and goats in these conditions may need regular treatment with effective anthelmintics to reduce worm burdens.
- The same approach is required with external parasites such as ticks, lice and flies.
- Spraying or dipping of animals is needed to reduce external parasites during periods of high infestation.

Disease prevention program

Disease prevention programs can be developed by the animal health staff and the *Kebele* Development Agent (KDA) considering local information on disease occurrence together with epidemiological knowledge. In addition to following the recommendations above on management and husbandry, vaccinations are also needed. The program will include the following elements:

- Routine vaccination using some of the following vaccines:
    - ♦ Pasteurellosis
    - ♦ Sheep and goat pox
    - ♦ Anthrax
    - ♦ Pest des petits ruminants (PPR)

- Ring vaccination is carried out during outbreaks of Contagious Caprine Pleuropneumonia (CCPP).
    - ♦ Goats that are found around the outbreak areas will be vaccinated. This will serve as a barrier to halt the spread of infection.

Importance of vaccination programs

Properly conducted and managed vaccination programs are critical to enhancing the immune status of the herd. Proper timing of vaccinations and booster immunizations will assist in combating disease and minimize the severity of any disease outbreak.

Transferable Message

The KDA will carry out the following disease control activities:

1. Coordinating the community on the prevention of animal diseases.
2. Reporting on disease outbreaks to appropriate authorities.
3. Keeping records of livestock resources on the station.
4. Provide regular public awareness education on the prevention and control of animal diseases.

Table 9.1. Locally available vaccines for bacterial and viral diseases of sheep and goats.

Disease	Vaccines	Dosage, administration, revaccination, and precaution	Package
Peste des petits ruminants (PPR)	PPR 75/1, Vero 76	Sheep and goats, inject 1 mℓ under skin; immunity lasts 1 year, revaccinate annually	Vial of 100 doses
Ovine pasteurellosis	*Pasteurella multocida* type "A"	Sheep and goats, inject 1 mℓ under skin; immunity lasts 1 year, revaccinate annually	Vial of 50 doses
Anthrax	Sterne 34 F^2 strain of *Bacillus anthracis*	Sheep and goats, inject 0.5 mℓ under skin; immunity lasts for one year, revaccinate annually	Vial of 100 doses
Sheep & goat pox	Sheep & goat pox ksgp-0180	Sheep and goats, inject 1ml under skin, immunity lasts for one year, revaccinate annually	Vial of 100 doses
Contagious Caprine Pleuropneumonia (CCPP)	F38	Goat, inject 1 mℓ under skin, immunity lasts for one year, revaccinate annually	

Source: National Veterinary Institute, Debre Zeit.

9.1.2. Disease occurrence and transmission

Diseases can be classified into infectious and non-infectious.

Infectious diseases:

- Diseases that can be transmitted from a sick animal to sensitive healthy animals.
- The agents for infectious diseases are germs such as viruses, bacteria, fungi, and several parasites.

Non-infectious diseases:

- These are mainly related to feed (diet-related) such as mineral deficiencies, toxic plants and poisons.
- Some non-infectious diseases may be genetic (received from parents) or due to an injury.

Animals most likely to get sick are:

- The young, weak, underfed or pregnant.
- Animals under stress, living in unclean conditions or those that are poorly fed.

- The occurrence of a disease may be due to contact between a sensitive or susceptible animal and a source of the disease or another sick animal. This can occur under the following circumstances:
  - Bringing new animals into the flock. The new animals could be a source of disease.
  - A healthy animal may come into contact with a sick animal, such as in a market place.
  - Healthy animal eating toxic plants. Several plants contain substances toxic to animals. The plants may not cause sickness when consumed in small amounts. However, toxic effects appear at high consumption levels.
  - A healthy animal may accidentally eat or drink poison. Poisons such as insecticides and rodenticide carelessly stored can be consumed by animals and may have a fatal effect. Poisoning can also occur by inadequate cleaning of a poison container later used as a waterer or feeder. It is best to discard all poison containers and not reuse them.
  - Animal consumes feed contaminated with germs, parasites or poison.
  - Animal drinks contaminated water.
  - An animal is placed in a pen previously used by a sick animal where the germs are still present.
  - Disease-causing agents may be carried by insects, a farmer or animal health worker who just took care of a sick animal on a nearby farm or by the wind (aerosol spread).

Diseases introduced by vectors

Vectors are living transmitters of infectious agents. Vectors are usually invertebrates. Major diseases that are introduced by vectors are: Babesiosis of sheep and goats, Anaplasmosis, Heartwater, Bluetongue, Rift Valley Fever, Nairobi sheep disease and Trypanosomiasis.

Routes of disease transmission

Aerial transmission

- Airborne transmission of infectious agents.
- An example is the foot-and-mouth disease virus shed from ruptured vesicles and taken long distances by air. Healthy animals can be infected when they inhale the foot-and-mouth virus-contaminated air.

Contact

- Contact transmission is direct transmission without involvement of transmission factors (e.g., mechanical vectors) and without participation of an external medium.
- This is particularly important in relation to infectious agents that are shed from the body surface. Transmission may be through bites (e.g., rabies).

Inoculation

- Inoculation transmission is the introduction of infectious agents into the body by puncture of the skin, or through a wound (e.g., when tsetse flies infected with Trypanosoma puncture the skin of an animal to feed on blood and transmit the disease).
- Introduction of infectious agents by dirty instruments such as during treatment or vaccination using needles that haven't been sterilized.

Disease monitoring

Disease monitoring is an ongoing effort in Ethiopia, directed at assessing the health and disease status of animals found in a peasant association. There is a standard disease reporting format that is used for reporting disease outbreaks. The KDA should assist the Animal Health Assistant in collection of the data. He should also keep a copy of the report for use in planning disease prevention and control activities of the peasant association (PA).

The KDA should keep the following records of his operation area, i.e., peasant association:

- Disease outbreak reports
- Vaccination and treatment records
- General health records
- Laboratory test results

These records are useful for planning an animal health program of the PA in collaboration with the Animal Health Assistant, who is in charge of the animal health activities of three Peasant Associations.

9.1.3. Disease surveillance

Disease surveillance is very important to the country for monitoring and assessing health threats to livestock. KDAs and producers should, therefore, participate in disease surveillance programs. Disease surveillance is a more active system than monitoring and implies that some form of directed action will be taken. It provides data on the occurrence of a disease and its geographic and temporal patterns. A KDA can initiate a disease surveillance activity in his PA by examining the health records he keeps and providing them to animal health authorities. These records may indicate that specific health problems are present in the PA and that there is a need for conducting disease surveillance. The surveillance will be done by the Animal Health Assistant, who is in charge of the PA animal health activity, under the supervision of the *woreda* veterinarian and the responsible animal health laboratory. The collected samples will be tested by the regional laboratory. An animal health intervention, carried out by the Animal Health Assistant in collaboration with the KDA, may be undertaken based on the test results.

Disease surveillance entails the collection of various samples and performing necropsy of dead animals as described below. The animal health technician will have the proper equipment for collection and preservation of samples.

Collection of blood samples

- In some diseases, there may be a need to isolate the causal agent from blood.
- The most appropriate time for taking blood samples is when the animal has a high body temperature.
- The skin should be shaved at the site of puncture (jugular vein), cleaned with 70% ethyl alcohol and allowed to dry.
- Blood is then drawn with a sterile needle and syringe and 10 mℓ is added into vials containing anticoagulant depending on the type of test required.
- Shake the vials to ensure thorough mixing.
- Label clearly, and place on wet ice in an ice box.
- Send to the nearest animal health laboratory.

Collection of tissue samples

- Blocks of tissue not more than 0.5 cm thick and 1–2 cm square are cut and placed in neutral buffered formalin.
- The amount of formalin used should be at least ten times the volume of the tissue sample.

Collection of fecal samples

- Restrain or hold the animal.
- Using a plastic glove, or a hand covered with a plastic bag, use a finger to expel a few fecal pellets from the rectum.
- Sometimes, as animals move in a pen they naturally defecate and these fresh pellets can be caught before they hit the ground.
- Place the fecal pellets in a clearly labeled plastic bag and either refrigerate or put on ice.

Necropsy

- If an animal dies, it is helpful to carry out a simple post mortem examination to try to find the cause of death.
- This is important in identifying infectious diseases and preventing their spread to other animals in the flock.
- It is useful for extension staff to learn how to conduct a simple post mortem examination and systematically record what is observed.
- How to do post mortem:
  - ♦ Find an area that is isolated from other animals and nearby houses, and a place where the dead animal can be burned or buried at a depth of at least 1 m.
  - ♦ Never perform a post mortem close to water supply or a grazing area.
  - ♦ Dig a small hole beside the carcass, into which organs and fluids can be placed.
- Observe the dead animal. If there are any dark, bloody discharges from the mouth, nose or anus, do not open it, as it may have died of anthrax. Anthrax spores can contaminate the area and also infect the personnel doing the post mortem.
- Touch the body to check for any gas under the skin. Does it crackle under the skin? If yes, there may have been a clostridial infection. Check the body for any external abnormalities. Check for ticks. How severe is the infestation? If there are any ticks, take samples. Check all legs for foot rot and wounds.
- Lay the body on its back or side and cut the skin in a line along the centre of the abdomen and chest. Remove the reproductive organs (testicle or udder). Pull the skin back. Bend the top foreleg and hind leg back.
- Open the body by cutting the ribs along the line of the back bone and along the chest to remove the rib cage.
- Remove the whole digestive tract without opening it, by tying the top and bottom ends of the tract with string. Remove the tract with the liver and spleen and keep it for later examination.
- Check the heart for fluids inside the outer membrane If a lot of fluid is present, heartwater may have been the cause of death.
- Cut the top of the trachea and remove it with the lungs and keep them for later examination.
- Look for kidneys, which will be in some fat at the back of the abdominal cavity. Extract the kidneys from the fat, remove and keep them.
- Check the bladder, open and observe the color and quantity of urine. Check inside the bladder for any hemorrhage or dots of blood. If present, suspect poisoning.
- Look for the spleen, which is attached to the rumen close to the liver. Check the length and edge of the spleen. Is it sharp or blunt? A normal spleen is firm, with sharp edges. Feel the consistency. If the spleen is enlarged and soft with a blunt edge, then the cause of death was possibly Anaplasmosis. If the spleen is very swollen and lymph nodes are swollen, suspect Trypanosomiasis.

- Check the liver for size and consistency, cut across the length in 2–3 places and press. If liver flukes are present, dark colored flukes will come out.
- Check the lung by opening the trachea and continuing to cut into the lung. Check for foam, worms, and blood. Adult worms in the bronchi indicate lung worms. Cut across the length of the lung to look for any foam. If there is much straw colored fluid, then suspect Contagious Caprine Pleuropneumonia (CCPP). If there is clear fluid and the lower part of the lung is red, then suspect Pasteurellosis. If there are oozing abscesses in the lung, then suspect melioidosis.
- Check the kidneys; they will normally start to putrefy 12–24 hours after death. However, if the kidney putrefies within six hours after death, suspect enterotoxaemia (pulpy kidney).
- Check the digestive tract by first observing the whole tract for any dark patches.
- Observe the small intestine, if there is a dark patch, open that area, if the small intestine appears normal, cut it open at random places. Remove the contents into a container. Cut along the length and check for any attached worms. If the contents are bloody and nodules are present on the intestinal surface, suspect Coccidiosis.
- Check the large intestine, looking carefully for blood lines, the so called “zebra markings,” which are common in Peste des Petits Puminants (PPR) cases.
- Cut the rumen along its greatest curve. Remove the contents. Look for worms attached to the wall. Small red worms full of blood indicate paramphistomum.
- Check the contents of the reticulum for foreign material such as nails, plastic bags, wires, etc.
- Check the contents of the omasum for foreign material.
- Open the abomasum and put the contents into a container. Wash the flaps of the wall into the container. Look for small white worms with red spiral patterns attached to the wall, these are probably *Haemonchus contortus*. The presence of many worms indicates a major worm problem.

Taking samples during a post mortem

- Any organ found abnormal can be taken fully as a sample.
- Put the organ in a plastic or glass container.
- When taking samples from different organs, always take both the affected part and the normal part of the organ.
- Samples should be preserved in 5% formalin or frozen. If that is not possible, preserve samples in a strong saline solution.
- Samples should reach the diagnostic laboratory within 12 hours.
- Clearly label the sample and send it to the laboratory with a copy of the post mortem examination record.

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9.1.4. Disposal of dead animals

- Burial is a common method of disposing off dead animals.
- The burial site should be far away from water and should not be a place that is easily flooded.
- Dig a 2 m deep hole, insert the dead animal and cover it well to prevent excavation by dogs.
- If the cause of death is anthrax, put quicklime under and above the dead animal.

9.2. Routine Health and Diagnostic Procedures

9.2.1. Signs of ill health — clinical examination

A complete clinical examination/observation consists of three important elements: case history, inspection of the environment, and physical examination of animals.

9.2.1.1. Clinical examination

- Make an inspection of the environment; particularly those places known to favor disease, such as marshy, damp areas, should be closely observed.
- Identify the animal by some means, brand, nick name, ear tags, etc. Carry out the examination while the animal is still quiet. Further examination can be carried out later while the animal is restrained.

You should ask several questions during the clinical examination. The answers may allow you to form an opinion of the disease responsible before conducting the physical examination. The following are some of the procedures:

- Closer inspection of all body regions:
  - ♦ First, look at the animal from a short distance before you disturb it.
  - ♦ Observe the animal's behavior. Is the animal calm? Is it excited or aggressive? Is its breathing normal or distressed? How fast is the animal breathing? Is it shaking and grinding its teeth? Does it move normally? Is it with its group or does it stand alone?
- Closer examination of the nose, mouth, eyes, head and neck:
  - ♦ Is there a discharge coming from the nose? What type of discharge? — runny, thick, clear, cloudy or colored? Are there any sores on the nose? Does the breath smell bad?
  - ♦ Is there abnormal salivation?
  - ♦ Are there ulcers around the lips, gums, tongue, etc.?
  - ♦ Is there any discharge from the eyes? What color is the mucous membrane inside the eyelid?
- Closer examination of the skin:
  - ♦ Are there any places where the wool or hair is missing?
  - ♦ Are there any sores or blisters on the skin? Wet, sore patches of skin may allow disease-agents to enter, causing infection.
  - ♦ Are there any swellings under the skin? These may be *lymph nodes or abscesses.*
  - ♦ Is the coat normal and healthy?
- Closer examination of udder and genitals:
  - ♦ Is the udder swollen or warmer than usual?
  - ♦ Is the udder painful to the touch and does the animal refuse the udder being touched?
  - ♦ Are there injuries on the teats, udder?
  - ♦ Is the milk normal in color, quantity, and consistency?
  - ♦ Is there any vaginal/vulva discharge?
  - ♦ Are there any ulcers/scabs around the vulva?
  - ♦ Is there any injury on the scrotum?
  - ♦ Is there any discharge from the penis?
- Closer examination of legs and feet:
  - ♦ Is the animal lame? Examine the foot and legs for wounds, swelling or pain.
    - o Are one or more legs involved?

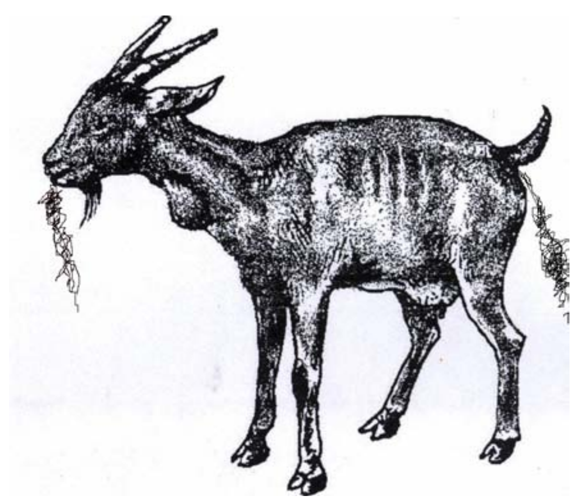


Figure 9.1. A sick goat with nasal and mouth discharges and diarrhea.

- Closer observation of changes in ways of defecation and urination:
  - ♦ Does the animal pass urine and feces normally?
  - ♦ Does the animal look distressed when it passes feces and urine?
  - ♦ Does it have a strange pose during defecation and/or urination?
  - ♦ Is the feces watery, and passed more frequently than normal?
  - ♦ Is there blood or mucous in the feces?
  - ♦ Is the color of urine normal?

In general, during clinical observation and/or examination you can notice the following:

- A healthy sheep/goat:
  - ♦ has a good appetite.
  - ♦ appears bright, alert and responsive when playing and climbing.
  - ♦ stays with the flock.
  - ♦ has smooth, clean and shiny coat.
  - ♦ has clear eyes with some pink color in the eyelids.
  - ♦ has an erect tail and a moist nose.

- Healthy lambs/kids are active and alert, and breath normally. They are up on their feet in 30–60 minutes after birth, move freely and feed often.

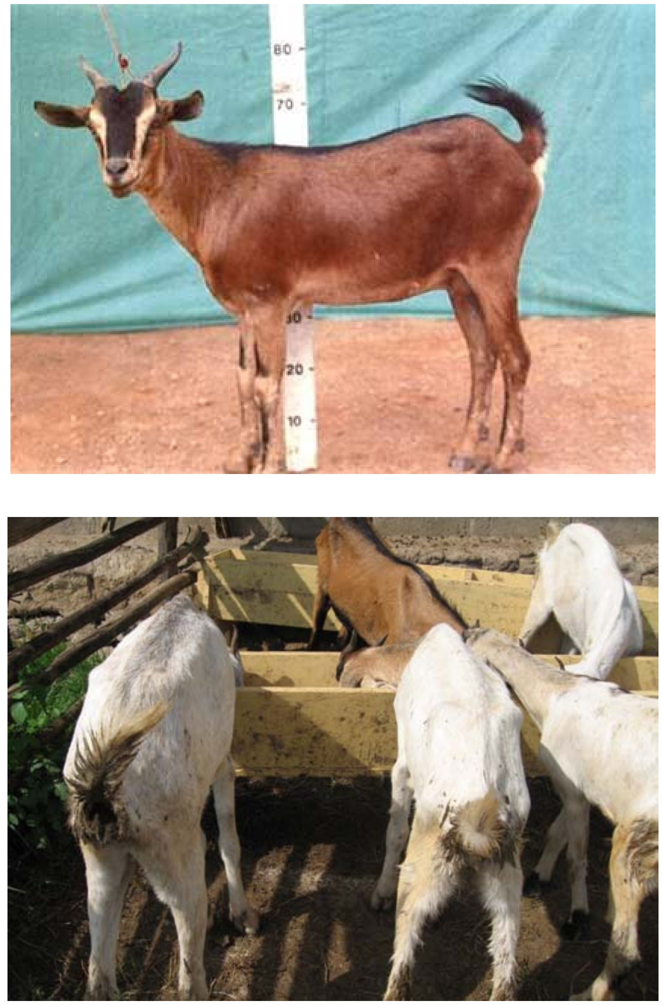


Figure 9.2. Healthy goat (top) and sick goats (bottom).

- A sick/unhealthy sheep or goat:
  - ♦ has reduced appetite.
  - ♦ has breathing that is too fast or too slow.
  - ♦ sits or lies separated from the flock/herd.
  - ♦ has an ill-appearance with a dull, matted coat, hunched-up stance and tail and ears that droop down.
  - ♦ has a dry nose or has discharge from the nose, eyes, and/or mouth.
- Unhealthy lambs/kids are:
  - ♦ often unwilling to move or feed.
  - ♦ appear weak, cold, lazy and hunched up.
- Unhealthy older lambs/kids show similar clinical signs as smaller lambs/kids. Often they stand separate from the rest of the flock in pain, scouring (wet tail with feces), and move slowly.

Taking temperature

A sick animal may have a body temperature higher or lower than normal. You can estimate the temperature of an animal easily by feeling its back or ear with your hand. This is not applicable when the animal is hot because of the sun. Follow the steps below to measure the body temperature of an animal using a thermometer.

- Turn the thermometer until you can see the silver line, the place where the line stops marks the temperature.
- Hold the thermometer at its end firmly and shake it so that the line of liquid (mercury) stops near the bulb of the thermometer.
- Smear a little Vaseline on the bulb end of the thermometer.
- Have someone hold the animal, or if you are alone, tie it up. Lift the animal's tail and gently insert the thermometer about 5 cm into the rectum.
- Keep the thermometer in the rectum and touching the wall for at least two minutes.
- Take the thermometer out, wipe it clean and turn it so that you can see the line and read the temperature.

  Normal temperatures of sheep and goats:
  - Adult sheep: minimum, 38.5°C; maximum, 40.5°C
  - Lamb: minimum, 38.5°C; maximum, 40°C
  - Goat: minimum, 38.5°C; maximum, 40.5°C
- Finally, shake the thermometer again, wash it in cold water and dry it before storing it.

Pulse or heart rate

An animal's heart rate is usually measured after the animal has rested for at least five minutes. You can feel the left side of the chest behind the leg and tell how fast the heart beats by placing your hand directly over the heart.

Each instance the heart pumps blood through the arteries is known as a pulse. You can feel the pulse by putting your fingers over arteries, usually done by feeling the femoral artery inside the back leg.

- The pulse rate of sheep and goats normally ranges between 60 and 80 per minute.

Respiration

An animal's respiration is measured by watching the rib cage movement. Animals breathe in three separate movements: breathing in, breathing out and a short pause. Very young, very old, very fat or pregnant animals breathe faster than other normal animals. An animal resting in the shade breathes slower than those standing in the sun. Sick animals breathe slower or faster than a normal animal.

- Sheep and goats normally breathe roughly 12–15 times per minute.

Rumen movement

Push with your hand just behind the last rib on the left side of a sheep or goat to check whether the rumen is contracting normally. You must feel the rumen contracting about once every minute.

- Average rumen contractions occur at a rate of 1–2 per minute

Checking mucous membranes

The thin skin that lines the inner surface of the body is called the mucous membrane. Mucous membranes are often wet with mucous. They are good indicators of what is happening inside the body, since they are so thin and transparent that you can observe blood vessels through them. The mucous membranes inside the mouth, at the vulva/vagina and inside the eyelid are easy-to-observe examples. The easiest place to look at mucous membranes is inside the eyelid.

Follow the following steps to examine the mucous membranes of the eyelid:

- Examine the sheep/goat in good, natural light.
- Open the eyelid as shown in the figure.
- Push the upper eyelid up with the upper thumb, while the lower thumb pulls the lower lid downward. Open the eye for a short time only, if open for a longer time congestions will take place and your reading will be false.
- Look at the color inside the lower eyelid.

Normal, healthy animals have pink/red mucous membranes (Figure 9.3). When an animal is sick, the mucous membrane becomes pale, white, yellow, very dark-red, red-blue or brilliant. These are signs of ill-health. For example:

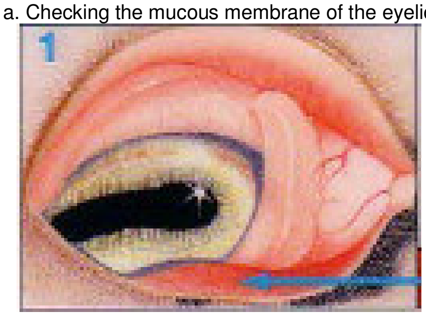
- Pale mucous membranes are signs of *anemia*.
- Yellow mucous membranes can be a sign of liver diseases due to liver flukes.
- Brilliant red is a sign of *cyanide poisoning*.

9.2.1.2. History

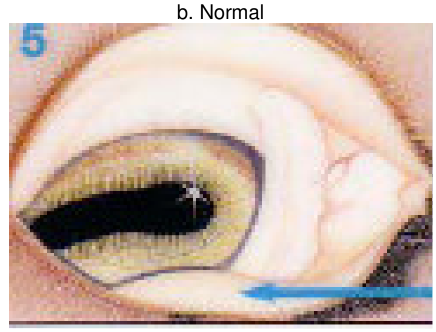
The history of a disease situation must be obtained from the people associated with the animals. Such a history can be obtained by asking questions like the following:

- Why do you think the animal is sick?
- When did people first notice signs of disease?
- How old is the animal?
- What sex is it?
- What kind of place does the animal come from?
- Has the animal been in contact with other animals?
- Which treatments or vaccinations have been given?

a. Checking the mucous membrane of the eyelid



b. Normal



c. Anaemic

Figure 9.3. Checking the mucous membrane of the eyelid.

General enquiries usually involve assessment of the following issues:

- Number of animals in the flock involved.
- Previous treatment or vaccinations given.
- Recent movements of the flock.
- Any contact with animals from other flocks.
- New introductions of animals into the flock.
- Variations in weather conditions, particularly temperature, humidity, wind direction and speed.
- History of disease occurrence, the time the disease was first noticed, including hour of the day.
- Number of animals affected, their ages, physical condition, sexes and the time of death.
- Feeding and watering routines.

Transferable Messages

1. Disease problems are mostly reflected with signs or symptoms likely to be recognized by farmers. During farmer training sessions, encourage farmers to share their experience on how they identify animals that need medical attention.
2. Let each participating farmer mention symptoms of illness in sheep and goats before your descriptions or presentation of your prepared teaching materials.
3. Remember that many diseases can show similar symptoms and animals may not always show the same signs, even when they have the same diseases. Signs of illness do not usually happen at once or in the same order. For example, sheep or goats often stop eating when they are sick. The animal may have stopped eating because of foot problems and will not walk to its feed, or due to some other simple reason such as a problem in the mouth.
4. It is general knowledge that one should not expect to find out exactly what is wrong with the sheep or goat from clinical signs of diseases. Such signs of illness may help to recognize some important diseases.
5. It would be best if training of farmers/pastoralists on how to detect sick animals among their flocks is carried out with a demonstration using a sick sheep or goat. Carry out the demonstration from nose to tail, on a step-by-step basis, explaining that farmers should perform observations for symptoms of diseases before taking their animals for treatment.
6. The use of flipcharts is often good for the training of farmers. Prepare flipcharts where you write the symptoms observed on one side and the possible or suspected disease types on the other side. For example, if one or two sheep or goats have died, and dark blood comes from the mouth, nose or anus and no signs of diarrhea, show that the suspected cause of death is anthrax. If diarrhea and signs of bleeding from the anus are observed, then the cause of death may be heartwater. If liver flukes are found in the liver of the dead sheep, the possible cause is liver flukes.
7. Similarly the KDA can prepare flipcharts showing signs of disease concerning eyes, ears, skin, lumps and swellings, breathing problems, eating and digestion problems, reproduction and udder, urine and feces, and signs relating to behavior and movement of animals.

9.2.1.3. Veterinary procedures and activities

Restraining animals for treatment

Mass handling

Without a handling system, health programs or activities will be delayed or not accomplished.

- Handling systems that are properly designed allow sheep or goats to flow through smoothly with minimal stress and injury.
- When you have to work with sheep and goats and there is no handling system, it is necessary to pack them into a small, fenced space or in a long working pen, 1 to 1.5 meters wide. Work your way (vaccinating, spraying, other health activities) along the pen, keeping the treated animals behind you. Make sure to separate treated from untreated animals.
- Weighing scales, tipping cradles and treatment crates can all be arranged in the line of traffic of animal flow.

Catching and restraining individual sheep/goats

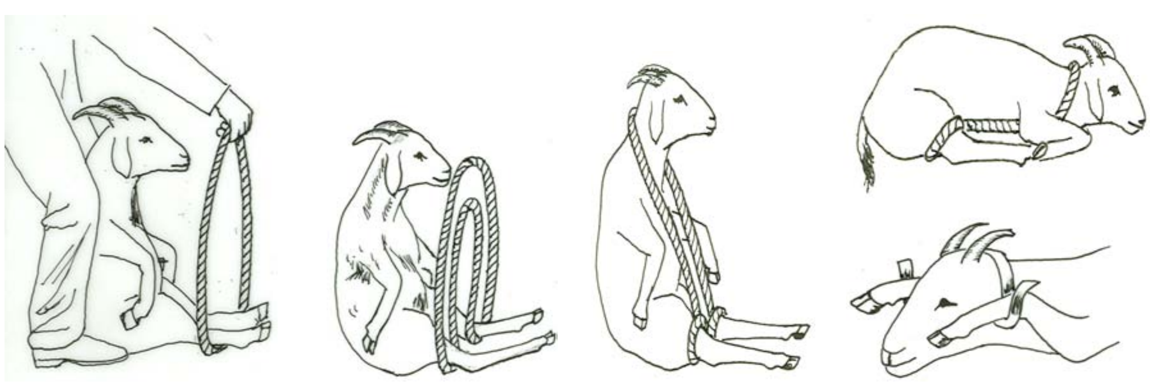
A group of sheep or goats can be herded into a collecting pen or enclosure from where individual animals can be caught. Approach an animal from the side and attempt to bribe it with some kind of feed and be fast to catch the horn, legs or neck. Get assistance to hold it firmly so that you can examine the head, the neck, eyes, and other parts of the body. Adult animals and big lambs/kids can be individually restrained by holding the skin under the chin and by holding the tail head on its rump. The easiest technique to hold a sheep or goat is in the following way:

- Grasp the animal by the neck or upper part of a back leg.
- Put your right hand on its muzzle and turn its head slowly but firmly sideways. The animal will fall to the ground. Shift it into a sitting position with it leaning slightly against your legs keeping its feet off the ground.
- The animal should now be relaxed and you can examine its udder or testes, collect various samples such as ticks, lice and other external parasites (maggots), take blood from the jugular or ear veins, trim its hooves, etc.

There is an alternative way of handling a sheep/goat in a sitting position. First, reach under the belly and gently pull the two furthest legs towards you. With the animal on its side lean over to catch both front legs, and turn the body towards you so that it sits on its bottom, as in Figure 9.5, Step 3.

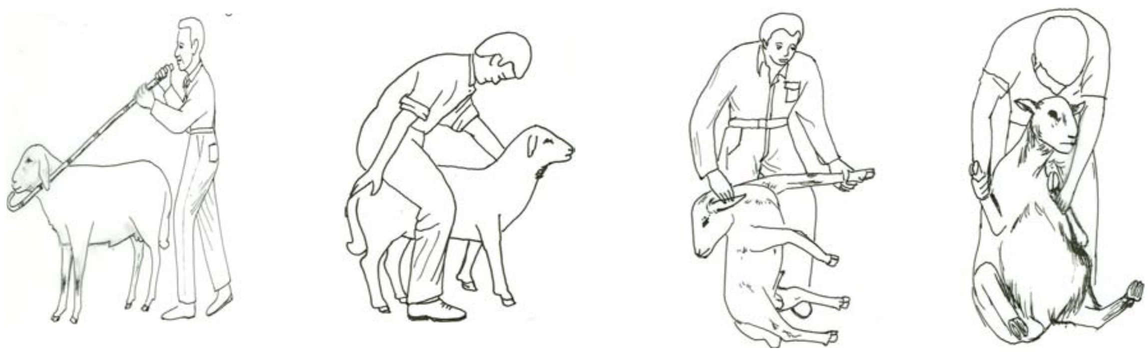
To restrain a sheep or goat in a standing position, its head can be held in a loop of rope or strong string. The loop should be about 50 cm in circumference and tied to a tree or a post at the same height as the sheep's shoulder. Tying a knot that does not slip but holds the loop at a fixed size prevents the animal from being strangled. Catching and restraining of sheep (rams) is easy when they have collars. Under these conditions, you can simply collect fecal samples directly from the rectum and other samples from different preferred sites.

Animals can also be restrained in a standing position using a neck crush. The neck is trapped between two pieces of strong, upright planking.



Step 1 Step 2 Step 3 Step 4

Figure 9.4. Restraining a goat.



Step 1 Step 2 Step 3 Step 4

Figure 9.5. Holding and twisting a sheep to restrain it in a sitting position.

Treatment

Sick animals should be isolated from the flock and treated as soon as symptoms appear. The following are some of the useful basic veterinary supplies for the clinical care of sheep and goats.

Figure 9.6. Pulling two furthest legs towards you.

Veterinary equipment

- Stethoscope
- Automatic vaccination syringes, size 20 mℓ with corresponding needles
- Dosing gun for anthelmintic treatment
- Blood collection tubes with no additive (for serum) or with Ethylene Diamine Tetra acetic Acid (EDTA) (for whole blood).
- Clinical thermometer
- Water-based lubricant gel
- Disposable gloves
- Bacterial culture swabs
- Rope halter
- Hoof shears or trimmer
- Elastrator and rubber rings or Burdizzo for castrating and docking
- Sterilization kit
- Knapsack sprayers
- Plastic buckets of 5, 10, 20 liters capacity
- Knives

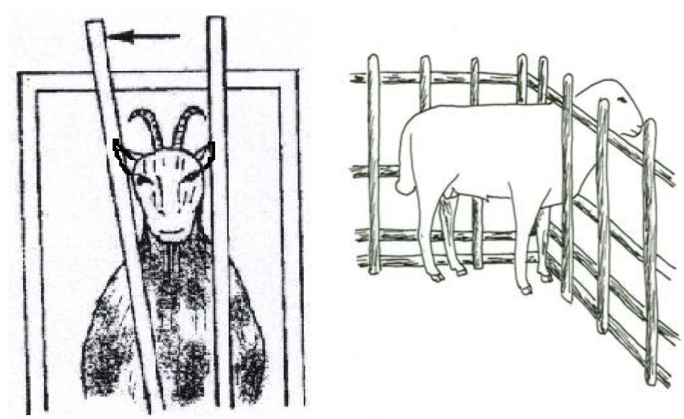


Figure 9.7. Restraining of an individual goat or sheep in standing position in a neck crush.

Drugs, chemicals and reagents

- Sterile 50% dextrose solution
- Sterile calcium-magnesium-phosphorus-dextrose solution (CAMPD)
- Iodine solution, with cotton or other materials for applying iodine to wounds
- Oxytetracycline aerosol spray, wound powder, etc.
- Injectable antibiotics (long- and short-acting oxytetracycline, penicillin and sulfonamides, antibiotic ointments)
- Anthelmintics
- Acaricides
- Anticeptics
- Vaccines
- Vitamins and mineral supplement
- Denatured alcohol

Deworming of animals is needed when:

- an animal is thin, probably poorly-fed;
- an animal is not growing well;
- an animal eats less than normal;
- an animal is weak, tires easily and lags behind the flock;
- an animal has rough coats;
- you observe a number of animals with diarrhea and dehydration; and
- you observe swellings or edema (e.g., bottle jaw) or see animals with pale mucous membranes.

Drenching and dosing

A variety of routes exist for administration of medications to sheep and goats, including several methods for the oral dosing of small ruminants.

Figure 9.8. Drenching an animal using a syringe.

- When dosing a sheep or goat orally, the head of the animal should be kept in a reasonably normal position to enable the animal swallow the drench.
- Administration is easily accomplished using dosing guns. However, dosing guns are often expensive for farmers to buy and cheaper means are available.
- Use a syringe to drench animals. This prevents animals, particularly older ones that recognize drugs in boluses or pills, from spitting them out minutes later.
- When administering a drug or anthelmintic, the dosing gun or syringe should be placed on the base of the tongue. The drug will then go to the rumen.

Tubing an animal

Large volumes of medication or liquid substances may have to be given by stomach-tube for adult sheep and goats.

- The tube to be used should be soft and with an inner diameter of 0.5–1.0 cm depending on the size of the animal. There must be no sharp edges on the tube.
- The total length of the tube to be inserted is estimated by measuring from the mouth to the last rib. Mark the length on the tube before it is inserted into the animal's mouth.
- The end of the tube is lubricated using edible oil, then placed in the animal's mouth and slowly pushed towards the throat and down the esophagus towards the stomach. The tube should be seen and felt going down the neck. If it is neither seen nor felt, check the position to make sure the tube has not entered the trachea and traveled to the lungs.
- The location of the tube in the stomach is indicated by possible smell of rumen gases. It is confirmed by ensuring that there is no air passing through the tube as the animal breathes. (If air is flowing through the tube, it is in the lungs and giving medicine there may kill the animal.)
- The medication/liquid is administered slowly by means of a syringe attached to the stomach tube.

Lambs are often fed colostrum via stomach tube instead of bottle feeding. Kids that are weak and unable to suckle must be given colostrum with a stomach tube. Tubing is also a temporary measure for feeding potential foster lambs, preventing them from becoming fixated on milk bottles. Sterilize tubes with boiling water before use. The technique for stomach tubing of lambs and kids is as follows:

Figure 9.9. Tubing a lamb.

- Place the lamb/kid wrapped in a towel on your knee.
- Lubricate the tube with vegetable oil.
- Hold the jaw with your left thumb and forefinger, with the fourth finger across the neck.
- Let the lamb/kid chew your finger, then slide the tube over the tongue and into the stomach until about 5–8 cm are left.
- Normally, the lamb/kid will relax and chew the tube.
- Attach the full syringe to the tube and empty the contents gently.
- When finished, pinch the end of the tube and withdraw it slowly. Clean the tube and store.

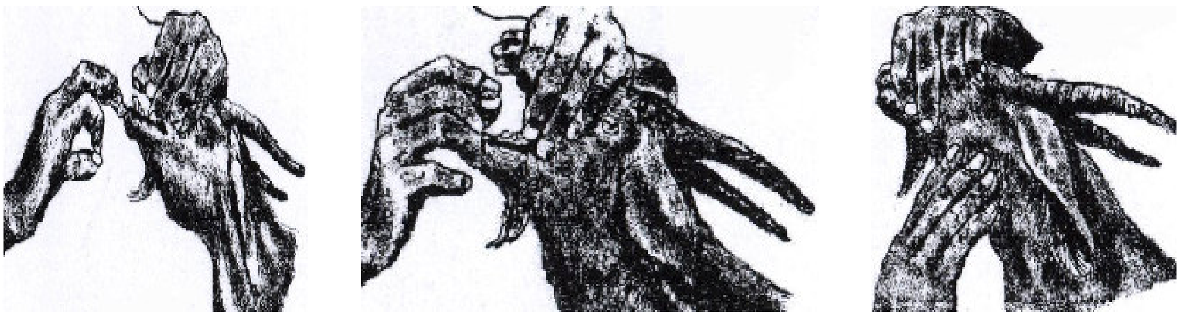
Bolus/pill administration

Boluses are one of the easiest and most reliable ways to administer medicines. Always follow the maker's instructions when preparing the dose. You can break boluses into two or four parts to get the correct dose.

Use the balling gun to administer boluses or pills to sheep and goats. The bolus is inserted into the opening of the balling gun and pushed out by the plunger. Care should be taken to place the bolus behind the tongue in order to activate the swallowing reflex.

In the absence of a balling-gun, boluses/tablets are simply given to sheep and goats by hand with or without wetting them with drinking water. You can dip boluses in edible oil so that animals can easily swallow them.

Hold the animal securely, with one hand firmly over the top jaw to open the mouth (Figure 9.10, Step 1) and place the bolus behind the tongue of the animal. Hold the mouth closed and keep the head tilted upwards stroking the throat to stimulate swallowing (Figure 9.10, Step 3). For both procedures, observe the animal for a few minutes to make certain the bolus was swallowed and not spit out.



Step 1. Open the mouth

Step 2. Put the bolus on the tongue at the back of the mouth

Step 3. Hold head up with the mouth closed and stroke the throat

Figure 9.10. How to give boluses to goats.

Figure 9.11. How to give a bolus using a tube (balling gun).

Proper equipment, dosage and injections

There are various types of syringes and needles with different gauges and sizes. –

- Disposable syringes, 3 mℓ, 5 mℓ, 10 mℓ, 20 mℓ
- Hypodermic syringes, 12 or 15 mm, 16 or 18 gauge needles.

Dosage

Careful use of anthelmintics and antibiotics, as well as other medicines, is necessary if drugs are to remain effective. Underdosing or overdosing and frequent use of drugs may lead to the development of resistance. Therefore, it is always good to give accurate doses by calculating the weight of individual animals. For group treatment, some people estimate the dose based on the weight of the heaviest animal or the average weight. In this case, some animals will be overdosed and some underdosed. Accurately estimate the weight of animals you treat. Weigh some of them if you can. There is a useful technique to correctly estimate the weight of an animal. This is known as girth measurement. Estimation of body weight using heart girth measurements is presented in the Management section of this handbook.

Dose calculation for antibiotics

Dosage should be measured according to the manufacturer's recommendations based on the weight of the animal. The following example shows the steps needed to calculate how much medicine to give:

- You estimate that an animal weighs 50 kg.
- The manufacturer's dose tells you to give 10 mg/kg bodyweight of oxytetracycline.
- Multiply the animal's weight, 50 kg, by the dose rate (10 mg/kg). This shows you that the animal needs 500 mg of actual medicine (50×10=500).
- The medicine you have contains 50 mg/mℓ of oxytetracycline (which means that 50 mg of actual medicine is available in each mℓ of the injection).
- Divide the amount of actual medicine the animal needs (500 mg) by the strength of the medicine (50 mg/mℓ) to find that the animal needs 10 mℓ of medicine (500/50=10).

Injections

- Assemble the syringe and needle, shake the bottle, and swab the cap with clean surgical spirit.
- Always check the recommended dose on the bottle label.
- Draw a volume of air into the syringe slightly more than the volume of liquid to be withdrawn.
- Thrust the needle through the rubber cap of the bottle.
- Turn the bottle upside down and push the plunger to inject the air in the syringe into the bottle (you will have difficulty withdrawing the dose if you do not do this).
- Make sure that the needle tip is below the surface of the fluid.
- Pull the plunger down, drawing slightly more liquid into the syringe than required.
- Push the plunger slightly to expel any air bubbles and adjust the right dose.
- Detach the syringe, leaving the needle in the cap for next dose withdrawal.
- Finally, attach a second needle to the syringe; expel any air from the needle.
- Needles should be changed between every 5–10 sheep/goats. If a blood-borne disease is suspected in the flock, a new needle must be used with each animal.
- Always discard partly-used bottles of medicine at the end of the day.

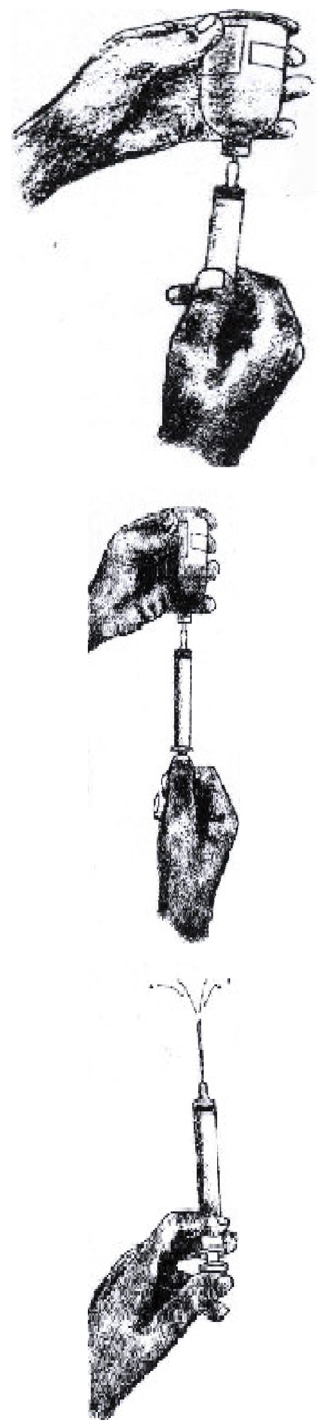


Figure 9.12. Filling a syringe with medicine.

Care of syringe and needles

- Immediately after use, the syringe should be dismantled, thoroughly cleansed, and then sterilized by boiling in clean water for twenty minutes.
- Do not inject animals within four weeks of slaughter
- Never vaccinate animals in wet conditions. Wet fleece carries a greater risk of infection.

Types of injections and procedures

- **Intramuscular (IM)** is the most common injection method. Use an 18-gauge needle, 2–3 cm long, to inject antibiotics. In small, young lambs and goats, a smaller 20-gauge needle should be used. Inject into the neck muscle just in front of the shoulder or the fleshy part of the shoulder itself. Injections should not be given in the hind leg or quadriceps muscles of the thigh. Injections can leave injection-site lesions that could decrease the value of the meat. To give an injection:
  - ♦ Gently tap/hit the muscle two or three times with your fist to accustom the sheep/goat.
  - ♦ Insert the needle quickly, straight into the muscle.
  - ♦ Before injecting, draw the plunger out slightly to check if the needle has entered a blood vessel. If blood enters the syringe, withdraw the needle slightly and redirect into the muscle.
  - ♦ When a correct spot has been entered, slowly press the plunger down. Volumes of no greater than 2 to 4 mℓ should be injected into a single IM site.
  - ♦ Remove the needle from the animal and rub the injection site or press with cotton to prevent excess bleeding. This will also help the medicine to stay in the muscle.
- **Subcutaneous (SC)** injections are given under the skin, often in the skin just behind the shoulder or in the neck or inside the elbow of the front leg. A short needle, 1–2.5 cm, should be used to inject under the skin:
  - ♦ Pull out a fold of skin and insert the needle at a right angle to the skin-fold. Care must be taken to ensure that the needle does not pass through the skin and exit on the other side.
  - ♦ Gently press the plunger down.
- **Intravenous (IV)** injections are given into veins in order for the antibiotics to enter the blood stream as quickly as possible. Common sites for intravenous injections include the cephalic vein and the jugular vein. Use an 18-gauge or 20-gauge hypodermic needle.
  - ♦ During an IV injection, the compound is administered slowly and the animal monitored for evidence of respiratory or cardiac distress. If there is any adverse reaction, the injection should be stopped**.**
  - ♦ An intravenous injection should only be given by a veterinarian or experienced animal health technician.

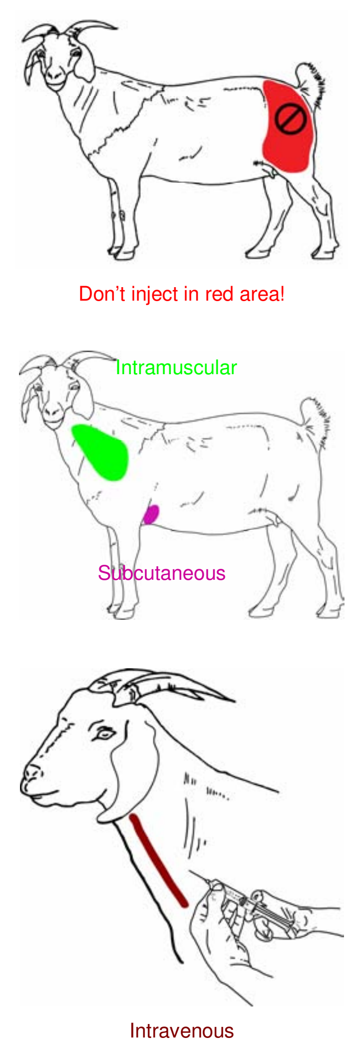


Figure 9.13. Injection sites for intramuscular and subcutaneous injections.

Abscesses

An abscess is the result of a traumatic skin penetration with consequent infection. An abscess may also be the result of infection with the disease *Caseous lymphadenitis*.

- Subcutaneous abscesses are common in sheep and goats.
- Foot abscesses occur in sheep during the wet season. Lameness is the main symptom.
- The common sign of an abscess is swelling. The lump will grow and eventually burst.
- Abscesses contain bad-smelling pus enclosed in a pocket.
- Abscesses commonly occur under the throat, behind an ear, at the point of shoulder, in front of or inside the hind legs.
- A more serious form of abscess involves the development of internal abscesses, often on the lungs, causing pneumonia and loss of body condition.
- Abscesses must be opened, drained and treated as an open wound. Lancing abscess is carried out as follows:
  - Isolate the infected sheep or goat away from other animals.
  - Clean the abscess with soap and water, or antiseptic.
  - Stick a needle into it. If blood comes out, stop immediately. If pus comes out, continue and incise the abscess with a sharp, sterile blade, making a downward cut to allow the pus to drain.
  - Drain the pus onto cloth, paper or other material that can be burned or buried. Wash the abscess with boiled salty water or mild alcohol.
  - Use dressing forceps and cotton wool to clean the inside edges of the abscess.
  - Finally, wash with iodine or other antiseptic.
  - Treat the animal with sodium sulfadimidine solution (1 g/8 kg body weight), sulfonamide that may need to be continued for several days, procaine penicillin (3 mℓ/50 kg), or long-acting tetracycline 5 mℓ/50 kg) once, and if needed, every 3 days.

a. Treat when hair has fallen and there is a soft spot in the middle

b. Cut a cross over the soft spot with a sharp sterilized knife

c. Squeeze out the pus

d. Clean wound with boiled salty water

e. Wash with iodine or other antiseptic

Figure 9.14. Lancing abscesses in sheep.

9.3. Internal Parasites

Internal parasites are worms. Worms are small creatures that are found inside animals. Sometimes they can be seen with the naked eye, but sometimes they are not easily seen. Unless you specifically look for worms in an animal that dies or which is slaughtered, you may not see worms.

9.3.1. Signs of internal parasites in live animals

Some animals are more badly affected by worms than others, while some animals never develop a bad worm infection. How will you know if an animal is suffering from worms? There are a number of signs that may indicate that an animal has a worm infection. However, the signs will not tell you that the problem is definitely caused by worms, but should make you suspicious. Some commonly seen signs are:

- Bottle jaw
    - ♦ You may notice that a sheep or goat has a bottle jaw. This is a soft, cold swelling under the chin of the animal. It may be seen with a serious worm infection.
    - ♦ Brisket edema or swelling between the front legs and belly.
- Pale mucous membrane (*anemia*)
    - ♦ Sometimes the inner eyelid of animals may be very pale. This may be a sign of bad worm infection.
- Shabby wool or hair (poor condition)
    - ♦ Animals may have poor hair or shabby wool during the dry season. You may notice at first that sheep or goats are emaciated. You should feel the animals over their lower backs.

Loss of condition and rough hair coat

- Diarrhea
    - It may be difficult to see that a sheep with a fat tail has diarrhea unless you look carefully under the tail.
    - Diarrhea can be caused by round worms, coccidian or liver flukes. It may also have other causes. Sometimes toxic plants or an inappropriate diet may cause diarrhea.
- Weakness, depression and lying down abnormally.
- Eating less than usual or stopping eating altogether.
- Decrease in milk production.
    - Ewes or does may not have enough milk for their lambs or kids. The young may die of starvation.
- Pass tape worm segments in their feces.

Signs of bad worm infection in dead or slaughtered animals

You may notice the following signs of worm infection when you open the carcass of a dead or slaughtered animal.

- Worms and bleeding in the milk stomach
- Worms and fluid in the intestines
- Fluid in the body cavities
- Bumps on the intestines
- No fat on the carcass
- Pale carcass

9.3.2. Types of internal parasites

The major types of internal parasites of sheep and goats can be categorized into four groups according to their locations in the animal.

- Abomasal worms – nematodes (round worms)
- Liver flukes – trematodes (leaf-like worms)
- Intestinal worms – cestodes (tape worms)
- Protozoa (coccidia)

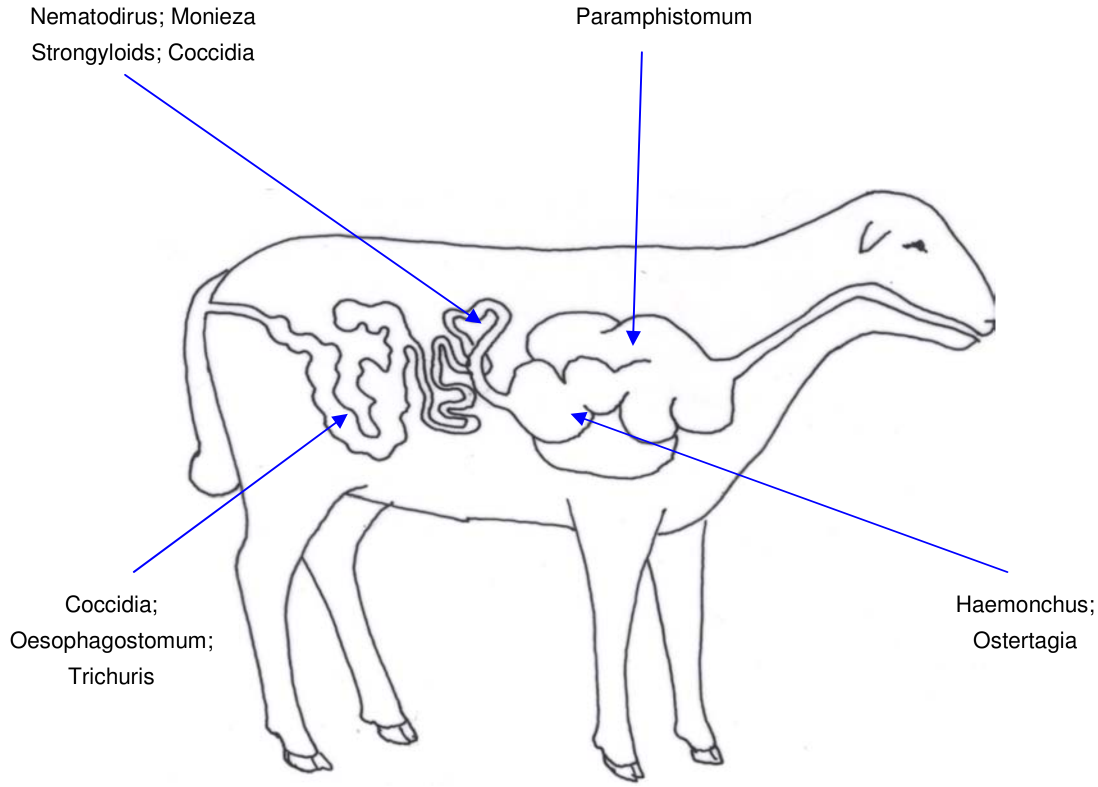


Figure 9.16. Locations of main parasites in sheep and goats (adopted from Peacock, 1996).

Table 9.2. Major parasites of small ruminants.

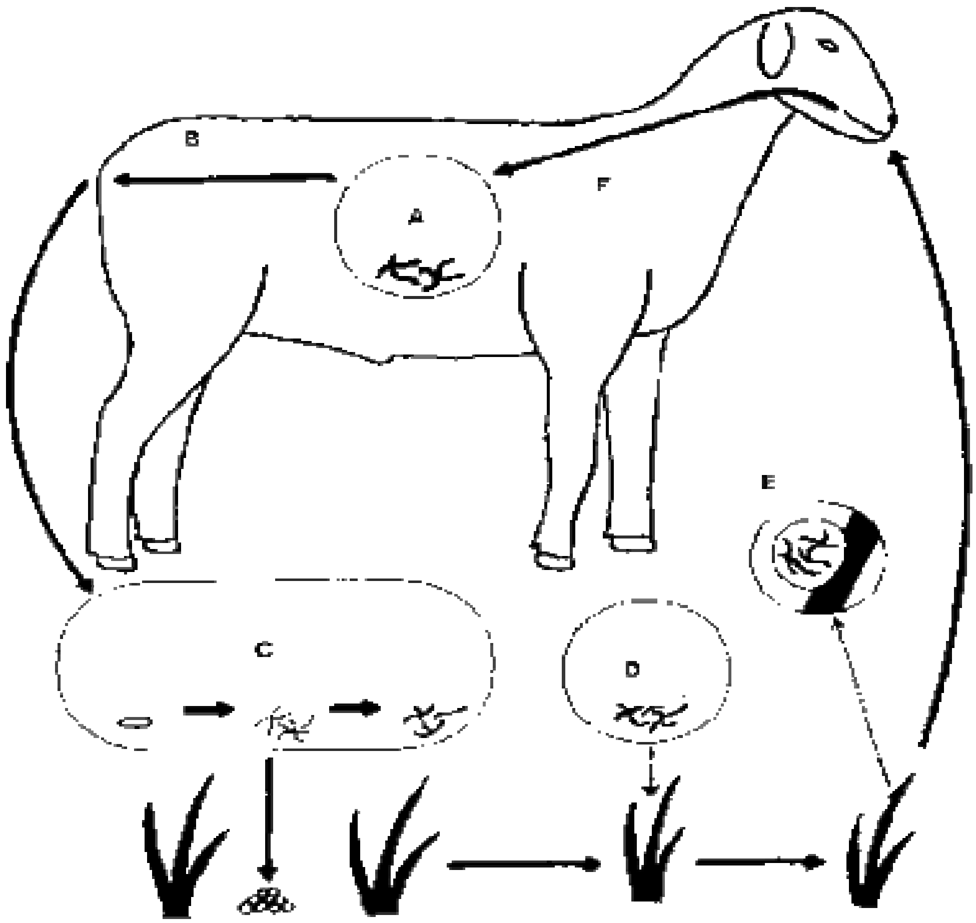
Location	Specific name	Common name
Abomasum	*Haemonchus contortus*	Barberpole worm
	Ostertagia circumcincta	Small brown stomach worm
	Trichostrongylus axei	Stomach hair worm
Liver	Trematodes	Liver flukes
	Fasciola hepatica	
	Fasciola gigantica	
Small intestine	*T colubriformis*	Black scour worm
	Nematodirus spathiger	Thin-naked intestinal worm
	Strongyloides papillosus	Thread worm
	Cooperia punctata	Small intestinal worm
	Bunostomum trigonocephalum	Hook worm
Large intestine	*Trichuris ovis*	Whipworm
	Oesophagostomum columbianum	Nodule worm
	Chabertia ovina	Large-mouthed bowel worm
Lungs	*Dictyocaulus filaria*	Large lung worm

Nematodes (round worms)

Of all the gastro-intestinal parasites that affect sheep and goats, abomasal worms are by far the most important type.

- *Haemonchus contortus* is the most dangerous worm. In the adult form, it is a small worm, 1–4 cm long, which is usually found attached or freely swimming in the contents of the gastrointestinal tract. The male is red, while the female has red and white stripes in a spiral up its body, giving it the common name 'barberpole worm'. It is a blood-sucking parasite. It is estimated that twenty adults can suck 1mℓ of blood per day from a sheep or goat. In acute infections, where large numbers of larvae ingested over a period of days lead to large adult worm populations, anemia can cause death before any effective treatment. In chronic infections, where the rate of infection has been slower, anemia results from the loss of whole blood.
- In infections with *Ostertagia* spp., *Trichostrongylus* spp., *Nematodirus* spp. and other intestinal parasites, animals show signs attributable to reduced feed intake, while others develop severe diarrhea with dark green or black feces. Some animals die quickly while others linger for days or weeks and become progressively weaker. This accounts for much of the lost productivity associated with these parasites.
- Life cycle of round worms:
  - Round worms are a single-host parasite, meaning that they live and reproduce in a single animal.
  - The adult worms live in the stomach and intestine of the animal where they lay eggs.
  - The eggs are passed out in the dung of the animal, but are too small to be seen in the dung.
  - The eggs hatch and young worms crawl up the moisture on blades of grass.
  - When a sheep or goat eats the grass, the animal takes in the young worms.
  - The worms then grow into adult worms in the intestine and stomach and the cycle begins again.

Figure 9.17. Barberpole worm in the stomach of a goat.



A - Adult worms in abomasums or intestines
B - Eggs released by female worm and incorporated into fecal pellet
C - Egg to L1 larvae to L2 larvae
D - L3 larvae in grass
E - L3 larvae suspended in dew drop
F - Swallowed larvae develop into adult

Figure 9.18. Life cycle of *Haemonchus contortus*.

Liver flukes

- The liver can be infected with two main types of flukes: *Fasciola hepatica* or *Fasciola gigantica.* Both use a snail as an intermediate host. Liver flukes are widely distributed in the highland and semi-highland areas. Marshy, poorly-drained pastures and grasslands beside irrigation channels are common sources of infection for both sheep and goats. Infection often occurs during the dry season.
- In the life cycle, eggs shed from ruminant animals hatch and produce cysts able to swim and infect the snail host. In the snail, they further develop into larvae (metacercariae) that are able to infect sheep and goats or other major hosts. Once ingested by sheep or goats, the larvae penetrate the intestinal wall and develop further in the liver, which may become severely damaged. Acute hepatic fascioliasis occurs 5–6 weeks after the ingestion of large numbers of metacercariae due to the sudden invasion of the liver by masses of young flukes.
- If unusually large numbers of flukes invade the liver over a short period, the damage may be sufficiently severe to cause acute hepatitis. Adult flukes in the bile ducts cause biliary obstruction, fibrosis and anemia. The adults are tissue feeders which possibly suck blood, leading to losses of plasma protein into the gut. Anemia results from the combined effects of mechanical blood loss, decreased red blood cell production and increased destruction of red blood cells.

Clinical signs include weight loss, diarrhea, sub-mandibular edema (bottle jaw) and sudden death due to anemia following acute or chronic infections.

Lung worms

- Most lung worms are caused by *Dictyocaulus filaril*. Lung worms are usually found in the highland and semi-highland areas. They inhabit the air ways of the lung.
- Male worms may be 3–8 cm long and females 5–10 cm. Eggs are laid in the lungs, coughed up and swallowed, then passed out in the feces. Once outside the animals, the larvae take 6–7 days to develop and become infective. Infection is by ingestion of larvae on herbage. After consumption, the larvae penetrate the intestinal wall, entering the lymphatic vessels, then blood vessels, and eventually the lungs.
- The principal signs of infection are coughing and difficulty in breathing. The disease is very important in both sheep and goats. Mortality rates can be high in weaned lambs/kids, and lactating females, and low in non-lactating (dry) adults. From 2 to 10% can die within a few days of an outbreak before preventive action is taken. Deaths in young lambs/kids from malnutrition following parasitism in lactating dams can also be important.
- Lung worm infection can be mistaken for pneumonia or pasteurella infection, and as a result, lung worms go untreated. Coughing without any fever usually indicates lung worm infection.

Cestodes (tape worms)

- Almost all domestic and wild animals, birds and fish are susceptible to tape-worm infections. In sheep and goats, tape worm parasites cause diseases and economic loss. Often animals carry moderate or even heavy infestations without showing any ill effects. Heavily infected young animals will have stunted growth and may die when factors such as under nutrition or drought are present.
- *Moniezia expansa*, up to 6 m in length, and *Avetelina* spp. more than 3 m long, occur in small intestines of sheep and goats. *Stilesia hepatica* occurs in the bile ducts. It ranges from 20 to 50 cm long.
- The symptoms of tape worms in sheep and goats may not be too obvious, and the clinical effects of such as rough hair coat, digestive disturbances, constipation followed by diarrhea, pot belly, anemia, and edema may also be caused by round worms. However, when large numbers of tape worms are present, they may cause obstruction of the intestine and precipitate enterotoxemia or overeating disease.
- Larval tape worm infections of sheep and goats are very important because of zoonotic significance. The adult parasite, *Taenia hydatigena,* lives in the small intestine of dogs. The larval stage, *Cysticercus tenuicollis,* is found in the peritoneal cavity of sheep and goats. *Taenia multiceps* is found in dogs. The larval stage, *Coenurus cerebralis,* occurs in the brain and spinal cord of sheep and goats. *Echinococcus granulosu*s is a very small tape worm of dogs. The larval stage, hydatid cyst, is found in sheep and goats and in many other intermediate hosts. Cystic echinococcosis is a major helminthosis with regard to public health. The threat to human health can be minimized by preventing dogs from eating any animal organ meat that contains hydatid cysts. The disease may also need attention to meet the future requirements of meat and live-animal export markets.

Coccidiosis

- All kinds of animals, particularly young animals, get coccidiosis.
- Coccidiosis is caused by protozoal parasites that live in the intestines of animals. The most well-known parasites that cause coccidiosis belong to the *Eimeria* and *Isospora* species.

- Animals get coccidiosis from food or water contaminated by feces of infected animals. Animals become sick with coccidiosis when large doses of protozoa enter into their stomach, usually when they live in wet and dirty places that are contaminated by the parasites.

Animals show the following signs when they are infected with coccidia parasites:

- Reduced feed consumption.
- Weakness and lethargy (fatigue, tiredness).
- Diarrhea, potentially severe, with blood and mucus in the feces. Animals strain to pass feces.
- Most animals recover quickly but animals with severe infections may take a few weeks or more to recover.
- Young animals suffer most and death is common.
- Treatment must be given to sheep and goats as soon as possible. Medications can be given in food or drinking water.

Prevention and control of coccidiosis can be done the following ways:

- Separate sick animals from the flock and treat as soon as possible.
- Keep animal shelters clean and dry.
- Keep animals, especially young lambs and kids, on clean, dry bedding.
- Clean fecal material away from places where animals live.
- Keep feed and water containers off the floor to prevent feces contamination.

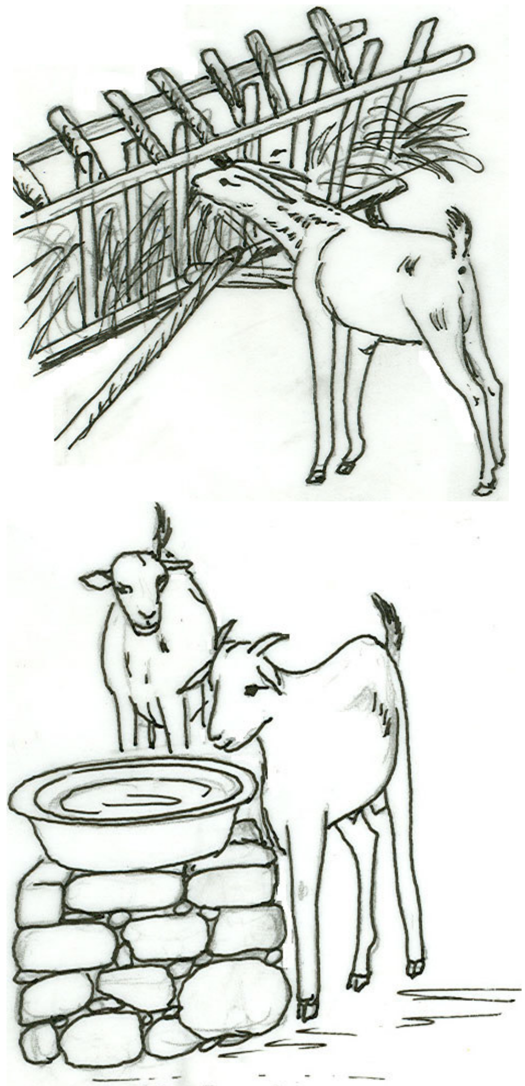


Figure 9.19. Feeding and watering animals by keeping food and water off the ground.

Fecal egg counts

Feces are collected in order to identify the parasites found inside the animal. This can be achieved by microscopic examination of the eggs, larvae and adult parasites of nematodes, trematodes, cestodes and protozoa. For laboratory techniques and procedures, refer to Hansen & Perry, 1994. The number of eggs per gram (epg) provides an indication of the severity of parasite infection with nematode parasites. Table 9.3 provides a rough guide to help interpret the results of fecal egg counts.

Table 9.3. A guide to the interpretation of fecal egg counts.

Species	Light	Medium	Heavy
Haemonchus	100– 1000	1000–4000	4000+
Trichostrongylus	100– 1000	1000–2000	2000+
Nematodirus	50–100	100–600	600+
Oesophagostomum	100–800	800–1600	1600+

Adopted from Hansen and Perry (1994).

9.3.3. Prevention and control of internal parasites

At present, internal parasites are mainly controlled by use of anthelmintic drugs. Unfortunately, drug resistance has become a problem to sheep and goat production areas throughout the world. It is inevitable that it will also occur in Ethiopia. Meat and live animal importing countries now require livestock products to be free from drug residues. Therefore, follow an integrated worm management program for sheep and goats as described below.

9.3.3.1. Curative deworming

As with other infections, the treatment of gastrointestinal parasites should be preceded by removal of the source of infection. However, in a communal grazing system, keeping animals away from sources of infection is difficult. You can use anthelmintic treatment to remove the parasites. There are several options from which to choose in deciding which animals to treat.

- Treat targeted groups:
  - ♦ Animals lagging behind the flock, showing weakness, ill-thrift, anorexia, diarrhea.
  - ♦ Young animals, lambs, kids/weaners, which are susceptible to infection.
  - ♦ Pregnant/lactating ewes and does because of weakened immune response during this physiological state.
- Treat anemic animals:
  - ♦ Use FAMACHA to check highly anemic animals. FAMACHA is a method developed in South Africa for testing for anemia caused by parasites, particularly for *Haemonchus contortus*
  - ♦ There is a 5-number scale on a FAMACHA card. Categories 1 and 2 need no treatment; an animal registering a 3 needs treatment only if it looks sick while categories 4 and 5 need treatment. Always treat sheep and goats with a score of 4 and 5.
  - ♦ Repeat the FAMACHA test every 4 weeks and treat as necessary.
- Treat animals based on parasitological parameters:
  - ♦ Use egg counts to monitor infection and proceed with the curative treatment by selecting appropriate drugs.
  - ♦ Goats require twice the cow dosage of all dewormers, except for Levamisole. Give Levamisole at 1.5 times the cow or sheep dose.

9.3.3.2. Preventive deworming

Preventive deworming (drug prophylaxis) consists of eliminating worm infections by regular treatment of herds/flocks.

- The treatment program should eliminate worms at peak infection and prevent reinfection of pasture during high-risk periods. Several treatment programs are proposed for different times of the year. In practice, a number of regular treatments for diseases such as fasciolosis should be given. The following program may be considered for sheep and goat production areas of Ethiopia.
- Treatment may be given at the end of the rainy season (September/October) according to the altitude. At this time, animals are well nourished and may have large numbers of parasites without seemingly being affected by the worms. Killing these parasites with anthelmintic drugs will improve performance during the upcoming harsh, dry season conditions.
- Another treatment is given at the end of the dry season (April/May). The entire herd/flock should be treated. This treatment reduces infestation of pastures by residual parasites and parasites which occur throughout the year. Two treatments per year, with improved management, seem to be an optimum.

Suggestions

- Kebele Development Agents and senior regional extension workers call a meeting with farmers to discuss herd health. Training is given on disease control and the danger of communal grazing areas if everyone doesn't treat their animals.
- Farmers should be encouraged to form consultative planning groups and appoint someone to make sure that the rules are followed.
- The farmers set guidelines for communal grazing and agree to follow them. This includes deworming, controlling grazing and not allowing sick animals on communal grazing areas.
- Penalties would have to be set for anyone not following the rules (e.g., ban from grazing until compliant). It is best if farmers themselves set these rules and work together to see that they are enforced.

9.3.3.3. Strategic deworming

Strategic deworming of animals with approved drugs is an important strategy in controlling internal parasites. Annual rotations of anthelmintic drugs are not currently recommended as this can increase rate of resistance to all drugs. Using one class of a broad spectrum drug until it is no longer effective and then switching to another class of a broad spectrum drug is considered a better strategy. The new strategy is thus recommended for use. Moreover, it is necessary to consider the following points seriously:

- Use a full dose of anthelmintics whenever treatment is carried out. This is recommended to help prevent the development of resistance.
- Treat all newly introduced animals before allowing them to mix with the remaining flock.

Two treatments are recommended at the beginning of the dry season and two treatments at the beginning of the rainy season. The interval between the first and second treatments should be 2–3 weeks. The treatment at the beginning of the dry season is done to eliminate the current parasite burden, enabling animals to better cope with the nutritional stress during the dry season. A treatment before the rainy season will prevent contamination of pastures at a time when conditions are becoming favorable for egg and larval development.

Transferable Messages

1. There are several types of worms of sheep and goats known by farmers. Farmers should be given opportunities to present their knowledge about worms in different animals during the training sessions. Encourage them to list the different symptoms of diseases caused by pathogenic worms. Prepare the lists of worms of sheep and goats clearly written as they are officially (scientifically) known, and the way they are called in the local languages.
2. All animals can be infected from different types of parasites. Clearly indicate which animals are mostly affected and why.
3. Discuss with the trainees on how poorly-fed animals often have worms. Sheep or goats utilize feed poorly because they have worms. Animals need better feed for maintenance for living, production and health.
4. Sick animals need treatment for worms. What are the remedies for worm infections? Discuss where true anthelmintic drugs can be purchased. Indicate all the possibilities of adulterated drugs that can be purchased at the different open markets, contrabands and illegal drug vendors. Some drugs with unknown sources may not be true drugs. Drug resistance occurs because of underdosing, frequent use of drugs or the use of the same drug for long periods without rotating different groups of drugs.

9.3.3.4. Pasture management

- Pasture management is designed through long-term planning with such factors as the age groups of animals and the time and intensity of grazing.
- **Pasture rotation:** dividing a pasture into paddocks and moving animals from one paddock to another to optimize use of grass. Use of a “50/50” grazing system, (all the animals on half of the farm).
- **Grazing height:** some experts recommend that animals be allowed to graze new pastures very close to the ground so that the sun can diminish the chances of survival of the parasites brought in with the animals.
- **Grazing time:** the drier the grass, the more parasites will stay at the base of the plants. The risk of infection is greatly lowered by waiting until the dew has lifted or until the grass has dried after the rains.
- **Graze by age group:** the susceptibility of animals varies with age. It is logical to graze younger animals in fields where parasite populations are very low and separately from adult animals. Alternate grazing pastures annually.
- **Multi-species grazing:** graze cattle after sheep and goats. Cattle clean the pasture after sheep and goats have grazed. The cattle ingest a significant quantity of mature larvae from the lamb stools, but cattle are not affected by most internal parasites of sheep and goats. If the cattle are allowed to graze the grass down to 3–5 cm from the ground, many parasites will be killed off due to exposure to the sun.
- **Improvement of drainage:** pasture that remains wet for a long period is an ideal environment for survival of internal parasite larvae. Drainage of a field reduces the larvae’s chances of survival.

Transferable Messages

1. Animals usually get worms from pasture contaminated with worm eggs or larvae. Worms often start causing problems at the start of the wet season because many worm larvae develop on the pasture at the same time.
2. Animals also get infection from parasitic larvae when they graze on the banks of streams or marshy areas. A good example is the case of liver flukes. Animals get liver fluke infection when they eat the metacercaria (young liver fluke) while grazing near such water bodies. Farmers can work together to reduce or control worm infections such as nematodes and liver flukes.
3. Remember the pasture-management approach and the guidelines for communal grazing areas, including strategic deworming, controlling of grazing areas, etc. Include in the training materials techniques of keeping animals away from areas of liver fluke danger by fencing water-logged areas and avoiding pastures that have been flooded. Encourage use of water from bore-holes or wells, use of forage from tress (cut-and-carry method), etc.

9.3.3.5. Control options through breed choices

Parasite control is possible through an integrated approach by combining different control strategies. The use of breeds that have increased worm resistance is one strategy. Some breeds of sheep and goats are more resistant to parasites.

- In sheep for example: Florida Native, Louisiana Native, Barbados Black Belly, Red Massai of Kenya, etc., are resistant breeds.
- Resistant breeds can be introduced in an area to replace existing susceptible breed(s) provided that they are productive under the new circumstances.
- A local breed can be crossed with a resistant breed imported from other areas.
- Note that sometimes one breed is economically desirable despite its relative susceptibility to major diseases (e.g., Merino for fine wool production despite its relative susceptibility to diseases from round worms such as *Haemonchus contortus*).
- Resistance of Ethiopian sheep and goat breeds to internal parasites is not known.

9.3.3.6. Anthelmintic drugs and dosages

There are different formula and presentation of anthelmintic drugs. The following are some examples:

- Boluses/pills or tablets — these are practical and easy to use.
- Liquid preparations/drenches — these are locally available ready-to-use preparations.
- Pastes — easy to administer if you have a dispenser. Not commonly available in local markets.
- Medicated blocks — difficult to control the amount of drugs consumed. Not locally available at present.
- Slow-release formulations — drugs placed in the rumen and hence will be delivered continuously. Not locally available.

Principal anthelmintics and their use

Nematocides

Most of the anthelmintics belong to the five chemical groups: **Benzimidazole** compounds, **Imidazothiazole** derivatives, **Pyrimidine** derivatives, **Pyperazine** and its salt, and **Organophosphates**. The following are the principal anthelmintics currently used in Ethiopia:

- Albendazole: Trade name, Valbazen. Active against nematodes such as *Haemonchus* and other trichostrongyles round worms; to some extent, liver flukes (*Fasciola hepatica)*; tape worms (*Moneiezia*, *Taenia saginata),* etc. Dosage: 5 mg/kg for round worms, and 10 mg/kg for flat worms (trematodes).
- Camebendazole: trade names, Camben, Noviben. Good for the control of round worms, especially for lung worms and also for the control of tape worms. Dosage: 25–30 mg/kg.
- Fenbendazole: trade name, Panacur. It is very active against larval and adult form of round and tape worms. Recommended dose: 7.5 mg/kg.
- Mebendazole: trade name Vermox. It is very active against round worms, tape worms and liver flukes. Recommended dose, 15–20 mg/kg. Optimum dose: 35 mg/kg, in split dose.
- Oxfendazole: trade name Systamex. It is active against larval and adult gastrointestinal and lung worms. Recommended dose: 4.5–5 mg/kg. Effective against tape worms (*Moniezi expansa*) and adult liver flukes, at a very high dose.
- Thiabendazole: trade name TBZ, Thibenzole. Active against gastrointestinal round worms. Recommended dose between 75 mg/kg and 120 mg/kg (usually 80 mg/kg).

Imidazothiazole derivatives

Imidazothiazole derivatives include **tetramisole** and **levamisole**.The active form is levamisole.

- Available in several trade names such as Nemicide, Nilverm, Vermipan, etc. Active against gastrointestinal- and lung-worms. Recommended dose for tetramisole is 15 mg/kg and for levamisole, 12 mg/kg.

Pyrimidine derivatives

These are pyrantel and morantel form of pyrantel. Examples of trade names are:

- For pyrantel, Combantrin, Nemex; for morantel, ExparGylox. Active against gastrointestinal round worms. Recommended doses, pyrantel, 15 mg/kg; morantel, 7.5 mg/kg.

Piperazine and its salts

- Piperazine: trade name Dictyomazine, Larvazine, Vermizane, etc. Active against round worms, immature and mature lung worms, etc. Dosage depends on preparation, for example, piperazine dithiocarbamate, 150 mg/kg. 20 mg/kg for lung worm for 3 days or 40–50 mg/kg single dose.

Other nematocidal anthelmintics

- Phenothiazine: trade names, Nemathiazine, Neoavilep, etc. Active against gastrointestinal nematodes. Dose, 300–500 mg/kg.
- Febantel: trade name, Rintal. Active against nematodes of the digestive tract.

Trematodicides

These are effective against both adult and immature forms of liver flukes (*Fasciola* spp.). The worm killers are phenol derivatives. Some examples of anthelmintics against liver flukes are:

- Nitroxynil: trade names, Dovenix, Trodax. Active against both adult and immature liver flukes. These are also effective against gastrointestinal worms. Recommended dose: against adult liver flukes 8–12 mg/kg; against immature, 15 mg/kg or more.
- Oxyclozanide: trade names, Diplin, Zanil. Active against adult form of liver flukes. Recommended dose, 15 mg/kg.
- Rafoxanide: trade name, Ranide, Flukanide. Active against immature and adult liver flukes and against abomasal or intestinal round worms. Recommended dose: against immature and adult liver flukes; 7.5–10 mg/kg; against adult Fasciola, only 5 mg/kg.
- Closantel (Flukiver), Albendazole (Valbazen), Trichlorphen (Bilarcil): these are the other trematodicidal anthelmintics, which are active against round worms, liver flukes and Schistosoma.

Cestodicides

Products that are active against the whole cestode family are rare. A drug may be active against some species, but not others. However, from the discovery of the activity of salicylanilide (niclosamide), a number of effective drugs have been developed. The following is an example of a drug against cestodes (tape worms):

- Niclosamide: trade names, Yomesan, Mansonil, Cestocid. Active against Anoplocephalosis (all species). Recommended dose varies: against *Moniezia*, 80 mg/kg, Avitellina and Stilesia, 100 or 150 mg/kg.

Ways of controlling most tape worms

- Keep uncooked meat and offal with tape worm cysts away from dogs.
- Avoid eating uncooked meat. Meat cooked until it becomes brown in color is safe to eat.
- When you kill sheep/goat at home, do not burst/open cysts if found, rather bury or burn them. Never give them to dogs.
- Treat dogs for tape worms regularly.
- Teach farmers/pastoralists to be treated for tape worm infection if they are infected.
- Always wash your hands after handling your dogs.

Combinations of anthelmintics

Several anthelmintics can be combined to increase the spectrum of activity of drugs. Such combined drugs are available in the market. Some examples are:

- Equinoxes = piperazine + thiabendazole
- Nilzan = oxyclozanide + tetramisole
- Ranizole = rafoxanide + thiabendazole
- Trivermax = bithionol-sulphoxide + phenothiazine
- Polypar = niclosamide + oxibendazole
- Wormex = bithiono-sulphoxide + tetramisole

Table 9.4. Anthelmintics for sheep and goats.

Generic name	Common commercial names	Dosage (mg/kg)	Spectrum of activity			
			GI	L	T	F
BENZIMIDAZOLE						
Albendazole	Valbazen	5–10	+	+	+	+
Febanel	Rintal	5–10	+	+	+	-
Fenbendazole	Panacur	5–7.5	+	+	+	+
Mebendazole	Telmin	12.5	+	+	+	-
Oxfendazole	Synanthic	5	+	+	+	-
	Systemex					
Oxibendazole	Widespec	10	+	-	-	-
Thiabendazole	Thibenzole	44	+	+	-	-
Thiophanate	Wormalic	50	+	+	-	-
Triclabendazole	Fasinex	10	+	-	-	+
IMIDAZOTHIAZOLES						
Levamisole hydrochloride	Nilverm	7.5	+	+	-	-
	Nilzan					
	Nilvax					
Levamisole phosphate		8–9	+	+	-	-
Tetramisole		15	+	+	-	-
SALICYLANIDES						
Rafoxanide	Ranide	7.5	+	-	-	+
Niclosamide	Seponver	53	-	-	+	-
Closantel	Superverm	7.5	+	-	-	+
Oxyclozanide	Zanil		-	-	+	+
TETRAHYDROPYRIMIDINES						
Morantel	Exhem	10	+	-	-	-
Pyrantel tartrate		25	+	-	-	-
MISCELLANEOUS						
Avermectin	Ivermectin	0.2	+	+	-	
Nitroxynil	Trodax		+	-	-	+

GI = Gastrointestinal nematodes, T = Tape worms, L = Lung worms, F = Liver fluke; + = Effective, - = Ineffective

9.4. External Parasites

9.4.1. Effects of external parasites

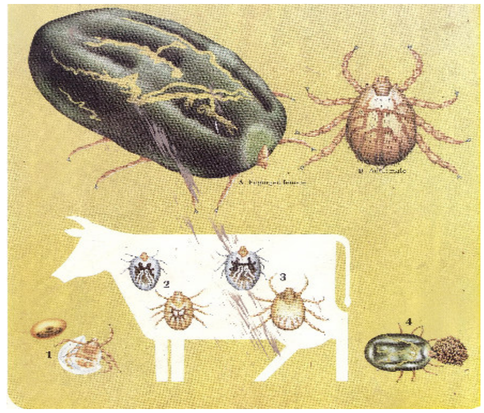
External parasites are responsible for a great diversity of animal health problems.

- Attachment to the host causes irritation of the skin with subsequent ulceration and secondary infections. The wounds attract screw worms and other flies, and myiasis can develop.
- Heavy infestations are associated with anemia, since adult female ticks can suck up to 10 mℓ of blood.
- The presence of large numbers causes annoyance and animals become restless. This may cause loss of weight and condition.
- One of the most damaging effects of external parasites is their ability to transmit diseases to their hosts. Some of these are serious with fatal consequences.
- Cause tick-paralysis.
- Bites can damage sensitive areas of skin (teats, vagina, eyes, etc.)
- Tick attachment between the claws of the feet may cause severe lameness.
- Transmit diseases.

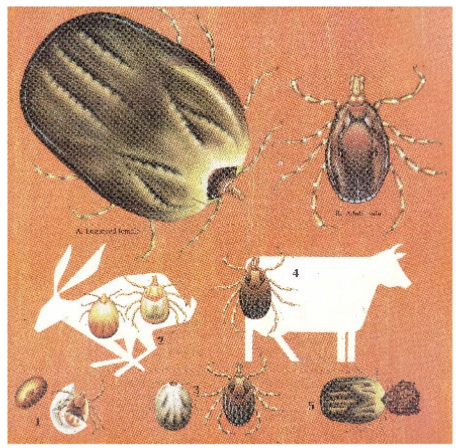
- There is an associated economic loss through skin damage, rendering the skin unsuitable for the leather industry.

9.4.2. Ticks

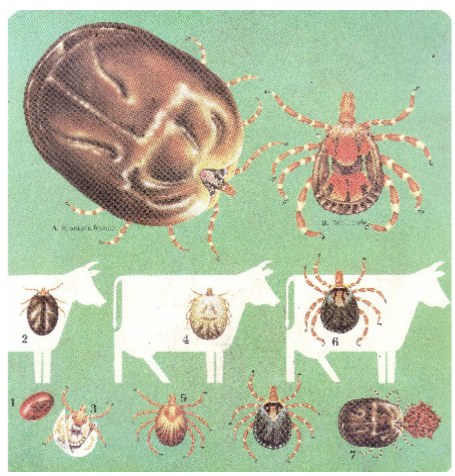
- The tick is the most important ectoparasite of livestock.
- Ticks may be divided into two major groups, namely the soft ticks (Argasids) and the hard ticks (Ixodids).
- Soft ticks:
    - ♦ The soft ticks lay their eggs in cracks of walls and wood.
    - ♦ The larvae and nymphs suck blood and lymph and drop off the host to become adults.
    - ♦ Ixodid ticks such as *Amblyomma* and *Rhipcepahlus* lay their eggs under stones and clods of soil. Their larvae climb onto grass and shrubs and wait for a suitable host.
- Hard ticks can be classified into 3 groups according to the hosts they infest.
    - ♦ One-host ticks complete their life cycle on one host (one host from the larval stage to the adult stage). The egg hatches on the ground, the larval tick attaches itself to the host animal, matures and drops off as an engorged adult to lay eggs.
    - ♦ Two-host ticks are those in which the egg hatches, the larva attaches itself to the host animal, develops to the nymph stage and drops off. The nymph attaches itself to a second host where it develops to maturity before dropping off to lay eggs
    - ♦ Three-host ticks are those which infest 3 different hosts at different stages of their development.



One-host tick (example *Boophilus*)



Two-host tick (example *hyaloma*)



Three-host tick (example *Ambyloma*)

Figure 9.20. Types of ticks based on number of hosts required.

Treatment, prevention and control of ticks

- Treat with acaricides only where ticks are present in large numbers.

- If tick numbers are not large, do not use acaricides. In this case, it is possible to kill them by hand using a needle or thorn.
- Shear the animal's hair and then use an insecticide such as Amitraz.
- Solutions can be sprayed on the animal, used as a dip or pour-on.
- Knapsack spraying is the most practical method if more intensive control measures are needed for a small number of animals. The most efficient method of hand-spraying is as follows:
  - Spray along the entire length of the back.
  - Spray the sides and flanks in a zigzag pattern.
  - Spray the brisket.
  - Spray each leg.
  - Spray the belly, udder or scrotum.
  - Spray the tail and anal area.
  - Finally, spray the head, face, neck and ears.
- Pour-on acaricides: a small volume of a special acaricide is poured along the back of an animal. It is a very effective method of control.
- Dipping is very effective. Currently, mobile dipping vats for sheep and goats are available.
- After treating, place the animal in the sun to dry.
- Check recently purchased or borrowed animals for ticks, especially around the shoulders.
- If ticks are seen on an animal, it should be treated immediately to prevent transmission to other animals.
- Some traditional methods of external parasite control include:
  - Washing the animal with salt water.
  - Smearing the animal's body with spent oil.
  - Using repellent herbs.
  - Using kerosene to rub the predilection sites.
- Ticks can develop resistance to acaricides and this is encouraged by frequent dipping and the use of dip solutions at lower than recommended concentrations. The manufacturer's recommendations should be strictly followed.
- Acaricides are toxic to people as well as animals and care should be taken to limit contact with the skin and prevent any possibility of dip fluid being drunk, or contaminating ground water.
- Acaricides are also very damaging to wildlife and fish, so great care is needed when discarding used dip fluid.

Do not recommend unnecessary tick control.

- It can create a disease problem.
- It will waste a farmer's money.

Other ectoparasites can usually be controlled by improving animal nutrition, ensuring better hygiene of animal houses and by occasional spraying or dipping.

Transferable Messages

1. Discuss with farmers that there are some ways to control ticks without the use of chemical insecticides. One of the ways to control ticks and the disease they spread is probably by not completely killing all the ticks. Why is that? Elaborate the following points to the farmers:
   - It is good to try to get a balance between ticks, the disease they carry, and animals' resistance. This balance is called "enzootic stability."
   - Young animals that get bitten by ticks develop immunity to diseases spread by ticks. Animals in such areas develop enough resistance to withstand sickness.
   - If enzootic stability occurs in the area, dip or spray animals when they have numerous ticks. Do not dip or spray them if they have only a few ticks.
   - It is important to often check animals for ticks.
   - It is possible to remove ticks by hand. However the tick's head and mouth parts should not be left buried in the skin because they may cause an abscess.
2. There are also good reasons for controlling ticks by using chemical insecticides based on recommendations by veterinarians.
   - Spray or dip animals when they move to new areas where ticks spread new diseases.
   - Spray or dip animals when some diseases such as East Coast Fever (ECF) and other tick-borne diseases (TBD) are suspected of spreading.
   - Spraying animals is a good way to use insecticide when you treat a few animals.
     - Farmers should learn how to apply sprays using a knapsack sprayer.
       - Tie the animal securely.
       - Spray the entire animal.
       - During spraying, a strict sequence must be observed. Start at the head, finish at the tail, and spray all areas of the body thoroughly.
   - It is also possible for farmers to make a good dip tank using half of an old drum or they can purchase such material made of plastic.
   - Farmers need to keep records of which animals get dipped and the chemicals used.
   - Use thick grease and/or old engine oil, to reduce tick numbers on animals. Soak cloth with a mixture of old engine oil and insecticide and hang it on a tree or on a pole where animals will rub against it.
3. Farmers should also be aware of ways to reduce the number of ticks on pasture.
   - Pastures that have many ticks should be avoided as long as possible.
   - Chickens can be kept in places where there are many ticks, for example around watering places, etc.
   - Animal houses need to be cleaned regularly and grass/plants around the barn removed.
   - Animals with heavy tick burdens should be separated from the flock.

9.4.3. Lice

- Infestation of sheep and goats with lice is common.
- Lice are wingless insects and have flattened bodies.
- Lice infestation can be quite serious or fatal. They are easily overlooked because of their small size. They can multiply very fast before being discovered, by which time the animal may be too anemic and emaciated to recover. Transmission among animals is by way of direct contact. Confinement rearing favors transmission.

Signs

- Lice cause considerable irritation to the skin. This is usually shown by the animal biting and rubbing itself against fixed objects.
- Wool-breaks and general unthriftyness, matted, dull fleece with tufts of wool may indicate lice infestation.
- The saliva and feces of lice contain substances capable of causing allergies, giving rise to severe irritations, followed by skin thickening and sometimes self-inflicted trauma. Animals exhibit reduced weight gain and loss in production. Anemia and sucking or biting stress also attributes to the decrease in production.
- Lameness can result from the foot louse of sheep.
- Lice are associated with development of cockle. Cockle is an inflammatory response of the skin to the presence of lice and their saliva. This is seen after the wool or hair has been removed from the skin.

Figure 9.21. Sheep louse.

Figure 9.22. Sheep ked.

Treatment and control

Spraying or dipping with insecticides is effective and should always be carried out twice. The first time to kill the lice currently on the body and the second, 14 days later, to kill lice hatching from eggs present at the first treatment. The eggs are not affected by insecticides.

9.4.4. Sheep Ked

- Flat, brown wingless fly.
- About 6–7 mm in length.
- It is an important parasite of sheep, commonly called sheep ticks.
- It is a blood sucker and permanent ectoparasite.
- A sheep ked has mouth parts adapted for piercing the skin of the host and sucking blood.
- The ked cannot live long away from the host and transmission from host to host is by direct contact.
- Keds are generally prevalent in colder, wetter areas.

Signs

- Keds cause loss of blood when present in large numbers, with consequent anemia and loss of body condition.
- They cause intense irritation, manifested by scratching, biting and stamping.
- Animals in poor condition are likely to suffer.
- Skin prick caused by blood-sucking keds causes the development of cockles in the finished sheep skin.

Treatment and control

- The shearing of wool sheep greatly reduces the infestation, not only because of the removal of the keds with the wool, but also exposing those remaining on the skin to the environment. This greatly reduces their development.
- Spraying or dipping with insecticide after shearing will destroy keds.

9.4.5. Mites

- Mites are small arthropods. The majority of species are free-living but some are parasitic on animals and cause the condition known as mange.
- The life cycle of mange mites is similar to ticks in that there are egg, larva, nymph and adult stages.
- All these stages stay on the host, feeding on the epidermis, serum, hair, and in some cases, burrowing beneath the epidermis or into hair follicles.
- Mites spread from one animal to another mainly through direct contact.
- Mites do not live very long when removed from the host.
- Mange may be sarcoptic, psoroptic, chorioptic or demodectic according to the species of the infesting mite.

9.4.5.1. *Psoroptic ovis* — the sheep scab mite

- *Psoroptes ovis* is a parasite of sheep.
- The parasite is located on most areas of the body, especially those heavily wooly and hairy such as shoulders, sides and back.
- *Psoroptes ovis* feeds on tissue fluid and causes the formation of scabs under which they live.
- The eggs are laid on the skin at the edge of a scab and hatch in 1–2 days.
- The whole life cycle is completed in 10–11 days.
- All stages are capable of survival away from the host for up to 10 days.
- Optimum conditions for development include moistness and cool temperatures.
- When conditions are adverse, as in summer, mites survive in protected sites of the body.

Signs

- Affected skin is covered with exudates (fluid). This dries to form a scab.
- Massive loss of hair usually occurs.
- Lesions may cover the entire body.
- The sheep will usually die if it is not treated.

Figure 9.23. Sheep affected by *Psoroptes scabiei* variety ovis. (Source: Kassa Bayou, 2006).

Treatment

- Infected sheep should be dipped, not sprayed, with acaricides such as Diazinon 60%.
- Ivermectin injection (200 mg/kg) is also effective.

Prevention

- Newly introduced animals are the main sources of infection for a flock. These animals must be checked carefully and possibly treated before being introduced into the new flock.
- Quarantine of newly introduced animals is also a very useful way of preventing the parasite's spread.
- Animal houses and pasture fences must be sprayed with acaricides.

9.4.5.2. *Sarcoptic ovis*

Sarcoptic mange

- Sarcoptic mange is caused by infestation with *Sarcoptes scabei* variety capri in goats and *Sarcoptes* variety ovis in sheep
- Sarcoptic mites burrow into the skin forming galleries where they remain for the rest of their lives.
- Eggs are laid in the burrowed skin at the rate of two or three each day.
- Infestation is spread mainly by direct contact between infected and healthy animals.
- Sarcoptes are very susceptible to dryness and are unable to live more than a few days away from the host.
- Sarcoptes mites are severe in goats, spreading extensively, and in some instances causing death.
- Sarcoptic mange is more acute than the other forms of mange in that it may involve the entire body surface in a short period of time.

Figure 9.24. Goat affected with Sarcoptic mange

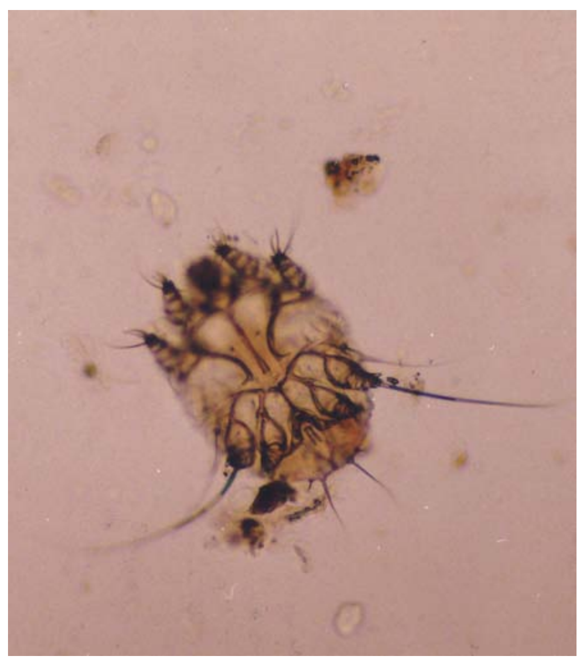


Figure 9.25 *Sarcoptic scabie* variety Capri.

Signs

- It causes small red papules and general erythema of the skin.
- The affected area is itchy and frequently excoriated by scratching and biting.
- Loss of hair, thick brown scabs and thickening and wrinkling of surrounding skin is observed.

Treatment

- Infected sheep should be dipped, not sprayed with acaricides such as Diazinon 60%.
- Ivermectin injection (200 mg/kg) is also effective.

Prevention

- Newly introduced animals are the main sources of infection for a flock. These animals must be checked carefully and possibly treated before being introduced into the new flock.
- Quarantine of newly introduced animals is also a very useful way of preventing the parasite's spread.

Demodectic mange

- Invades hair follicles and sebaceous glands of all species of domestic animals.
- The disease is very severe in goats, spreading extensively before it is suspected, causing death in some instances.
- The disease causes significant damage to the skin, causing small pinholes in the skin which interfere with its industrial processing and limit its use.
- In most cases, the lesions are difficult to see externally.
- The disease spreads slowly and transfer of mites takes place by contact.

Signs

- It causes small nodules and pustules, which may develop into large abscesses.
- The lesions occur most commonly on the brisket, lower neck, forearm and shoulder.
- In severe cases, there may be general hair loss and thickening of the skin.
- The contents of the pustules are usually white in color and cheesy in consistency.
- The pus is more fluid in large abscesses.
- Severe cases in goats are commonly the result of being affected with several skin diseases such as mycotic dermatitis, ringworm, besnoitiosis and myiasis.

Treatment

- Repeated dipping and spraying with acaricides such as Diazinon 60%.
- Ivermectin injection is also effective.

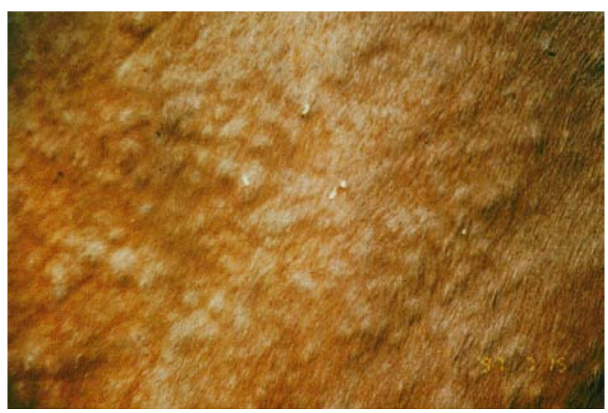


Figure 9.26. Demodectic mange. White spots in the center represent pus squeezed out of the nodules.

Source: Kassa Bayou (2006)

Acaricides disposal

- When the contents of a mobile dip are to be discarded, care must be taken to avoid contamination of the environment. Dip contents can be drained into pits. The pits should be at least 150 m away from water sources.
- It is extremely dangerous to reuse an empty acaricide container. Plastic or metal containers should be punctured or crushed. The containers should then be buried in an isolation area at least 50 cm below ground surface.

9.5.2. Flies

- Flies are blood suckers causing many disturbances to animals and are capable of transmitting diseases. They have a life cycle consisting of the egg, and one or more larvae, pupa and adult stages.

Black flies - Simulidae

- These small flies can occur in vast numbers and cause serious annoyance.
- Flocks will stampede, often with disastrous consequences
- Bites are inflicted on all parts of the body, giving rise to vesicles which burst, exposing the underlying flesh.
- Skin wounds with secondary infection and myiasis may result.

Control

- Fly breeding sites may be eliminated by drainage.
- Fly breeding sites can be treated with diesel oil thinned with water to kill the larvae.

Haematopota spp. Horse flies

- These large robust flies suck blood and inflict a painful bite.
- Several species of horse flies attack sheep and goats.
- Animals get restless when horse flies are around and even small numbers of these flies are sufficient to hinder grazing.
- Losses become significant when infestations are heavy.
- They mechanically transmit a number of diseases such as anthrax, Anaplasmosis and Trypanosomiasis.
- They breed in or near water.

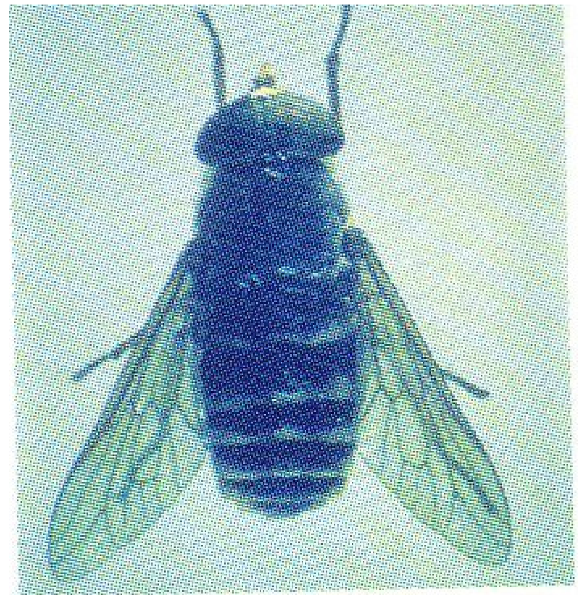


Figure 9.27. Biting fly – *Tabanus..*

9.5.3. Mosquitoes

Mosquitoes are of various species such as Anopheles, Culex and Ades. They are important vectors of diseases like Rift Valley Fever, Bluetongue and others. They may occasionally attack animals in large numbers, causing severe losses in production. They are dependent on water for breeding. They are usually more prevalent during and after rainy periods.

Control

- Mosquito breeding sites may be eliminated by drainage.
- Mosquito breeding sites can be treated with diesel oil thinned with water to kill the larvae.

9.6. Important Infectious Diseases of Small Ruminants

9.6.1. Strategies and approaches used in Ethiopia

Serious outbreaks of sheep and goat diseases such as sheep and goat pox, contagious caprine pleuropneumonia (CCPP), peste des petits ruminants (PPR), pasteurellosis and anthrax continue to occur in Ethiopia contributing to significant production losses. Widespread epidemics are controlled through prophylactic measures and nationally organized campaigns in the face of outbreaks. However, none of these diseases has been eradicated so far. Production losses resulting from such outbreaks are still considered significant, but are lower than those caused by poor nutrition and internal parasites.

9.6. Common Diseases

9.6.1. Contagious caprine pleuropneumonia (CCPP)

CCPP is a per-acute, acute or chronic contagious disease of goats affecting the respiratory system. Infection occurs by direct contact between goats. The disease is widely distributed in the Rift Valley and lowland parts of the country.

Signs

- Many goats are usually sick at the same time, 20–30 days after infection with CCPP.
- Some animals die before they show signs of the disease.
- Affected goats cough and have a discharge from the nose.
- In severe occurrences that happen quickly:
  - animals have distressed breathing.
  - animals become weak and tired and have a high fever.
  - many goats die after 4–5 days.
- With the mild form of the disease that lingers:
  - animals develop joint problems.
  - does may get mastitis.
  - goats become thin and look very sick. Most recover slowly but some become very sick and die.
- In dead animals, the lung looks very dark and has some yellow pus in it. The lungs often stick to the side of the chest. A lot of yellow fluid is observed in the chest.

Treatment

Treatment of sick animals with broad spectrum antibiotics is effective.

Prevention

- Ring vaccination of CCPP vaccine is given around the outbreak sites. The National Veterinary Institute (NVI) at Debre Zeit produces a limited amount of CCPP vaccine.
- Ring vaccination of CCPP should be given around an outbreak area in order to stop the spread of the disease.
- Restriction of movement of goats from and to the outbreak areas is necessary to prevent spread of the disease.

Figure 9.28. Goat artificially infected with CCPP.
Source: National Veterinary Institute

9.6.2. Foot and Mouth Disease (FMD)

- The disease is common in Ethiopia and neighboring countries.
- Animals become sick with FMD 2–14 days after infection.
- Animals get infection from direct contact with infected animals, from feed infected by the saliva of infected animals and from people or things that infected animals have touched. Infective organisms can also spread hundreds of kilometers through the air.

- Sheep and goats get a much milder type of foot and mouth disease.

Sign

- Blisters in their mouth. The blisters are often very small.
- Most blisters are on the dental pad.
- It is difficult to see blisters on the feet.
- The feet are painful and the animals are often lame.
- Animals usually recover but often lose body condition for a long time.

Treatment

- There is no treatment for FMD but it is helpful to give infected animals plenty of water, shade them from the hot sun, and give soft, green feed.
- Antibiotic treatment is important to prevent bacterial infection of the blisters.

Prevention and control

- Due to limited production capacity of the National Veterinary Institute, vaccine is given only for improved cattle and cattle intended for export. Sheep and goats are not vaccinated since the disease is mild in them, but they could be sources of infection for cattle.
- Movement of animals to and from outbreak areas should be restricted in order to stop the spread of the disease.

9.6.3. Maedi-visna

The occurrence of Maedi-visna in Ethiopia was reported in imported sheep in 1986 at Agarfa, Bale. It was also reported in eastern Amhara. Lambs are infected by drinking infected colostrum or milk during nursing. Adult animals become infected when they come in contact with nasal discharges of infected animals. The disease occurs principally in sheep but has also been observed in goats.

Signs

- Animals become sick with Maedi-visna 24–36 months after infection.
- The sign of maedi is a slow-progressive pneumonia. Visna is rarer.
- The signs of visna are slow-progressive neurologic signs with hind limb weakness and loss of condition, incoordination, muscle tremors, and paresis.

Treatment

- There is no treatment for Maedi-visna.

Prevention

- In endemic areas, prevention can be attempted by separating the lamb from the ewes at birth, giving them no colostrum or feeding other sources of colostrum and rearing them separately
- Restriction of inter-farm movement of sheep.

9.6.4. Peste des petits Ruminants (PPR)

PPR is common in Ethiopia. It is an acute contagious disease of sheep and goats that is particularly severe in goats. Transmission of PPR requires close contact between healthy and sick animals.

Signs

- A clear discharge from the nose.
- Sores in the mouth that come and go.
- Intermittent diarrhea.
- Low fever.
- In dead animals:
    - ♦ The eyes and nose will have a dirty white/grey discharge.
    - ♦ The animal's rear will often be covered with bad smelling, watery feces.
    - ♦ The mouth has many sores in it.
    - ♦ Upon necropsy, pus will be found in the lungs.

Figure 9.29. PPR depression, hemorrhage, diarrhea.
Source: National Veterinary Institute

Figure 9.30. PPR in a goat : mouth lesions

Treatment

- There is no treatment for PPR but antibiotic treatment will stop secondary infection with bacteria.

Prevention and control

- Immediately isolate animals with signs of PPR.
- Vaccine for PPR is effective. Vaccinate before start of the rainy season. Vaccinate all the sheep and goats around an outbreak area. Vaccine for PPR is produced by the National Veterinary Institute.

9.6.5. Rift Valley Fever (RVF)

Rift Valley Fever is a viral infection of ruminants and humans. Animals become sick with RVF 1–5 days after infection. Animals are infected when bitten by infected mosquitoes. The disease only occurs every few years and usually after a very wet period when mosquitoes hatch from infected eggs lying dormant in dry mud. The occurrence of this disease interrupts export market of live sheep and goats.

Signs

- The animals have a high fever, nasal discharge and vomiting.
- Animals stagger about. Young animals usually collapse and die within a few days.
- Adult animals have a less severe condition that happens slowly:
    - ♦ Animals look weak and tired.
    - ♦ Abortions occur in ewes/does.

Warning

- It is dangerous to open the body of an animal with RVF because people can get this disease.

Treatment

- There is no treatment for RVF.

Prevention

- Vaccine is not produced in Ethiopia.
- It is best not to move animals from places where RVF is prevalent until the disease dies out.

9.6.6. Anthrax

Cattle, sheep and goats get anthrax most often. People also can get anthrax. Animals become sick with anthrax 12–24 hours after they get infected. Animals get the disease while grazing on infected pastures.

Signs

- Animals, especially ruminants, often die before disease signs are seen.
- Infected animals have a very high fever and may have blood in the urine, feces or milk.
- They often have difficulty breathing and usually collapse and die after 1–3 days.
- Dark blood often comes from the nose, mouth and anus of dead animals.
- This blood stays liquid (does not clot) and the body does not go stiff after death.

Treatment

- People usually do not see animals with anthrax soon enough to treat them.
- Sometimes when the disease is less severe, there is time to treat animals with antibiotics.

Prevention

- Bury or burn the dead bodies of animals infected with anthrax. Avoid taking animals for grazing to places where anthrax was found.
- Follow annual vaccination with anthrax vaccine produced at the National Veterinary Institute.
- Vaccinate animals every year a month before disease occurrence is expected in common infection areas.

9.6.7. Sheep pox

Sheep pox occurs in both sheep and goats. It is severe in very young animals. Some young sheep and goats die before showing signs of the disease. The disease spreads by direct contact between animals and contaminated materials.

Signs

- Sheep and goats become sick 1–7 days after infection.
- Most animals are weak and tired and stop eating.
- They have a high fever for a short time.
- A watery discharge comes out of the nose and eyes.

- Animals have increased salivation.
- They have small red patches on the skin, usually around the mouth, on the head, under the tail and between the legs. The patches become swellings under the skin. Then they become blisters that break and become open sores that soon develop scabs.
- Animals often have distressed breathing.
- Pregnant ewes and does often abort.

Treatment

There is no treatment for sheep and goat pox but the following measures may help animals to recover:

- Topical antiseptic treatment of bad or deep sores.
- Antibiotics to prevent secondary infection.

Prevention

- Annual vaccination with sheep and goat vaccine produced at the National Veterinary Institute. The vaccine gives protection for at least one year.

a. Sheep affected by Sheep pox

b. Goat affected by sheep pox -note skin damage

Figure 9.31. Sheep and Goats affected by sheep pox.
Source: Dr. Muhumed - SORPARI

9.6.8. Nairobi sheep disease

Nairobi sheep disease is a tick-borne infection of sheep and goats. The common vectors for the disease are ticks, *Rhipicephalus* spp. and *Amblyomma variegatum.* Adult animals are more seriously affected than young animals.

Signs

- Animals become sick within 4–14 days after infection with Nairobi sheep disease.
- Infected animals have high fever.
- A grey/white discharge comes from the nose and eyes.
- The animals have diarrhea. The feces is often green and watery with blood mucus in it.
- The animals are weak and tired. They stop eating and collapse. Death occurs within three to four days.

Treatment

- There is no effective treatment.

Prevention

- Measure should be taken to control ticks.
- Movement of sheep and goats into and out of endemic areas should be strictly controlled.

9.6.9. Bluetongue

Bluetongue is an infectious disease of sheep. Goats can be affected but usually do not show signs. It is caused by a virus which is transmitted by an insect vector. Transmission is by blood sucking flies, C*ulicoides* spp. Sometimes mosquitoes or infected needles may spread the disease.

Signs

- Sheep become sick 5–10 days after infection with Bluetongue virus.
- A high fever accompanied by unwillingness to feed.
- Rolling movement of the tongue and licking of the lips.
- Nasal discharge and salivation. The nasal discharge is at first thin and watery but soon becomes thicker and mucous-containing.
- The nasal mucosa is congested and may ulcerate.
- Blood then appears in the nasal discharge.
- Lips and tongue are very swollen.
- The head and ears may also be swollen.
- Erosion and ulceration are often found in the mouth.
- Lameness or stiffness is often observed.
- Pneumonia can occur from secondary infection.
- Diarrhea, which may be blood stained, is sometimes seen.

Treatment

- Antibiotics are useful against secondary infection.
- Mouth lesions may be treated symptomatically with an antiseptic.
- It is important to keep infected animals in the shade as sunlight appears to aggravate the condition.

Prevention

- Infection can be avoided by moving sheep during the rainy season to high, well-drained ground.
- House sheep in barns at night to avoid insects.
- A smoking fire at night and spraying or dipping animals in insecticides are useful methods of vector control.

9.6.10. Babesiosis of sheep and goats

- Babesiosis is a disease caused by protozoan parasites such as *Babesia ovis*.
- The disease is mainly transmitted by the tick of the *Rhipecephalus* family, which introduces the organism into the host blood stream while feeding.
- Sheep and goats found in an endemic area normally have immunity. Newly introduced animals into endemic areas are always susceptible.

Signs

- Animals become sick within 1–4 weeks after being bitten by infected ticks.
- Urine becomes red due to red blood cells.
- Animals become weak and lethargic with reduced appetite.
- High fever. Mucous membranes turn pale and soon become yellow.

- Animals exhibit rapid breathing.
- Accelerated heart rate.
- Older animals die in 3–4 days.
- Animals younger than six months old are not severely affected.
- Animals that recover are weak for a sustained period of time, during which they are susceptible to secondary infections/diseases.
- The blood of dead animals looks thin and watery.
- The flesh is yellow. The liver is also yellow.
- The gall bladder is large and full of green fluid.

Treatment

- Treatment should be started as soon as possible.
- Diminazine aceturate (Berenil) gives good results.

Prevention and control

- Prevent babesiosis by controlling ticks.

9.6.11. Anaplasmosis

- Anaplasmosis is caused by a rickettsia, *Anaplasma ovis*, which invades red blood cells and causes anemia.
- The disease may be transmitted by ticks and biting flies as well as contaminated needles and equipment.
- It is rare in sheep and goats reared in the presence of the disease.
- Sheep and goats introduced into these areas should be closely monitored.

Signs

- Animals become sick 20–28 days after they get infected with Anaplasmosis.
- Mucous membranes are pale and may become yellow.
- Animals breathe faster than normal and have a very fast heartbeat.
- Animals have high fever.
- Animals go off feed and do not pass feces.
- Older animals that have never been infected can be severely affected and often die in 3–4 days.
- Animals younger than six months are not severely affected.

Treatment

- Treatment works well if started soon enough.
- Give an antibiotic. Oxytetracycline works well.

Prevention and control

- Prevent anaplasmosis by controlling the vectors that spread it.

9.6.12. Trypanosomiasis

- Tsetse flies from the *Glossina* spp. are responsible for the spread of the disease. The fly has infested an estimated 130,000–200,000 square kilometers of fertile land in the western and southwestern parts of Ethiopia.

Signs

- Animals become sick with Trypanosomiasis 1–3 weeks after being bitten by infected tsetse flies.
- The disease lasts for a prolonged period.
- Animals become weak and tire easily, often lagging behind herd mates.
- Animals have rough, dull coats, slowly lose weight and become thin.
- Eyes have a watery discharge and may become cloudy.
- The animals blink a lot.
- Lymph nodes are swollen and noticeable under the skin.
- Mucous membranes become progressively pale over a period of weeks.
- Animals exhibit intermittent fever.
- Pregnant animals often abort or have weak offspring.
- Poor feeding, stress or overwork increases severity of the disease.

Treatment

- Medicines such as Diminazine aceturate and Nomidium chlorides are known to be effective.
- However, chemotherapy is becoming very difficult because trypanosomes have become resistant to available drugs. Underdosing and overuse of the drugs leads to the development of resistance.

Prevention and control

- Use insecticide-impregnated targets to kill mosquitoes.
- Use trypanocidal medicine routinely.

9.6.13. Heartwater

- Heartwater is one of the most important tick-borne diseases of sheep and goats.
- It is caused by rickettsia, *Cowdria ruminantum*, leading to the disease known as cowdriosis.
- The rickettsia is transmitted by *Amblyomma variegatum* ticks.

Signs

- Animals become sick 1–4 weeks after being bitten by infected Amblyomma ticks.
- In sudden, severe onset, animals quickly develop a high fever, collapse, convulse and die in a few hours.
- In slower disease onset, animals show the following signs:
  - Decreased appetite, nervousness, easily prone to agitation.
  - Muscle uncoordination, a very high stepping gait, often walking in circles.
  - Teeth-grinding and licking lips.
  - Collapse, convulse and die after 1–7 days.

The mild form of the disease occurring in sheep, goats, sometimes even in young cattle has the following symptoms:

- A few animals have diarrhea, which is often bloody.
- Animals have a low fever but few other signs of disease.
- The sac around the heart of dead animals is full of fluid. There is also fluid in the chest and abdomen. [Cattle have less fluid around the heart than sheep or goats.]

Treatment

- Treatment only works if it is started soon enough.
- Give an antibiotic, tetracycline.
- Check other animals in a group with a sick animal and immediately treat any that have a fever.

Prevention and control

- Control of ticks by spraying or dipping small ruminants with acaricides.

9.6.14. Brucellosis

- The disease is caused by *Brucella melitensis*. The disease is very severe in goats and death may occur. Sheep are more resistant.
- Large numbers of *B. melitensis* are discharged during abortion.
- Close contact between animals is necessary for infection to be transmitted.
- This is a zoonotic disease, which is transmissible to humans from infected goats.

Signs

- Animals become sick 3–20 weeks after infection.
- A primary infection following the introduction of disease by an infected male or female may at first result in a few abortions.
- This usually progresses to a serious storm of abortions.
- Goats seldom abort more than once due to brucellosis but many sheep abort twice or have dead lambs at the pregnancy following the abortion.
- Abortions usually occur beginning the fourth month of gestation.
- Mastitis is often the first sign seen, with milk appearing clotted and discolored.
- Lameness; orchitis may be found in males.

Treatment

- There is no effective treatment.

Prevention

- Hygiene and good management practice is essential.
- Dispose of all aborted material, including the fetus, and disinfect the surroundings.
- A separate shed should be used for kidding.
- Isolate infected flocks to prevent the spread of the disease.

9.6.15. Ovine Pasteurellosis

Ovine pasteurellosis commonly occurs in sheep and goats in many parts of the country.

Signs

- Sheep and goats become sick 7–10 days after infection.
- Many animals are affected simultaneously.
- Animals may go off feed and tire easily.
- Severe cases:
  - have high fever.
  - cough and have distressed breathing that increases in intensity.
  - in some cases, collapse and die in a few hours.
- In less severe cases:
  - animals lose weight, becoming emaciated and weak.
  - some animals may have a swollen abdomen.
  - animals grind their teeth.
  - animals have rapid, shallow breathing.
  - animals have diarrhea.
  - death after 5–6 days if not treated.
- Lungs of dead animals have red/grey patches in them. The air ways have mucus.
- Animals that were sick for several days have yellow fluid in the chest.

Treatment

- Antibiotic treatment, one of the following drugs can be used:
  - Sulphadimidin, streptomycin, and oxytetracycline are effective.

Prevention and control

- Avoid overcrowded conditions.
- Annual vaccination with Pasteurella vaccine produced by the National Veterinary Institute.

9.6.16. Orf

Orf or sore mouth is a common disease of sheep and goats. It is caused by a virus and is highly infectious.

Signs

- Sore patches around the mouth, usually starting at the corner.
- An affected lamb or kid may spread the disease to its mother's udder.
- Ewes and does with painful teats will not allow lambs or kids to suckle. The lambs and kids may die of starvation.
- Adult animals that are affected will not eat properly and may lose condition.

Treatment

- There is no treatment for orf. Antibiotic sprays or powders will prevent secondary infections in open sores.
- Affected animals should be isolated.
- Owners should be warned that humans can become affected by the sores.

9.6.17. Bloat

Cause

Bloat is the result of failure to expel stomach gases normally and, if not treated, can be fatal. Animals may bloat when they feed on lush legumes and froth develops in the rumen preventing gas from escaping. Bloat can also be caused by obstruction or blockage in the esophagus or stomach. A good example is animals eating plastic bags.

A bloated animal:

- Will be restless.
- Have difficulty breathing.
- The upper left side of the stomach will appear bigger than normal and will sound hollow when tapped.
- The animal urinates and defecates frequently.
- It bleats and walks unsteadily.
- Death due to restricted breathing and heart failure follow unless action is taken.

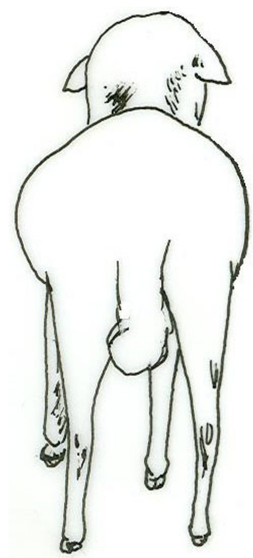
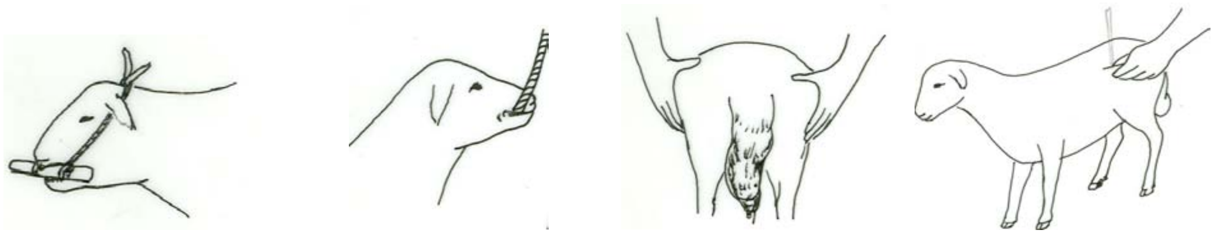


Figure 9.32. A bloated sheep.

Treatment

- Keep the animals in standing position.
- Tying a piece of wood in the mouth will help stimulate saliva production that can assist in breaking up froth in the stomach.
- Apply side- or lifting-pressure to the stomach to help expel the gas by lifting the animal from below the stomach.
- Walking may also help in getting rid of the gas.
- If the condition does not improve, a small diameter rubber tube (0.5–1 cm opening) should be forced down the throat and into the stomach to release the gas.
- To make certain the tube is in the stomach, smell the gas released. It should smell like stomach contents.
- Another method is to place an ear next to the stomach on the left side of the animal and blow into the tube. A bubbly sound should be heard. This also helps to clear the opening of the tube.
- If it is a gas bloat, gas may be immediately expelled once the tube enters the stomach; in some cases, it may be necessary to move the tube and try to find the gas pocket.
- If it is a bubby bloat, pouring a small amount of vegetable oil (100–200 mℓ) through the tube will help break up foam.
- For best results, use a tube within the first few hours of bloat occurring.
- If all other attempts fail, and as a last resort, a small tube can be inserted into the stomach through the side of the animal.
    - First, a small area on the top left side of the stomach is shaved and cleaned with iodine solution.
    - Determine the area to stab, about 3–4 fingers from the back bone in between the ribs and hip bone. Stab the area with a short piece of narrow metal tube (5 mm in diameter), which has been dipped in iodine solution.
    - Before stabbing, pull the skin slightly so that after the tube is pulled out, the wound will close.
    - The gas coming out through the tube will have a bad smell.
    - After the gas is released entirely, pull the tube out and clean the wound with iodine solution.



1. Tie a piece of wood in the mouth
2. Force-feed a half glass of oil
3. Apply some pressure to the inflated stomach
4. Stab with a narrow metal tube or trocar and cannula if available

Figure 9.33. Treatment of bloat

Prevention

- Do not give animals too much wet lush legumes, grass, and grains that may cause bloating.
- Always feed dry roughage before feeding lush grass or before letting animals go on lush pasture.

Contagious foot rot

Cause

Foot rot in goats is caused by infection with two bacteria, *Dichelobacter nodosus* (from the feet of infected animals) and *Fusobacterium necrophorum* (commonly found in the environment). The source of *D. nodosus* is the hooves of chronically infected carriers that occur in approximately 10% of affected small ruminants. Because of *D. nososus'* short life-span outside the hoof (usually less than four days), pastures or paths left alone by sheep and goats can be considered to be noninfectious after two weeks in wet/warm environments and after one week in a dry environment. Outbreaks of foot rot occur only when pastures are continually wet. Wet conditions soften tissues surrounding the hoof and can lead to infection or dermatitis, making the skin more permeable to infectious bacteria.

Signs

- In the mild form:
  - ♦ Skin between the hooves will be inflamed and swollen. There may be some secretion.
  - ♦ Mild lameness.
  - ♦ Can disappear spontaneously when the feet are exposed to dry conditions.
  - ♦ Usually only a few animals are affected.
- In the severe form:
  - ♦ The foot is red, swollen, and moist.
  - ♦ As the infection progresses, the hoof exudes a dark, foul-smelling pus.
  - ♦ The animal will limp or walk on its knees due to the painful hooves.
  - ♦ An animal may have a fever and will lose productivity.

Treatment, prevention, and control

Treatment, prevention, and control generally consist of combinations of antibiotic use, foot baths and foot trimming. Injectable antibiotics are highly effective. Keep animals in a dry environment for at least 24 hours following treatment. Topical treatment with antibiotics (5% tincture of tetracycline) or antiseptics (10% zinc sulfate, 10% copper sulfate solution) is adequate for mild foot rot in small flocks of animals. Large goat herds are treated more practically with foot baths.

In an outbreak:

- Treat weekly for four weeks.
- Separate infected from non-infected animals, treat, and then place on separate pastures.
- Foot baths must be deep enough to allow complete coverage of the foot and can be made from concrete, fiberglass, or plastic-lined wood. Foam rubber or wool can be placed in the solution to prevent splashing of caustic substances.
- Provisions should be made for drainage and proper solution disposal to prevent environmental contamination.
- Copper sulfate (5%) and zinc sulfate (10%) are commonly used foot bath chemicals. Both chemicals are slow to penetrate the hoof and soaking periods of an hour or longer are necessary. Using a detergent, such as dishwashing detergent, in the solution may help penetration.
- Dry foot baths (85% limestone, 15% zinc sulfate) can also be beneficial.

Foot trimming

Routine foot trimming is crucial in the prevention and treatment of foot rot. Overgrown hooves provide an anaerobic environment for *D. nodosus* to grow, and stress the foot, increasing the chance of damaging skin and allowing entry of bacteria. In treatment, it is crucial to trim the feet adequately to expose infected areas when topical disinfectants are used. Do not trim so severely as to cause bleeding.

Dermatophilosus, streptothricosis, rain scald

Dermatophilosus is a contagious skin condition seen in moist, humid, wet conditions. It is caused by the bacterium *Dermatophilus congolensis*. The ears, nose, face, and tail may be affected beginning with a low-grade, scaly, skin infection that spreads along the back and flanks. In severe cases, animals may scratch constantly. The bacteria can survive in soil or dust on an animal's skin during dry weather and are transmitted by direct contact, infected equipment, flies, etc. This disease is zoonotic, so care should be taken when handling affected animals.

Signs and symptoms

- Scabs form around the ears, face, nose, lower legs, or tail.
- These form crusty, scaly lesions that spread over the back and flanks of the animal.
- Affected areas are susceptible to secondary bacterial infection.
- Lesions around the mouth may be confused with orf.

Treatment, prevention, and control

- Antibiotics can be injected.
- Topical treatment with zinc sulfate 0.2 to 0.5%, 0.2% copper sulfate, or 1% potassium aluminum sulfate.

Prevent by providing shelter from rain for animals on pasture and ensuring good nutrition and control of external parasites.

Pinkeye, infectious keratoconjunctivitis

This often refers to any condition resulting in watery, red, or cloudy eyes. Causes include air-borne irritants and foreign bodies such as dust or small hay particles; trauma to the eye such as scratching from hay, straw, or wire; or from an infectious agent. Certain viruses and parasites can also cause this condition. In most cases, an infectious agent is responsible and even in cases of irritation or trauma, treatment to prevent secondary infection by bacteria is commonly done. The onset of this disease is quick and it can spread through animal-to-animal contact.

Signs and symptoms

- Watery eyes, redness of the eye, swelling of the eyelids.
- Sensitivity to light.
- A cloudy cornea.

Treatment, prevention and control

Isolate affected animals to prevent disease spread. Treatment includes the use of an antibiotic eye ointment or antibiotic treatment. If it is not treated early, permanent eye damage or blindness can result. Inspect all new arrivals before mixing with existing herds.

Rabies

Rabies is a fatal disease in all mammals. It affects the central nervous system. It is transmitted usually through bites from an infected animal. If rabies is suspected, health officials must be notified.

Signs

- Paralysis of limbs.
- Abnormal behavior such as nervousness, excitability, irritability. Some animals may become uncharacteristically aggressive.
- Muscle in-coordination and seizures.
- Excessive salivation.
- Death.

Treatment

There is no treatment available. Animals suspected of having rabies should be destroyed and the carcass buried so no other animal has access. Animals in contact with infected sheep or goats should either be destroyed or quarantined to determine if they were infected.

Prevention

- Vaccination. Humans should be careful when handling animals suspected of rabies.

9.6.18. Plant toxins and pesticide poisoning

Cause

- Several plants, including some grasses and legumes, contain toxic substances.
- When consumed, may cause animals to suffer from the toxins.
- An animal that has consumed a toxic plant or poison may:
    - foam at the mouth.
    - have muscle spasms.
    - have blue spots on mucous glands.
    - have peeling skin.
    - have bloody feces.
    - have lesions on the face.

Treatment

Make sure the animal has plenty of water to drink and try one of the following treatments:

- Boil strong tea or coffee and let it cool. Give it to the animal to drink or force-feed it.
- Mix a small (handful) of fine charcoal powder in about one liter of water, give by mouth. Give daily for a few days if needed.
- Give vegetable oil by mouth.
- Give milk by mouth.
- Mix six eggs and ½ kg sugar with about 1 liter of water and give by mouth.

Prevention

- Do not graze animals where poisonous plants are present. Remove any toxic plants from grazing areas.
- Avoid pasture that has just been sprayed with herbicides or pesticides.
- Do not let animals graze near rubbish where people have thrown things that may be poisonous.

a. Skin lesion from toxicity after overconsumption of *Lantana camara ("Yewef kolo")*

Lantana camara ("Yewef kolo")

Figure 9.34. Example of plant toxin.

9.7. Community-Based Veterinary Service

Veterinary service-delivery is poor in most of the remote areas of Ethiopia. In these areas, livestock are highly valued, both socially and economically. Remote areas generally have harsh environments, difficult terrain, poor infrastructure and very few animal health personnel. Due to these constraints, a new approach towards veterinary service delivery for these areas is crucial. The new approach includes involvement of Community Animal Health Workers (CAHW) / Kebele Animal Health Workers (KAHW) to deliver basic veterinary services. In remote or inaccessible areas, the CAHW activity could be initiated by the community itself and the KDA. The community may select some community members who are respected by the community and recognized as knowledgeable and responsible livestock keepers to be trained as CAHWs and deliver basic animal health services. The CAHWs should be trained by qualified trainers, veterinarians or assistant veterinarians that have special skills in training CAHWs that may be illiterate. The objectives of the training are to:

- improve the community's access to essential veterinary drugs and basic animal health services in order to maintain the health of their animals.
- encourage CAHWs to train farmers and pastoralists in disease prevention and control.
- improve disease reporting and surveillance.

Duties of Kebele Animal Health Workers (KAHW)

- Treat minor problems such as wounds and carry out routine tasks such as deworming.
- Carry out castration.
- Spraying and dipping of animals with acaricides.

- Hoof trimming.
- Coordinate vaccination programs and assist the vaccination activity.
- Participate in disease-reporting activities.
- Report disease outbreaks to the nearest government veterinary service.
- Create awareness among farmers and pastoralists on disease prevention and control.

Questions

1. How do you help your community keep animals healthy?
2. Can you prioritize the constraints of animal health in your area?
3. In which season do you think farmers need to treat their animals against internal parasites?
4. How important are ticks, flies, lice and other external parasites in the health and productivity of sheep and goats in your area?
5. Internal and external parasites cause sickness and death in sheep and goats. Which of the methods you have learned in the manual can help farmers to minimize the problem? Is using and applying some of the control methods simple and practical for you?
6. The management of communal grazing pastures is important in controlling internal/external parasites and infectious diseases of sheep and goats. How can you implement the ideas suggested in this manual?
7. Have you noticed the impact of infectious diseases on the life of animals and their productivity?
8. Which of the infectious diseases are more dangerous to sheep/goats in your area? Which ones are transmissible to people?
9. What measures do you take to control and prevent infectious diseases in your area?
10. What common roles can Community Animal Health Workers (CHAWs), Kebele Development Agents (KDAs) and animal health assistants play for the betterment of sheep and goat health and the wellbeing of the community?

References

Blood, D.C. and Henderson, J.A. 1983. Veterinary Medicine, 6th ed. London: Bailliere Tindall.

Hall, H.T.B. 1982. Diseases and parasites of livestock in the tropics, ed. W.J.A. Payne, 3rd ed. Longman, London.

Hansen, J. and Perry, B. 1994. The epidemiology and control of helminth parasites of ruminants. A handbook. International Laboratory for Research on Animal Diseases (ILRAD), Nairobi, Kenya.

Kassa Bayou. 2006. Training manual for the control of skin diseases of ruminant livestock in Ethiopia. Addis Ababa, Ethiopia.

Kaufmann, J. 1996. Parasitic infections of domestic animals, Birkhauser Verlag, Bern, Switzerland.

MOA, 1990. Animal health extension manual, Fourth Livestock Development Project, Ministry of Agriculture, Addis Ababa, Ethiopia.

Peacock, C. 1996. Improving Goat Production in the Tropics, A Manual for Development Workers, Farm Africa & Oxfam, UK.

Merkel, R.C. and Subandriyo. (eds.) 1997. Sheep and goat production handbook for Southeast Asia, University of California, Davis, USA.

Soulsby, E.J.L. 1982. Helminths, Arthropods and Protozoa of Domestic Animals. 7th ed. London: Bailliere Tindall.

Steele, M. 1996. Goats. In: The Tropical Agriculturalist, ed. R. Coste & A.J. Smith, CTA, Macmillan.

Thrusfield, M. 1988. Veterinary epidemiology, 2nd ed. Blackwell, UK.

Chapter Ten

Sheep and Goat Products and By-products

Tekle Zeleke

Objectives

The objectives of this chapter are to explain how to:

1. use improved methods of skin preservation.
2. produce skins in quality and quantity.
3. purchase products based on standards.
4. create awareness in buyers, traders and producers.
5. supply raw material to the tanneries.

Expected Outputs

1. Improved awareness by producers, traders and buyers.
2. Improved quality and quantity of sheep and goat products and by-products.
3. Increased transactions based on standards.

10.1. Introduction

A number of products and by-products are produced from sheep and goats. The major ones include meat, milk, skins and manure. Milk, skins and manure will be discussed in this chapter. Sheep and goat meat will be discussed in Chapter 12. The discussion on skins takes the major proportion of the coverage due to the big export revenue currently obtained and the potential for increasing earnings from this product.

10.2. Goat and Sheep Milk

10.2.1. Milk composition

Goat milk is consumed in some parts of the country. Milk from sheep is rarely used. Goat milk is composed of fat, protein, lactose, ash and water. It has a pure white appearance when fresh. Typical figures for milk solids content are given in Table 10.1.

Cows have similar total solids to goats whilst sheep have much higher fat and protein. Milk composition differs somewhat among breeds but these values are representative averages. It has been well documented that goat and sheep milk have important advantages over cow milk for human nutrition.

Table 10.1. Composition of goat, cow, and sheep milk.

Composition	Goat %	Cow %	Sheep %
Total solids	13.9	13.5	19.3
Fat	4.8	4.8	7.6
Protein	3.7	2.8	5.5
Lactose	5.0	4.6	-
Ash	0.85	0.74	-

Source: Devendra and Mcleroy, 1982.

Compared to cow milk, goat and sheep milk have higher protein, energy and fat contents with beneficial amino acids. The higher proportions of short- and medium-chain fatty acids make goat and sheep milk easy for human digestion. Because of this, and the way it forms a fine curd in the stomach, humans can more easily digest goat milk than cow milk. Goat milk is an excellent source of calcium, phosphorus and chlorine. It is also believed that goat milk will not cause cow-milk-allergy (CMA) in many patients because of its species-specific proteins.

Goat and sheep products include liquid milk, powdered milk, cheese, yogurt, ghee and ice cream. As much as 50% of goat milk production is made into cheese world-wide. Their milk and dairy products can meet a significant portion of the daily nutrient requirements of humans in the world. In addition, goat and sheep products greatly diversify the diets of people and are considered as delicate treats in many developed countries. More importantly, they provide food security, needed nutrition and can be an income source.

10.2.2. Milk yield

Goats: Non-dairy breeds in the tropics have daily milk yields of up to 0.5 liters while specialized dairy goat breeds could give 2–4 liters per day. The milk production of goats is affected by different factors, including body size, weight, parity, stage of lactation, udder size, litter size, nutrition, breed and kidding season.

Sheep: A good dairy ewe produces about 1 kg (1 liter) of milk each day for about the first three months, and an outstanding ewe can produce 2–3 liters per day. Typically, milk yield rises after lambing and reaches a maximum within one or two months. Thereafter, milk yield slowly falls and drops. The same factors affecting milk production mentioned for goats also apply for sheep.

10.3. Sheep and Goat Skins

Ethiopia has 23.62 million sheep and 23.33 million goats. Hides and skins, leather and leather products are supplied to domestic and export markets and contribute significantly to the Ethiopian economy by providing 14–18% of the foreign exchange earnings. These earnings, however, are but a small portion of the potential income in view of the huge animal resources available. The main constraints to increased utilization of hides and skins are low quality and lack of grading/selection of the raw hides and skins purchased. About 80% of the hides and skins in Ethiopia are produced in rural areas. An extensive training and extension service is important in improving the quality of the raw materials entering the tannery industry. Additionally, it is essential to create facilities and make available the tools and equipment necessary for improved collection and enhanced quality of hides and skins available.

10.3.1. General structure of skins

The terms "skins" and "hides" have differences in meaning. The distinction is one of size and substance or thickness. Smaller and lighter skins derived from sheep, goats or pigs are termed "skins". In some species, the deciding factor will be the type of animal rather than size alone. For the purpose of this handbook, skin is defined as an outer covering from goats or sheep.

The skin histology of animals normally used in leather production is similar but species differences are readily observed. There are, for examples, differences in the relative amounts of the component tissues and their arrangement in different types of skin and in different places in the skin. The component structures of the skin are capable of flexing, stretching or contracting with the movements of the body.

An animal's skin has a number of functions, the most important being to:

- provide a light, durable covering for the body;
- assist in the regulation of body temperature;
- prevent or minimize possible injury to internal organs;
- provide a barrier to bacterial infection; and
- provide a waterproof covering for the body while allowing moisture to leave the body, e.g., through perspiration.

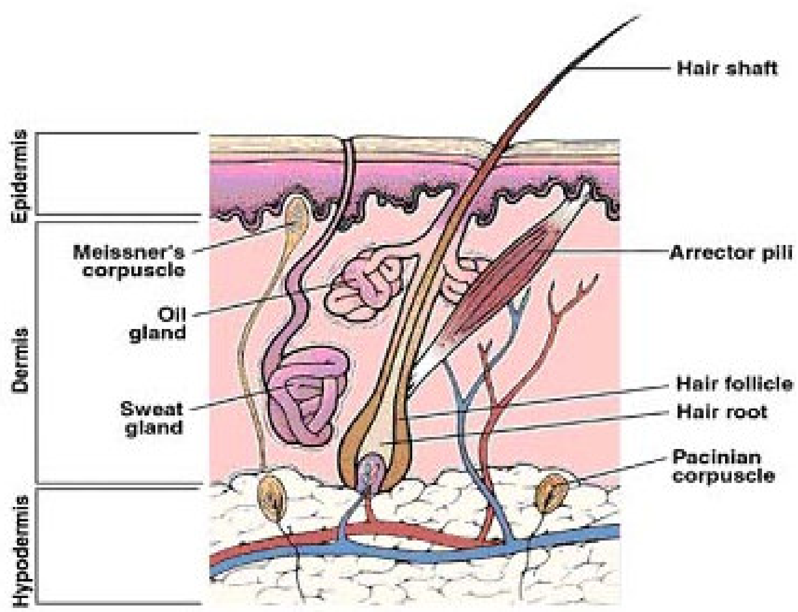


Figure 10.1 Main components of the mammalian skin

The general structure of mammalian skin is illustrated in Figure 10.1. This figure shows the skin before removal of hair or the cornified epidermal/outermost layer of the grain side by dehairing as occurs in the leather-making process.

There are three layers to the skin, of which two, the epidermis or outer layer and dermis or middle layer, are important in leather making. The third layer is the flesh layer and is composed of meat, fat, etc., and is removed in the tanning process. The most important layer for leather production is the dermis that is composed of a network of finely interwoven bundles of tissue. The dermis is composed of the grain layer, the corium layer, and the junction or layer where the grain and corium meet. The skin also contains structures and components such as hair, pores, sebaceous glands, hair erector muscles, white collagen, yellow fibers (elastin), blood vessels, sweat glands, hair root capillaries, hair follicles and underlying muscle sheath.

10.3.2. Production of skins

Ethiopia has a large potential for production of small ruminant skins, having 12.6% of the sheep and 11.6% of the goats raised in Africa. Annual off take rates have been estimated as 33% for sheep and 37% for goats. One constraint to skin production is high mortality with rates estimated at 11.4% and 11.6% for sheep and goats, respectively. Lamb and kid mortality rates are even higher. A negligible amount of skins are obtained from animals that die. The potential number of skins available for marketing can be estimated as 8.9 million sheep skins and 5.3 million goat skins.

Table 10.2. Quantity of skins supplied to tanneries in 1994/95 (Ethiopian Calendar).

Products	Supply (million) to:		% of total supply to tanning industry
	Tanning industry	Traditional tanners and other users	
Sheep skin	8.9	1.17	88
Goat skin	5.3	2.08	72

Source: Computed from MOA, 1997/98 and MEDAC, 1999.

Ethiopia exports semi-processed hides and skins at pickle, wet blue and crust levels of processing and exports some finished leather products of different standards. There are about 20 tanneries engaged in processing hides and skins. Only 6 of these have the facilities to produce finished leather. About 5% of the finished leather is supplied to domestic industries for the production of shoes, leather garments and hand bags. The rest is exported to international markets in the form of similar products. In 2004, the export value of 9,218,103 kg of leather and semi-leather products was reported as 362 million Birr. Most tanneries are not operating at full capacity and could increase utilization of existing processing capacity should more quality raw skins be available.

10.3.3. Factors affecting skin quality

10.3.3.1. Care during the life of animals

Skins in Ethiopia have greater economic return than most agricultural products and by-products. As a result, small ruminants should be given due care from birth to slaughter. Management practices should ensure the health of the animal and reduce the likelihood of injuries that could damage the skin. Treatment and vaccinations should be given on time as required. Treatment against ticks should be given through regular dipping or spraying. Providing proper feed and watering sites will help prevent sheep and goats from damaging their skins while searching for feed in the bush.

Fatigued animals, especially after a long trek on foot or rail, should be allowed to recover prior to slaughter or incomplete bleeding may occur. Removing the skin is also difficult in fatigued animals leading to more chances for the skin being cut. Animals should have free access to drinking water for at least 24 hours before slaughter and either held off-feed or given very little feed.

10.3.3.2. Care during slaughtering and flaying

Humane methods of slaughtering animals are encouraged; however, exact practices in Ethiopia differ according to local culture, customs and religious practices.

Stunning

Stunning is the practice of rendering animals unconscious just before slaughter. Proper stunning procedures reduce the chance of stained carcasses and blood splash. The following stunning options are available:

- Mechanical instrument (Captive bolt pistol) that traumatizes the brain so that the animal loses consciousness instantaneously.
- Electrical stunning.
- Use of carbon dioxide gas.

The animal must be killed as soon as possible after stunning by bleeding.

Religious slaughter

Religious slaughter methods include *Shechita* by Jews, *Halal* by Muslims and *Jatka* by Sikhs. The major blood vessels and the throat are severed by a transverse cut in the shechita and halal slaughter methods. In Jatka the animal is decapitated with a single stroke using a sword. The halal method of slaughter is of importance due to the Muslim target market for Ethiopian sheep and goat meat.

Bleeding

Whatever the slaughter procedures, bleeding is best performed with the carcass hoisted by the hind legs while leaving the forelegs to kick in the usual reflex action. Animals must be stunned prior to hoisting. For sheep and goats, some flayers prefer to complete most of the bleeding on the floor adjacent to a drain. When sheep and goats possess long hair, much more care must be taken to avoid contamination with blood and dung, and bleeding on a definite slope is to be preferred. In either case, final bleeding is best carried out after suspension of the carcass.

Ripping

- One long and straight incision from the jaw to the anus along the center line of the belly.
- Four circular cuts around the shanks at the level of the knee and hock joint.
- Two cuts on the inside of the forelegs, knees to the breast bone.
- Two cuts on the back of each hock joint to a point mid-way between the anus and scrotum.

Flaying

Flaying in sheep and goats can be done by first making a small incision on the inside of one of the hind legs. Air is blown into the incision to effect separation of subcutaneous tissues between the skin and the carcass. After this, vigorous pummeling is also done.

In many countries, skinning is done in case form to obtain a good quality skin and also to use the skin later as a water bag. The hind legs, including a small portion of the skin covering the abdomen and edges of the butt round the rump, are flayed with knife and fist while on the floor. The carcass is hoisted by the hind legs and the skin removed by pulling and fisting. Sometimes, the belly skin is removed using a knife leaving the surface of the carcass with close serrated scores. But in many countries a knife is not used in the final phase. The flayer uses the weight of his foot with downward pressure to remove the skin from the neck and forelegs.

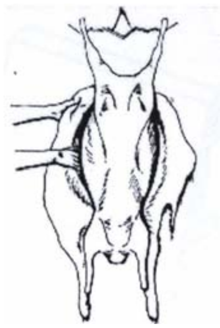


Figure 10.2. Flaying of goats and sheep using a fist.

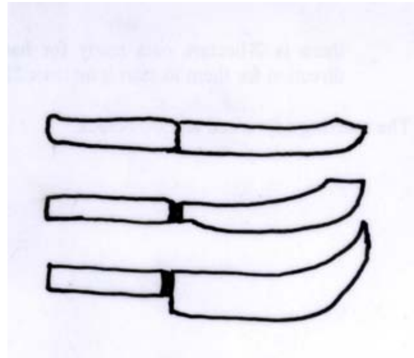


Figure 10.3. Proper ripping and flaying knives.

In other systems, the carcass is cut down the center of the belly and on the inside of each leg. The foreleg incisions join the center incision at the breast and the hind leg incisions follow the line of the rump to the anus. The bellies and legs are then flayed on the floor and finished on a hoist, if possible.

Appropriate flaying methods

- Incision: Blowing air into the cut in the hind leg. Relevant in case one wants to use as water bag.
- Flayed with blunted curved knife following ripping lines.
- Hoisted by the hind legs and skins removed by pulling and fisting.
- Mechanical flaying.
- Hand flaying machine.

Activities after flaying and before preservation

It is very important for the flesh side of any flayed skin to be as clean as possible. This is particularly important for skins that tend to have appreciable attachment of subcutaneous fatty tissue after flaying.

It is a good practice to wash skins on a firm surface in conjunction with brushing to remove extraneous material, e.g., blood, at this stage of preparation and handling of skins.

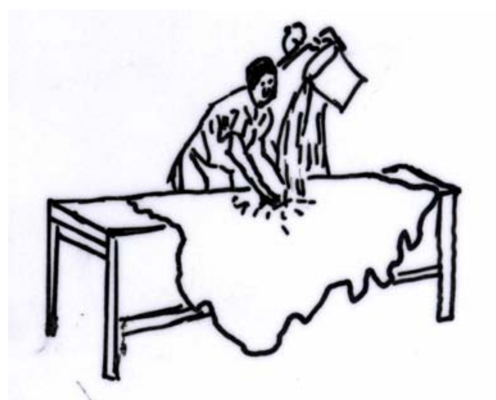


Figure 10.4. Washing of the flesh side before preservation.

How to flesh

- Use a curved-edge flaying knife
- The excess tissue can gently be removed by keeping the knife at a low angle and without exerting heavy pressure.
- Care should be taken to avoid cutting or damaging the skin.
- A wooden horse with sloping side will probably be found easier to work upon than a large table.
- Exotic skins should be suspended and scraped for cleaning and defatting.
- Suspend skins for defatting and, by scraping instead of cutting, remove the fat using a sharp curved-edged knife. As far as possible, the fat on the flesh side should be completely scraped off as fat will not permit proper curing and subsequent tanning.

- Flesh before tissue and meat dry up.
- Wash skins by pouring water over them after they have been spread out as flat as possible, over a wooden "horse." Use a firm "scrubbing brush" or coarse broom and make vigorous strokes down the skin to remove blood, dirt, etc., as the water is applied.
- Fleshing and washing can be conducted satisfactorily using a wooden "horse" as shown in in Figure 10.5. However, a large, curved top table (Figure 10.6) can be used if a "wooden horse" is not available.

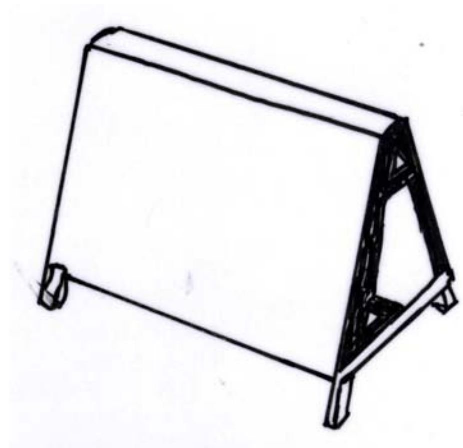


Figure 10.5. Wooden horse for fleshing.

Another method of fleshing uses a "fleshing beam" and a "fleshing knife." A fleshing beam is a piece of wood over which the hide is draped for scraping. A common type of fleshing beam can be fashioned out of a 15-cm wide board 1.75–2 m long. One end should be cut to a blunt point and all edges rounded and smoothed. Legs are attached near the pointed end so that the fleshing beam slants upward from the ground to waist level. While this is the most common type of beam, others such as rounded logs can be used. A fleshing knife is a blade with a handle on both ends allowing even pressure to be exerted as the blade is pushed down the hide. Blades should be dull as the goal is to push and scrape all fat, meat and membranes off the hide, leaving only the skin.

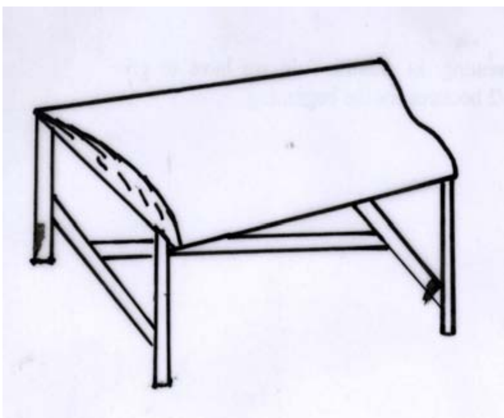


Figure 10.6. Curved-top table used in preparation of skins.

Figure 10.7. Fleshing beam.

Figure 10.8. Fleshing using a fleshing knife

To flesh a hide, spread it over the pointed end of the fleshing beam and let it drain briefly. Push downwards, scraping off unwanted material using the fleshing knife. To make fleshing easier and lessen the chance of cutting the hide, it is important to flesh with the lay of the hair. The legs should be fleshed towards the belly and the hide from the tail pushing towards the neck.

10.3.4. Preservation methods

Preservation prevents putrefaction and keeps skins in good condition until they are processed in tanneries. Being protein in nature, skins are susceptible to attacks by bacteria or mold that leads to putrefaction in hot and humid climates. Dust, dirt, soil, water, blood, fodder, etc., are sources of infection apart from micro-organisms that could be transmitted by air, insects, or contact with diseased animals. The weight of a fresh skin is about 60% water, ideal conditions for bacteria to thrive. The protein matter hydrolyzed by bacteria leads to loss of skin substance resulting in poor-quality leather.

Curing creates conditions whereby bacteria are prevented from destroying skins. The type of curing used depends on weather conditions, availability of materials, location of tanneries, and so on. For instance, some drying techniques do not work during the rainy season, and salting is preferred. In all techniques, the natural water is removed so that the low percentage of moisture makes the bacteria ineffective and as soon as this condition is reversed, bacteria become active again.

In tropical countries, it is advisable to begin curing within four hours of flaying depending upon outside temperature. Raw skins should be sent to the curing facility in closed carts and protected from exposure to the sun and without being rolled. Skins can be dried with or without a frame, in the sun or in a shed.

Wet salting, dry salting and brining are other methods of skin preservation. There are also more recent techniques not yet universally applied.

10.3.4.1. Principles of preservation

The following points should be considered in undertaking skin preservation:

- Point of application of the treatment and how long preservation is required.
- Methods of application and any extra equipment and handling involved.
- The cost-effectiveness of the treatment for the required period of preservation.
- The effect of salt and other chemicals in causing pollution.

The following are some of the common drying preservation techniques

- Air drying
  - Suspension drying
  - Line/wire drying
  - Skin drying sheds
- Salting
  - Wet salting
  - Dry salting
  - Brining

Air drying

Drying of skins can be done in different ways. The techniques include drying on the ground, using suspension/frame drying, drying by suspension over cords or wires, and tent and parasol drying. Drying depends on the temperature, relative humidity and movement of air. For example, a skin can be dried in three hours in a dry atmosphere.

A fresh skin placed in warm surroundings will dry more rapidly in moving air. Even if the air is humid but moving, it will dry a damp skin. Therefore, it is bad practice to hang a skin in a closed space with solid walls and no air movement, as this leads to putrefaction. Air currents should move freely in drying skins even if the air is hot. If a skin does not dry in 2–3 days, the chance of putrefaction is very high. Air drying can be done in the following ways:

a. Suspension frame drying: This can be practiced in different ways depending on local conditions and availability of skins. The best option is to frame-dry under a shed. While frame-drying in the open is cheaper, it is better to use a shed where suitable cross-ventilation occurs. Shed drying also allows for close supervision as well as protection from theft and control of damage from vermin. Drying sheds can have regular frames made of wood or metal pipes that are permanently fixed. Large frames meant for hides, 3 m × 3 m, can be adapted for skins by partitioning allowing four skins to be stretched (Figure 10.9).

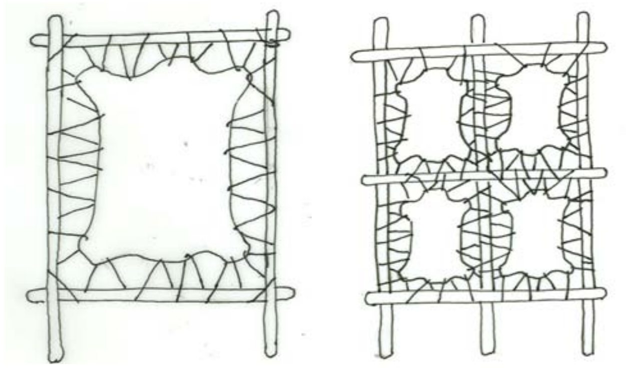


Figure 10.9. Frame drying of skins.

Suspension frame drying in the sun is acceptable provided that the temperature of the skin does not reach the point of degradation of collagen. Sun drying makes skins crack when folded and become very difficult to soak in the tanneries. Sheep skins are very sensitive to heat damage. Suspension frame drying has the following advantages:

- It allows free flow of air on both sides of the skin.
- If not in a shed, rain drains off the surface and does not collect in puddles on the skin.
- Sun rays strike obliquely not directly.
- It permits the skin to cool off rapidly from the large exposed surface area.
- Neither hair slip nor putrefaction begins as there are no folds or points of contact between the skin and any solid object. But during the rainy season, due to still air and high relative humidity, some percentage of skins may putrefy.
- Better grading possibilities.
- Dried skins can be stored for a longer period of time than salted skins.
- Transporting dried skins is cheaper as the weight is only half that of the salted skins.
- Corrosion is avoided as opposed to the case of salted skins where containers and transporting vehicles may become corroded.
- It is less expensive as salt is not purchased.
- Less worry of environmental contamination as compared with disposing used salt.

The following problems are associated with suspension frame drying

- Difficulty in rehydrating dried skins including extra cost and potential loss of skin substances leading to holes.
- Uneven shape by improper stretching during drying.
- Loss of surface area by the cuts for lacing and consequent trimming.

One has to make sure the skins are not overstretched. The method of stretching and securing to the frame is called lacing. The best lacing materials are strips from waste hides. Ropes are commonly used. Often, the slits made by knives are very long and an area inside the skin is wasted. It is better to use a punch for lace holes.

b. Suspension drying over cords or wire: This technique is employed where wood is scarce. Skins are suspended symmetrically along the backbone with the hair or wool hanging down over a wire not thicker than one's little finger. The overhanging sides of the belly and flanks must be prevented from touching each other and the shanks from folding inwards. Sticks or straw can be used to adhere to the wet flesh, ensuring that every part of the skin is free and open to the air (Figure 10.10).

The drying time is the same as frame drying. If the hair sides smell of goat during drying, all is well. If a portion of the skin is in contact with the pole it will not dry properly and will become putrefied. This is the main drawback of this technique.

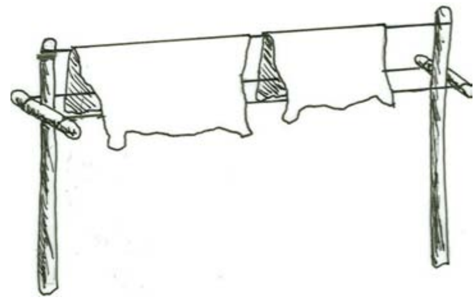


Figure10.10. Suspension drying over cords.

c. Ground drying: This method, in which skins are placed directly on the ground, is the worst technique to use. It produces dried material of the most appalling quality, and consequently of the poorest value to the producer. Because of the lack of air circulation between skin and soil, moisture is trapped under the skin and the physical damage is irreparable. Much of the damage caused at this stage may not be fully seen until processing.

Figure 10.11. Ground drying results in serious, irreparable damage to skins.

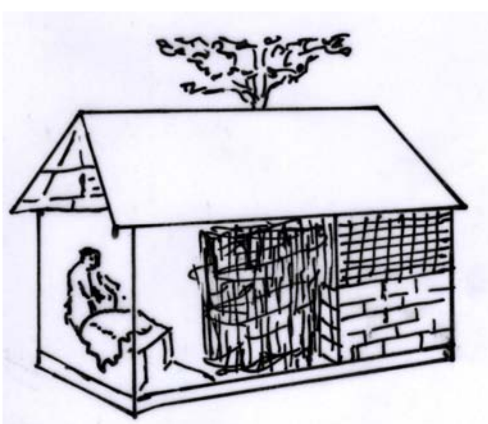


Figure 10.12. Skins drying shed.

d. Skins drying shed: Drying sheds have three sections:

1. Working area with a sloping floor where skins are prepared on tables for suspension.
2. Drying area: calculated taking into account seven days needed for drying. So for 40 skins daily, you need 70 3 × 3 m frames divided so as to hold 4 skins each.
3. Storing area: a slatted wooden platform raised 25 cm off the floor.

For a capacity of about 200 sheep and goat skins a year, the shed should measure 10 × 14 m, have a cement floor and a corrugated iron roof. The sides should be open and protected by strands of barbed wire with the exception of a line of corrugated iron sheets at the top and further corrugated iron sheet protecting the area where skins are stored. There should be 48 wooden frames (3 × 3 m divided for 4 skins each) giving 192 skin capacity fixed at a height of 0.5 m from the floor, and a distance of 30 cm between frames. The frames, tables and wooden horses will be arranged in an area set for washing of skins where there is also a proper drainage facility.

A cement wall, 2 m high, should separate the wet area from drying area. The storage area will be protected by corrugated iron but windows should be provided to ensure circulation of air (Figure 10.12).

Salting

a. Wet salting: The skin is spread on the floor or a wooden pallet and common salt is uniformly applied on the flesh side equal to 30–40% of the green hide weight. A second skin is now spread on the first one with the flesh side up and salt applied in the same manner. A pile of about 100 skins may be made or to an approximate height of 1 m. (Figure 10.13 to 10.15).

Figure10.13. Salting skins on a cement floor.

The salt absorbs water from the skins, and the brine (mixture of salt and dissolved fluids) is allowed to drain. The stack is allowed to cure for about five days. It is then opened and put in a new pile with the top skin going to the bottom, applying additional salt wherever necessary. Again, the skins remain for five days in the pile. The skins are then removed and excess salt removed from the flesh side and the grain side to keep it clean.

Figure 10.14. Demonstration of salting during ESGPIP training in Semera, Afar region.

Bacteria are not destroyed in this technique but a condition is created where they become ineffective. Salt absorbs about 20% of the water from the skin. Some salt is absorbed by the skin to the extent of 13–17%. In smaller skins, the percentage of salt used based on green weight is higher. Rock salt, lake salt and sea salt can be used. Any salt used should have a sodium chloride content of 94–95%. The salt should not be too fine or too coarse. If too powdered; the salt flows out as brine and is not absorbed to the desired extent. The suggested size is two to three millimeter grain. Rock salt is the most ideal salt for curing but sea salt is most commonly used. The main disadvantage of wet salting is the formation of "red heat" which makes the flesh side of the skin red through the action of halophilic (salt-loving) bacteria and other organisms that have salt tolerance.

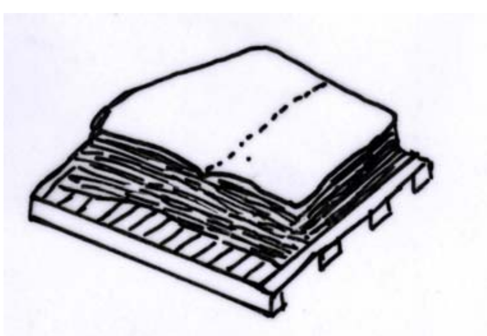


Figure 10.15.Salted of skins on a pallet.

b. Dry salting: This technique is very similar to wet salting but skins are dried after the initial salting. This method gives the advantage of both drying and salting. This technique is especially well-suited for preparing skins/hides for export and at the same time overcoming the problem of wet salting. The initial steps are the same as in wet salting; however, salting has to be done without any delay after flaying.

c. Brining: Green fleshed and washed skins are soaked in brine (salt solution) for 24 hrs.
It has been the practice in some countries to recover and re-use salt swept from skins before these are shipped or sold, sometimes after mixing with fresh salt. It must be recognized that the risk of contamination

of sound, fresh raw stock in this way is very high. This is generally practiced where salt is either considered too costly for economic use or is not readily available.

Generally, the best preservation method is salting depending on the distance of raw skin production from tanning factories. The second best option is air drying. Air drying takes a long time for processing. Dried skins require soaping and wetting before processing. This process has added cost to the tanneries.

10.3.5. Skin defects

Skins commonly exhibit defects caused by a variety of factors. Defects originating while the animals are alive are called *ante-mortem* defects while those originating after the death of the animal are called *post-mortem* defects. While some defects are common to all animals, some are specific to some species. The most common defects are listed below:

10.3.5.1. Ante-mortem

- Poor substance
- Sore marks
- Barbed wire and thorn scratches
- Rub marks
- Goad marks and whip lashes
- Bite marks from ticks, fleas, lice, leeches, etc.
- Scabies, mange, ringworm
- Pox
- Cockle
- Scars
- Diseases such as trypanosomiasis, streptothricosis, sweating sickness, etc.
- Injection punctures, shearing cuts
- Dung damage
- Natural characteristics of the skin

Defects due to ectoparasites ("*Ekek*")

Mange: This is a skin disease, of which the most common type is follicular or demodectic mange. It is caused by parasitic mites visible only under the microscope.

Scabies: The mites multiply under the skin surface leaving a coarse grain, lesions and scratch marks where the animal scratches itself.

Ticks: Blood sucking parasites found attached to the thinner and tender parts of the skin, the inner parts of the thighs, under the elbow and on the udder and scrotum. Ticks cause small holes marring the smoothness of the grain. Secondary infections may lead to more extensive damage.

Lice: Cause scars and inflammation on the grain surface more or less on regular lines around the rump and down the bellies finishing near the forelegs. These cause small punctures and give a bruised appearance to the grain.

Sheep ked: A flat brown insect that sucks blood. Normally infests sheep and spends all its life on the host. It causes irritation resulting in scratching, biting and damage to the fleece. It causes skin blemishes, downgrading the skin.

Warble flies: Occur in dry and arid regions and are generally absent in moist regions. This is due to the fact that moist soil is not conducive to the growth of larvae into flies. Hairy goat breeds with short and drooping ears are often attacked by these insects.

Cockle: A warty growth in wool sheep seen as rounded nodules scattered through the corium and appears to develop as fleece grows. The disease is due to a nutritional and digestive disorder.

Ringworm: A fungal disease that attacks the hair and its roots with circular inflammation leaving shiny scars.

***Pox**:* An infectious disease forming inflamed spots usually on the udder and other tender parts of the skin. The spots become charged with pus. Apart from lesions, the animals rub the irritating parts causing further infection and damaged grain.

Diseases such as trypanosomiasis, streptothricosis, sweating sickness, etc.: Cause thickening and coarsening of the epidermis and hair follicles, especially in the neck. This causes hair follicles to protrude above the grain, giving a rough finish. Streptothricosis also causes lesions which break spontaneously. These cause blemishes on the superficial grain tissues.

10.3.5.2. Defects occurring during slaughter and preservation

Flaying defects

A large number of skins contain defects due to careless and inefficient use of the flaying knife. Cuts, holes and scores produced through faulty flaying greatly diminish the value of skins. Use of an improperly pointed knife adds to the problem. Flaying on the floor causes more cuts and delays in flaying which makes the carcass cold and more difficult to flay. Other defects are due to unnecessary use of a knife, insecure position of the carcass, bad lighting, and lack of skill. Using a fist wherever possible will improve the quality. If the ripping line is not properly cut, the final shape will not be symmetrical and may affect the usefulness of the skin for commercial production of quality leather, ultimately affecting the value of the leather itself. Improper fleshing allows fatty tissues to remain on the skin, resulting in poor curing both by salting and air drying. In tanning and finishing, improper curing results in patches of different quality leather during later processing.

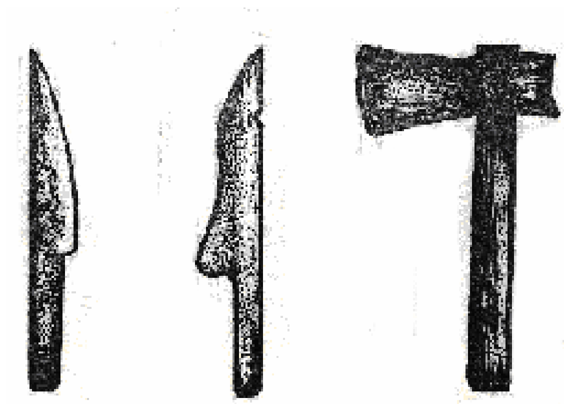


Figure 10.16. Improper knives used in flaying

Hair slip and putrefaction

The main constituent of the skin is protein that is liable to bacterial attack. The first sign of bacterial attack is hair slip, which leads to further putrefaction. If hair slip is not checked in time, putrefaction starts, which can be from both the grain and flesh sides, leading to the decomposition of the grain layer. The degree of attack depends on the temperature and putrefaction level. At a temperature of 10°C, putrefaction will begin in 3–4 days, whereas in a tropical climate of 38°C, putrefaction will begin within 12 hours.

Often, incomplete bleeding allows blood to remain in skin capillaries, along which bacterial attack is most rapid resulting in the destruction of nearby fibers. This will be evident in glazed leather as vein marks.

10.3.5.3. Defects occurring during storage and transport

Storage damage: To produce high quality hides, storage conditions are as important as proper preparation and preservation. In Ethiopia, a good percentage of skins are damaged during storage and transportation, especially during the rainy season. Problems that occur in rural drying sheds are the major source of damage and loss of skins. Rural drying sheds are highly infested with skin damaging insects, have leaky roofs, and do not use slatted platforms. Skins become damaged and many are totally rejected. While the main portion of insect damage happens in rural drying sheds, insect damage also occurs in tanneries and warehouses of large traders.

Take precautions to avoid damages during storage:

- Eliminate existing insects in all skin storage and drying sheds. Storage places and drying sheds should be washed or painted, whichever is possible.
- Repair all leaking roofs of storage and drying sheds.
- Provide protection for cured skins from rain and sun.
- Use slatted platforms or improvise using wooden poles for storing skins.
- Spray or dust dried skins with insecticide having an effective insecticide content of 0.5% BHC.
- Aerate and turn skins frequently to provide adequate ventilation.
- If there is a delay in shipping dried skins, they should be inspected and redusted with insecticide if necessary.

Storage sheds in rural areas may be improved with available materials. It may be possible to utilize available storage facilities of other government agencies or parastatals.

Rubbing damage during transport: Many types of vehicles are used to transport skins from production sites to markets. Skins are often loaded singly on a truck or tied in loose bundles. Any movement that causes surfaces to rub together can cause considerable damage, especially to the grain, folded edges and corners. Rubbing damage caused during normal transportation by road is more or less negligible, but a certain amount of care is required to ensure protection of bales against rubbing and tearing on the outside surface by adequately covering them with hessian or gunny sacks.

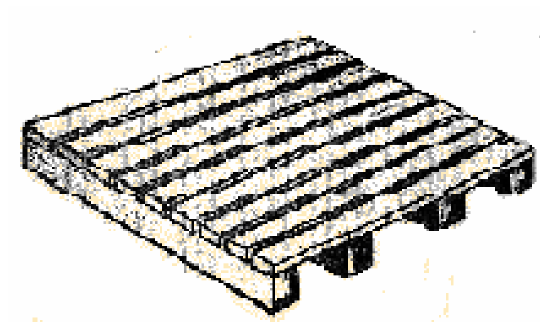


Figure 10.17. A slatted platform.

10.3.6. How to prevent defects

The following defects should be avoided or minimized by taking appropriate measures.

- Diseases: proper, timely treatments, spraying or dipping with required acaricides.
- Timely vaccinations.
- Avoid external injuries to the skin. Take measures to avoid or at least minimize the following damages: brands, yoke and harness scars, scratches, horn rapes, decorations, fighting scars, dung irritations, abscess, vegetation damage (thorns), marks, flay cuts, axe damage, dragging skins, timely preservation, etc. Maintain corrals and housing to prevent scratches and punctures from nails, barbed wire, etc.

10.3.7. General criteria for determining quality of skins

Having a standard system by which the value of a skin can be determined is vital. This is directly related to leather-making characteristics, mainly yield and quality. This standard system is essential both for the seller and buyer in the skin trade. The system is based on various quality grades taking into account all possible defects. The price of a skin depends on its grade and weight range. The principle of grading skins is similar in many countries. The following shows some of the Ethiopian standards related to skins.

10.3.7.1. Grading by appearance (based on defects) ES1201:2005

Skins are graded by their appearance as follows:

- All skin defects are identified.
- Each defect is then assessed according to its importance.
- An assessment is made on the basis of the number of defect units as shown in Table 10.3.
- Each lamb, sheep, kid and goat skin is then graded by its appearance according to the characteristics shown in Tables 10.4 and 10.5.

Table 10.3. Assessment of defect units on skins.

Defects	Defect units allocated on skins
Hand hole, hole(s) caused by beetles, each	2
Weak spot, gash, gouge or channel caused by beetles, each	1
Poor pattern	2
Siding or corduroying, per side	1
Edge soiled with urine or dung	2
Heating or grain damage, per average area of 10 × 15 cm	2
Salt spot, red or purple spots average area of 30 × 30 cm	2

ES: Ethiopian standards, 1201:2005.

Table 10.4. Classification and grading of raw sheep, lamb, and goat skins in relation to defects and useable area.

Grade by defects	Characteristics
Grade 1	No visible defect likely to depreciate the skin appearing beyond 2.5 cm from the edges, useable area of skin from the total area shall be 90–100%.
Grade 2	Defects assessed to a total of 1–3 defect units which are likely to depreciate the skin appearing beyond 2.5 cm from the edges, useable area of the skin from the total area shall be 80–90%.
Grade 3	Defects assessed to a total of 4–8 defect units which are likely to depreciate the skin appearing beyond 2.5 cm from the edges a useable area of the skin from the total shall be 70–80%.
Grade 4	Defects assessed to a total of more than 8 defect units which are likely to depreciate the skin appearing beyond 2.5 cm from the edges an unusable area at the most equal to 50% of the total area.
Rejects	Skins which have more than 50% of the surface unusable.

ES:1201:2005

Table 10.5. Assessment of kid skins in relation to defects and type of hair.

Grade by appearance and hair	Characteristics
Grade 1	Skins with wavy and smooth hair and no visible defects.
Grade 2	Skins with straight and rough hair and no visible defects.
Rejects	Skins with one or more defect units.

ES:1201:2005.

Each pickled skin is graded by its appearance according to the characteristics shown in Table 10.6.

Table 10.6. Classification and grading of pickled sheep skins in relation to defects and useable areas, %.

Grade category	Useable area by %	Description
1	90–100	No defects visible in all quadrants of the pelt which are likely to depreciate the skin appearing beyond 2.5 cm from the edges.
2	75–90	No defects visible in three quadrants; minor defects appearing beyond 2.5 cm from the edges of the pelt which are likely to depreciate the skin.
3	65–75	No defects visible in two quadrants; minor defects appear in the third and fourth quadrant of the pelt which are likely to depreciate the skin.
4	50–65	No defects visible in two quadrants; minor and major defects appear in the third and fourth quadrants of the pelt which are likely to depreciate the skin.
5	25–50	No defects visible in the first quadrant; minor and major defects appear in the rest of the quadrants of the pelt which are likely depreciate the skin.
Reject	Under 25	Major defect visible in all four quadrants of the pelt appearing beyond 2.5 cm from the edges which are likely to depreciate the skin.

ES:1201:2005.

10.3.7.2. Classification by size

Each pickled skin is graded individually into its size category as indicated in Table 10.7.

Sampling, Packing and Labeling

- Sampling lamb, sheep, kid and goatskins are carried out as 100% sampling inspection.
- Lamb, sheep, kid, and goat skins are packed in the form of bundles or bales.
- Each bundle or bale of lamb, sheep, kid, and goat skins should be labeled clearly with the following information:
    - State of skin: a) fresh, b) air dried c) dry salted, pickled, etc.
    - Type and grade of the skins.
    - Size of skins.
    - Any other labeling information required by the purchaser.

Table 10.7. Grading of pickled sheep skin in relation to size.

Classification	Categories by size (square feet)
Extra small	Below 2.5
Small	2.6–3.5
Medium	3.6–4.5
Large	4.6–5.5
Extra large	Above 5.6

ES: 1201:2005.

10.3.8. Standardization and quality control

The principal reasons for heterogeneity of the skins of each of the major domestic species include diversity of breed, age at slaughter, season of kill, standard of animal management, feed supply, flaying methods and equipment, curing method and facilities for storage and transport. In the leather sector, skins must meet standard description and classification, for example, sex, weight, cure and moisture content. Standardization is possible only when standard facilities and equipment are provided and properly organized training and supervision is conducted by qualified personnel at all levels.

One of the important factors in the improvement of skin production as a whole is the system of collection, which is far from efficient or complete. Lack of skin supply is evident almost entirely due to the lack of an effective collection system. A collection system based on incentives to encourage sheep and goat producers to collect and sell skins would result in establishment of its own network of traders in due course after mutual confidence has been established.

Market acceptance of skins is directly related to quality as determined by the criteria previously discussed. In developed countries, descriptive trade standards have evolved and have been codified in many cases and are often supported by national or international specifications. These are sufficiently respected in trade practice, to facilitate matching sellers' offers and buyers' needs. A similar situation exists in some developing countries. But when heterogeneity prevails, as in many developing countries, values are diminished and lower prices are realized. Therefore, as far as marketing is concerned, there is a need for both improvement of quality and of sorting/grading to achieve consistency in the lots offered to local tanners or for export.

As the greater part of the supply of raw stock comes from the rural areas, small farmers or butchers, the functions of grading, sorting and selection must be exercised in the collection centers. The success depends on the size of the collecting agency. Price incentives are built into the system and the number of middle men between the primary producer and the final buyer is determined not by custom but by necessity. The advantage of improving quality or grading of skins is unlikely to be appreciated. Market value would strengthen the bargaining position of the original sellers.

Bargaining position would be the application of quality control, partially by observation, which would define acceptable limits in respect of grading in terms of weight and quality. The application of quality control measurement would be equally important at central collection and at storage sites.

Ethiopian skins have a good reputation in the international leather market for their unique natural qualities of fitness, cleanness, and compactness of texture, thickness, flexibility and strength. The highland sheep skins, known as "Hair Sheep/Selale Sheep," are considered to be the world's finest and have a highly compacted texture. They are excellent raw material for high-quality leather for dresses, gloves, sport gloves and other garments. This unique feature of Ethiopian skins enables them to fetch higher prices in the international leather market.

Goat skins from the highlands are categorized as "Bati-genuine" and those from the lowland as "Bati-type" in the international market. "Bati-genuine" is associated with the highest-quality class goatskins in the world. The particular characteristics of Ethiopian Bati-genuine goat skins are high flexibility and a clean inner surface. They are known world-wide for being excellent raw material for producing high-quality leather.

10.3.9. Marketing of skins

The marketing of skins in Ethiopia starts at the producer/consumer level and passes through a chain of middle men until it reaches the tanneries. The market chain for raw skins consists of the primary producers/consumers, agents of traders, collectors, local tanners, regional medium/small traders, regional big traders and tanneries. The individual consumers who kill animals in their backyards sell the skins either to agents, collectors, or directly to regional small/medium traders. After preservation by air drying or wet salting, the skins are passed on to big traders and then to tanneries. The tanneries and big regional traders can be supplied directly from slaughter premises. The tanneries process the skins received from the supplier either in the green/fresh, air dried or wet salted form to semi-finished stages for both local and export markets.

10.3.9.1. Constraints of skins marketing:

The main constraints adversely affecting the production and marketing of skins are:

- shortage of raw material;
- quality deterioration;
- inadequate numbers of abattoirs and slaughter slabs;
- gap between demand and potential supply; and
- lack of incentive to suppliers motivating them to provide quality raw material.

10.3.9.2. How to get better prices for skins

- Quality is a major problem with a high level of avoidable damage to skins. Improvement of the quality of raw material is vital in expanding trade in the sector. Better-quality skins obtain a better price.
- Price is determined or set by the quality grades of 1–4. Eliminating defects that cause the down-grading and consequent rejection of the raw material will improve price received.

10.4. Manure

10.4.1. Sheep manure composition

The chemical composition of sheep manure is given in Table 10.8.

Table 10.8. Analysis of sheep manure (DM %).

Breed	N	P	K	Na	Ca	Mg
Local	1.87	0.37	1.34	0.017	0.66	0.17
Crosses	1.67	0.37	1.26	0.017	0.72	0.18

10.4.2. The importance and value of sheep manure

The annual collectable sheep manure output of the country is estimated at 1.7 million tons on a dry-weight basis. This corresponds to 31,124 tons of nitrogen and 6,158 tons of phosphorous, equivalent to 556,1279 quintals (q) of urea and 307,914 q diamonium phosphate (DAP). Taking the major nutrients, i.e., nitrogen and phosphorus, the value of sheep manure in the country can be estimated at ETB177.8 million per year (1994 price of 1q DAP equal to ETB 143.35 and 1q urea to ETB 131.15). Had the price of other nutrients available in sheep manure been estimated, the value would have been higher than indicated.

In the highlands, the overall soil fertility is declining and the use of chemical fertilizers is limited. Manure in these areas is normally used as fuel and only rarely as fertilizer. However animal manure, besides containing important nutrients for crops, adds organic material to the soil, which many Ethiopian soils are lacking. Moreover organic fertilizers such as manure do not have side-effects like chemical fertilizers. Therefore, considering the major problems of fertilizer and the rate of manure to sustain crop production, the potential of sheep and goat manure as fertilizer should be exploited. Hence, farmers should be encouraged to use their manures wisely for growing crops. Other fuel sources for areas where there is fuel wood shortage also need to be sought.

Comprehensive studies have not been done on use of manure as fertilizer in Ethiopia. Some studies have shown that goat manure is a highly valued organic fertilizer in the intensively cultivated areas of the eastern Hararghe highlands. Extensive use of goat manure as fertilizer was also reported elsewhere in the intensely populated highlands of the country.

Goat manure as is habitually applied to the soil constitutes a low-cost nutrient source. Its use becomes more relevant to the subsistence producers in view of the increasing prices of inorganic fertilizers following the withdrawal of fertilizer subsidies since the 1980's.

In Ethiopia, the key common inorganic fertilizers are nitrogen and phosphorus. The chemical equivalence of goat manure with inorganic fertilizer can be estimated on these nutrients. The relatively high labor requirements of manure applications are not relevant in the context of the Ethiopian highlands as manure is disposed of habitually in routine barn cleaning and accumulated in small pits near the homestead as compost. In fact, use of goat manure by the small farmer can be considered as having no direct costs. Composted manure is distributed in crop fields soon after ploughing and before final seedbed preparation and seeding. Manure is rarely applied directly to crop fields during the planting seasons. Occasionally, manure is also applied to the roots of perennial crops, for instance, chat (*Catha edulis*).

Manure excreted during grazing is effectively utilized (or not lost) as goats are often grazed around the homestead, crop fields, borderlines and roadsides. Even when goats are allowed to graze freely in the limited communal pasture and wastelands, the manure is beneficial to the whole community. The general tendency that defecation is commonly associated with certain physical activities such getting up after having laid down, walking and particularly watering means that more manure is collected around homesteads, where goats are tethered and supplied with water and supplementary feeds, etc.

10.4.3. Proper manure composting and utilization

10.4.3.1. Manure composting

Composting manure and other farm waste is an easy, inexpensive method of obtaining high-quality fertilizer. In addition to supplying nutrients, incorporating compost into the soil improves soil structure, texture and aeration. Water-holding capacity is also increased. Compost is easy to make and is an excellent method of using and recycling organic waste on the farm. Compost pile ingredients include grass, straw, leaves, manure, coffee grounds, etc. Some leaves, eucalyptus for example, can be toxic to other plants and should be avoided. Kitchen and food waste can be composted but animal fat, meat, bones, etc., should not be used. Important factors of composting include the carbon:nitrogen ratio, moisture, air, and soil.

The ratio of carbon to nitrogen in a compost pile determines the speed with which micro-organisms will be able to decompose the material. The micro-organisms use carbon for energy and nitrogen for protein production. A ratio in the range of 25–30 parts carbon to 1 part nitrogen is optimal for bacteria. Most compost materials, e.g., straw, dry grass, etc., are very high in carbon and low in nitrogen. These materials must be mixed with materials higher in nitrogen, such as manure, green legumes, etc., to obtain a proper ratio. In general, for vegetative materials, mix an equal amount of high carbon to high nitrogen materials for a proper ratio. Manure, because of higher nitrogen content, takes lesser amounts mixed with high carbon materials to reach the proper ratio. As an example of the value of manure, 1 part sheep manure (14:1 C:N) can be mixed with 8 parts wheat straw (53:1 C:N) to obtain a mixture with an acceptable ratio of 26:1. Chopping or shredding materials increases surface area for microbial attack and decomposes easier.

A compost pile must maintain 40–60% moisture for proper decomposition. If the pile is too dry, it will not decompose quickly. If a few drops of water fall from a squeezed handful of the pile material, the moisture content is fine. The pile should be placed so as to drain rainwater to prevent it becoming too wet.

A compost pile needs to be aerated by occasional turning. The micro-organisms doing the decomposition work need oxygen to survive. If the pile becomes too wet or dense, there is little air supply. The pile will not decompose and may produce an offensive odor. Turning the pile, perhaps weekly, will help avoid odors and speed up decomposition.

Soil is used to cover newly placed materials in the pile and as a source of micro-organisms. Ingredients for a compost pile can be layered as they become available, and then a small amount of soil is placed on top to prevent drying out and access to the pile by birds, etc.

As the micro-organisms break down the material, they will generate heat, warming the pile. This is one sign of a properly working compost pile. To check inner temperature, a stick or metal rod can be pushed into the pile. After some time, remove and feel its temperature. The pile temperature should be warmer than the air temperature and can reach up to 50–60°C. This temperature can kill harmful bacteria and weed seeds.

10.4.3.2. Compost use

When the pile has completed composting, the material should have a crumbly, dark brown appearance and a good smell. It is ready for incorporation into soil and to be used as a fertilizer. To improve poor soils, a 4–5 cm layer can be spread on the soil surface and then worked into the upper soil layer.

Table 10.9. Percent nitrogen (N) : carbon (C) ratio and moisture content of common compost ingredients.

Material	% N dry weight	C:N ratio weight to weight	Moisture content % wet weight
Cattle manure	2.4	19	81
Coffee grounds	–	20	–
Corn cobs	0.4–0.8	56–123	9–18
Corn stover	0.6–0.8	60–70	12
Hay, general	0.7–2.0	15–32	
Hay, legume	2.5	15–19	
Horse manure	1.6	30	72
Poultry manure	2.7	14	37
Sheep manure	2.7	16	69
Straw, wheat	0.4	50–125	
Vegetable waste	2.5–4	11–13	

Some common causes for poor composting include the pile becoming too dry, lack of mixing (aeration), or a poor C:N ratio. Checking the moisture content and turning can help revitalize a compost pile. If there is too much carbon in the pile, mixing some additional manure to the existing pile will help. If a pile becomes too wet, it may give off odors and needs to be turned or have dry materials added. This may occur during the rainy season if the pile is not in a well-drained place. A compost pile should not attract flies or rodents but the presence of other types of insects (millipedes, etc.) in the pile is normal. Ants and/or termites can be a problem with compost piles. Keeping compost piles heating properly will help.

10.5. Hair (Rough Wool)

The annual production of hair/wool in Ethiopia is not quantified and documented. Hair/wool can possibly be produced from highland and lowland coarse wool sheep. Among the Ethiopian sheep breeds, only the highland Menz sheep produce wool. Farmers produce up to 1 kg of coarse wool from a Menz sheep annually.

Breed, system of husbandry, and harvest of wool/hair is crucial in the production of quality hair/wool. The amount sheared is determined by breed.

The hair/wool produced can be sold as a raw material to factories, handicraft cooperatives and/or individuals. Locally produced coarse wool could be used to make blankets, carpets and local dress such as *Bernos*.

10.6. Conclusion

- Sheep and goats are largely slaughtered in backyards. This makes it very difficult to produce high quality skins. The scattered and limited number of slaughter premises in the country has aggravated the problem.
- Improper preservation techniques lead to poor quality skin. Better methods are needed to increase the recovery rate of skins.
- Alternative use and sometimes misuse of raw material before reaching the market reduces the number of skins reaching tanneries.
- Strengthening the extension system along a system of quality-based pricing should lead to a better supply.
- There is a need for an appropriate development program to increase the contribution of skin to leather and leather products production. The program should focus on improving the quality and increasing the recovery rate at the central market.

- Milk is an important product from goats, particularly for home use. More attention to research and extension on goat milk is warranted.
- Manure is a valuable commodity for use as a fertilizer. Composting is a beneficial activity to prepare manure and other vegetative waste for use to increase crop production.

Glossary

Abattoir: A slaughterhouse having proper facilities for all aspects of slaughter with the necessary equipment for proper handling of meat, skins and other animal by-products in an appropriate manner.

Corium: One of three parts of the dermis.

Correct pattern: A standard pattern for a flayed skin when laid out flat, which is adopted by the trade, and which enables the tanner to cut maximum area of good leather from a hide/skin.

Curing: The treatment of skins with common salt or by air drying to prevent putrefaction.

Defatting: The removal of unwanted fatty (adipose) tissue from the flesh side of a fresh skin during fleshing.

Dermis: The layer of skin under the epidermis consisting of the grain, corium, and junction.

Epidermis: The superficial, cellular structure covering the grain layer of a skin.

Flay cuts: Damage caused by careless use of a knife during flaying, sometimes cutting through the skin.

Flaying (skinning): The removal of a skin from a carcass.

Flaying knife: The knife used to sever the subcutaneous tissues when removing the skin from the carcass.

Flesh side: The inner side of a skin next to the body of an animal in life.

Fleshing: The removal of the residual connective and adipose tissues from the flesh side of a skin after flaying.

Fresh (grain, raw) skin: A skin which has received no treatment.

Gouges: Knife damage to the skin during flaying, taking out scooped portions of the corium.

Grain layer: The top portion of the dermis.

Hair slip: Loosening of the hair within the follicles of the skin, an indicator of putrefaction.

Off-take: The proportion of a herd killed, on average, during a given period, e.g., off-take in developed countries may be up to 35% but is frequently not higher than 10–15% in many developing countries.

Pattern: The pattern of skin when laid out flat.

Pelt: Skin from which hair or wool has been removed, may be limed, bated, pickled or tanned.

Pickling: Process involving the saturation of dehaired skins with a dilute acid solution and a strong solution of common salt, either as an end itself or as a preliminary stage before chrome tanning.

Poor pattern: The pattern of a skin, on being laid out, does not conform to the standard or correct pattern adopted by the trade, more simply, it is asymmetric and parts of it are displaced from the accepted position. The fiber structure is abnormal in the part transposed by the asymmetric cutting.

Putrefaction: Bacterial and enzymatic breakdown, rotting.

Ripping: Opening of a skin on a carcass, following an accepted pattern of cutting, before flaying.

Ripping knife: Knife designed to make the opening cuts on a skin before flaying. It can also be used for slaughtering, bleeding and other operations. N.B: Is similar to a flaying knife but has a straighter cutting edge.

Salt stains: Indelible stains on the grain surface or deeper, caused by negligent curing.

Scores: Knife damage to skins during flaying by cuts that do not fully penetrate through the skin.

Shank: The portion of a skin which covers the leg of an animal.

Trimming: Removal of unwanted portion of a skin.

References

Ahmed Mohammed. 2000. Ethiopian hides and skins. Proceedings of a Conference Held at Debub University, Awassa Ethiopia, 10–12 November 2000, pp.133–137.

Amha Sebsibe. 1995. Manure of sheep and goats. Proceedings of the Third National Conference of the Ethiopian Society of Animal Production, 27–29 April 1995, Addis Ababa, Ethiopia.

Devasy, T.D. and Getachew Argaw. 1989. Hides and Skins Improvement Handbook. MOA/FAO.

Elliot, R.G.H. 1985. Hides and Skins Improvement in Developing Countries, FAO/Rome.

FAO. Agricultural Development Paper No. 49.

Gatenby, R.M. 2002. The Tropical Agriculturist (sheep), Second Revised Edition.

Institute of Biodiversity Conservation. 2004. The State of Ethiopia's Farm Animal Genetic Resources: Country Report. A Contribution to the First Report on the State of the World's Animal Genetic Resources. IBC, May 2004, Addis Ababa, Ethiopia.

Leach, L. 1995. Hides and Skins for the Tanning Industry. FAO.

Quality and Standards Authority of Ethiopia. 2005. Grading of raw lamb, sheep, kid, goat and pickled sheep skins. Ethiopian standard (ES) 1201–2005.

MANN, I. A Handbook on Nigeria's Hides and Skins.

MOTI/LLPTI. 2004. Concept note on classification and grading of hides and skins, semi-processed and finished leather standardization.

Peacock, C. 1996. Improving Goat Production in the Tropics, A Manual for Development Workers, Farm Africa & Oxfam, UK.

Chapter Eleven

Sheep and Goat Economics of Production and Marketing

Adane Hirpa

Objectives

1. To explain problems related to marketing of sheep and goats and methods to solve marketing problems.
2. To explain the role of cooperatives in solving problems related to marketing of sheep and goats.
3. To explain the role of microfinance institutions in providing financial services to resource poor farmers and pastoralists.

Expected outputs

Users will be able to train farmers and pastoralists to be market-oriented producers, who have some basic knowledge of computation of costs and returns of sheep and goat production and marketing.

11.1. Introduction

Small ruminant production is important due to the fact that sheep and goats are easily managed, require a relatively small initial investment and their short generation interval lends itself to a fast return on investment. In Ethiopia, smallholder farmers raise sheep and goats as a major source of meat and immediate cash income. International demand for sheep and goat meat is increasing. Given the potential of Ethiopia in terms of livestock and geographic location, the small ruminant sector is not making a satisfactory contribution due to market-, breeding-, and management-related problems. Thus, understanding these problems and the socio-economics and marketing of sheep and goats is vital for future improvement of the sector. The material covered in this chapter is designed for sheep producers at various levels of sophistication. It will help inject economic concepts and the idea of market-oriented production, beginning with small-scale farmers and pastoralists. Some information will be especially useful to producers with clear market objectives.

11.2. Sheep and Goat Production as a Business Venture

To obtain the largest possible benefit from a sheep and goat business venture, producers should conduct an enterprise analysis that includes production, marketing and financial analyses.

Production analysis –Related to the analysis of physical performance measures like percent lamb/kid crop, lambs/kids produced per ewe/doe, weight of weaning lambs/kids, feed consumed per head, etc. These have been dealt with in detail in previous chapters. In production analysis, production efficiency is the main goal.

Marketing analysis – Related to the availability of markets for inputs and products, market calendar, market facilities and market information on sheep and goat transactions.

Financial analysis – Deals with the analysis of the profitability of the sheep/goat enterprises.

Most farmers and pastoralists spend much of their time planning production activities. However, marketing plan and financial analyses are also equally important for optimizing income. It is essential that Ethiopian sheep and goat producers become market- and business-oriented.

11.2.1. Production relationships

Profit is the driving force for taking risk in putting time and money into a given business venture. Farmers need to make decisions about allocation of their resources on a day-to-day basis as well as on a long-term basis. This includes decisions related to the whole farm such as what crops to grow, what animals to raise, what production system and inputs to use and how to market products. A farmer or pastoralist has to answer four basic economic questions:

- What should the farm produce?
- How much should be produced?
- How should it be produced?
- How should it be marketed?

Farmers obtain outputs when they use inputs. The farmer decides the amount of inputs he will use to meet his output goals. The amount and quality of the sheep and goat outputs (meat, milk, skin, etc.) are related to the type and amount of inputs (feed, medicaments, etc.). The value of outputs is also linked with the values and costs of other related products.

In real farm situations, farmers do not use levels of inputs that maximize profits, because:

- Their knowledge of the value of resources is imperfect and they are unsure of input/output relations.

- They are faced with risks such as uncertainty in future prices or future yields. Farmers forego future returns to reduce risk.
- They have a shortage of capital to buy the necessary inputs that will maximize profit. In this case, credit is a good method of financing inputs that allow farmers to produce the level of output that maximizes profit.

The farmer will need to know the relative price differences between alternative inputs and the output prices. This will help to decide which combination of inputs to use to produce a certain level of output.

There is also a relationship known as product–product relationship. In this relationship, two outputs are produced when the level of inputs is fixed. The farmer desires to produce an optimal combination of outputs for a number of fixed inputs. The farmer aims to maximize revenue since the cost is fixed.

There are two optima in transforming inputs into output through a production process: the biological optimum and the economic optimum.

Biological optimum is attained when the maximum output level is reached. As an example, if an animal in a fattening operation ceases to increase in weight while still being fed, that is the point of biological optimum.

Economic optimum is reached when, for instance, in the same fattening operation, the additional cost of feeding is equal to the additional return obtained due to the additional feeding. The additional cost is the marginal cost and the additional return is the marginal revenue. In most cases, economic optimum is reached before the biological optimum. Further feeding after the economic optimum will reduce the profit as the additional cost is greater than the additional return. Fattening length (duration) should coincide with the economic optimum to earn the highest possible profit.

11.2.2. Planning and budgeting of sheep and goat production

Sheep and goat production planning is a program outlining all production activities drawn up in advance. Planning here is the process of developing the program.

Sheep and goat production planning includes taking an inventory of resources (feeds, land, labor and capital), devising alternate uses for these resources, estimating costs and returns associated with the alternate uses of these resources, and choosing the best alternative of producing sheep and goats.

Budgeting is the process of estimating costs, returns and net profit of sheep and goat enterprises. A budget is simply the plan translated into monetary form.

Budgets help the farmer or pastoralist to organize financial and physical planning. Sheep and goats can be raised through different alternatives, for example, grazing, stall-feeding, combination of grazing and supplementation, etc. By employing budgeting principles, a farmer or pastoralist can compare costs and benefits of alternative plans of action for a sheep and goat business and use the best alternative.

Costs are the total amount of funds used for the production of sheep and goats. Costs can be categorized as variable and fixed costs.

- ***Variable costs*** are costs incurred directly to the enterprise being budgeted, such as feed, fuel, and hired labor. These costs vary with the level of output. Example, feed costs to produce three sheep are less than feed costs to produce five sheep.

- ***Fixed costs*** are costs that occur whether the enterprise is operated or not, so long as one continues to maintain the farm. Taxes, insurance, interest on capital and depreciation are examples of fixed costs.

Variable costs related to the production of sheep and goats include:

- **Feed costs:** Concentrates, grass and hay, mineral/supplements, grain, water, etc.
- **Other variable costs:** Medicines/vaccines, breeding fees, supplies, marketing, transportation, utilities, labor, stock replacement, etc.

Fixed costs related to the production of sheep and goats include: housing, beginning stock cost, land rent, depreciation, taxes, interest, etc.

Farmers and pastoralists should know the prices of inputs and outputs in order to compute costs and returns. The price of inputs and outputs differ from place to place. While analyzing the profitability of sheep and goats, farmers and pastoralists should use the farm gate price for inputs as well as outputs.

Farm gate price is the monetary value of the item at the production point. For example, the cost of concentrate purchased for Ethiopian Birr (ETB) 25 in town with a transportation cost of ETB 6 is 25 + 6, which is equal to ETB 31 at the farm gate.

The minimum price or the lowest price accepted by a farmer or a pastoralist is the price level which covers the entire cost of production until the sheep and goats are ready to sell. A selling price that is lower than the cost of production means a loss for the business.

The minimum price can be calculated in two ways:

1. The minimum price for the entire farming period, by taking into account the initial capital, fixed costs and the cost of raising the animals.

$$\text{Minimum price per animal} = \frac{\text{initial capital}(Birr) + \text{fixed costs}(Birr) + \text{production cost}(Birr)}{\text{total number of animals for sale}}$$

2. The price for one production process, for instance in the case of fattening, includes all costs from buying the animals to selling them.

$$\text{Minimum price per animal} = \frac{\text{Production cost}(Birr)}{\text{Total number of animals for sale}}$$

There are four main types of budgets available to help farmers or pastoralists in the decision-making process. Each budget is specific in its application, but each uses the same principles. The main budgets are:

- Whole farm or ranch budget
- Enterprise budget
- Partial budget
- Cash flow budget

11.2.2.1. Whole farm or ranch budget

The whole farm or ranch budget is a detailed listing of resources of the entire business along with a plan to use these resources to achieve long-term goals. The whole farm or ranch budget sets the direction the business will take and helps the manager achieve long-term goals.

11.2.2.2. Enterprise budget

The enterprise budget is a physical and financial plan for a specific crop or livestock enterprise. The enterprise budget estimates expenses and receipts for a specified period of time using a specified set of production practices.

A budget is based on a specified set of production assumptions and is designed to cover a stated period of time, frequently one year. It is in reality a projection of what is likely to happen. The budget sets up two basic categories, one of costs and the other of revenues, the difference in which is the projected profit or loss.

In the short run, farmers and pastoralists may go into the sheep and goat business if it pays more than the variable costs. That is, the producer is at least paying part of the fixed costs. It should be obvious that the producer cannot continue to operate in such a fashion forever. The short-run operating decision is based on gross margin (revenues minus variable costs).

The longer-run operating decision is based on an excess of revenues above total costs, both fixed *and* variable, and is called the operating profit or loss. Table 11.1 presents a sample budget, complete with assumptions, revenues, costs, gross margin, and operating profit:

Table 11.1. Meat goats, 50 head unit, costs and returns per buck per year.*

Particulars	Per buck	Per unit
Revenue		
Sale of market animals (150 @ ETB 200)	200.00	30,000.00
Total Revenue	200.00	30,000.00
COSTS		
Variable Costs:		
Concentrate (0.8 kg × 70 days × ETB 1.25/kg)	70.00	10,500.00
Hay (2 kg × 80 days × ETB 200/ton)	32.00	4,800.00
Animal health	3.00	450.00
Salt, minerals	1.00	150.00
Marketing, transportation	5.00	750.00
Supplies	1.00	150.00
Interest on operating money (ETB 16800 × 12% / 3)	4.48	672.00
Overhead (8% × ETB 17472)	9.32	1,397.76
Total Variable Costs	125.80	18,869.75
Fixed Costs		
Land (1 ha × ETB 150)	1.00	150.00
Interest on Capital Expense (11250 × 12%/3)	3.00	450.00
Total Fixed Costs	4.00	600.00
Total Costs	129.80	19,469.75
GROSS MARGIN (Revenue – variable costs)	74.20	11,130.25
PROFIT (LOSS) (Revenue – total costs)	70.20	10,530.25

*Assumptions

50 heads per unit, three fattening periods per year

Selling prices: ETB 200 per goat

Interest rate 12%

Purchase price ETB 75 per buck.

This budget may not look attractive in its present state. To make better sense, it must be applied to an individual farm. And even then, it should be used as a planning tool. That means making adjustments which can improve the bottom line (profit).

The appropriate short term decision is based on gross margin. In the above example, the gross margin of ETB 74.20 per buck is positive. In addition, the ETB 74.20 would be ample to cover fixed costs of ETB 4. We are left with a projected annual profit of ETB 70.20 per buck.

Possibilities for improving the budget include: 1) looking for a better market; 2) Reducing feed costs; and 3) Lowering of marketing and transportation costs. Good managers can find other factors, but these three offer substantial opportunity.

11.2.2.3. Partial budget

Partial budgeting helps the farmer or pastoralist to evaluate the economic effect of minor adjustments in some portion of the sheep and goat business; for example, a change in feeding practice. It is used to evaluate and decide to accept or not accept a new technology or practice. For example, if a producer is not using concentrate supplementation, the decision to use concentrate supplementation will be analyzed by using partial budgeting.

Many changes that do not require a complete reorganization are possible on a farm or ranch. Given a fixed set of resources, the producer can employ these resources in more than one way in response to changes in product price levels, feed costs or carrying capacity. Partial budgets are useful to evaluate changes such as:

- Expanding an enterprise.
- Implementing different production practices.
- Hiring a custom operation rather than purchasing equipment.
- Making a capital improvement.

Partial budgeting is based on the principle that a small change in the organization of a farm or ranch business will have one or more of the following effects:

- Eliminate or reduce some costs (positive economic effect).
- Eliminate or reduce some returns (negative economic effect).
- Cause additional costs to be incurred (negative economic effect).
- Cause additional returns to be received (positive economic effect).

The net effect will be the sum of positive economic effects minus the sum of negative economic effects.

The typical partial budget usually consists of a seven-point plan. The seven components are additional costs, reduced returns, reduced costs, and additional returns, totals of the first two and the second two, and a net difference. Table 11.2 shows the basic form of the typical partial budget.

Table 11.2. Partial budget form.

Column I			Column II		
	Additional cost	______		Additional returns	______
	Reduced returns	______		Reduced costs	______
A.	Total additional costs and reduced returns		B.	Total additional returns and reduced costs	
				Net change in income (B minus A) =	______

Each of the cost and return categories is used to estimate the effects of a proposed change in a business organization.

Column I in Table 11.2 estimates the negative economic effects that result from the proposed change. Additional costs are those that occur if the change takes place. However, this doesn't include costs common to the present and proposed business organization (i.e., any cost that does not change should not be included in the partial budget).

Reduced returns are returns that are not received under the proposed change. The total of additional costs and reduced returns is an estimate of the total negative economic effects of making the proposed change.

Column II in Table 11.2 estimates the positive economic effects of the proposed change. Additional returns are added receipts that are received if the alternative plan is adopted. Reduced costs are those that are no longer incurred if the change in the organization is initiated. Additional returns and reduced costs are totaled at the bottom of Column II.

The difference between positive and negative economic effects is an estimate of the net effect of making the proposed change. A positive net change says it would be economically wise to proceed with the alternate plan. A negative amount implies that it would not be economically profitable to proceed with the change.

The most important step in performing partial budget analysis is the proper identification of data on the costs and benefits associated with the alternative technologies in sheep and goat production.

The following essential data must be collected:

- Quantities of inputs which vary between alternative technologies.
- Prices of these variable inputs.
- Yields or productivity levels resulting from the alternative technologies.
- Prices of the outputs valuing non-market inputs or products opportunity cost (the value of the resource or product in its next best alternative use, e.g., family labor compared to market labor wages).

Important products of sheep and goats include reproductive capacity (offspring), milk yield, meat yield (weight gain), manure, skins and wool.

Inputs depend on the technology being used. Input costs should include cash costs (e.g., feed) and non-cash costs (family labor, capital costs, depreciation costs).

All benefits and costs should be calculated using farm gate prices (the actual price which the farmer pays for the inputs or receives for his products). Input prices should account for all costs. A farmer selling animals will encounter transportation costs, storage charges and marketing costs. If a technology affects the quality of the sheep and goats, market prices should reflect the quality factor.

11.2.2.4. Cash flow statement

A cash flow budget helps establish cash needs of the business over a specified planning period, usually a year. Further, the cash flow budget helps plan repayment of existing loan obligations, determine repayment capacity or ability to repay new operating loans or longer-term loans, and establish the cash feasibility of a major capital purchase.

Sheep and goat enterprises require an initial investment. It may be in the form of breeding stock and will likely include equipment, feed, and supplies.

The money needed to start the venture may come from savings or a loan. Revenues are not expected to begin for a time. This means there may be a period when cash is short, unless the shortfall is properly budgeted.

All expense items create an obligation, usually specific as to time. In other words, farmers and pastoralists know when they will need cash to meet those obligations. They also should know when they will have cash available based on when they have sheep and goats to sell. Almost certainly, the two flows of cash (the inflows and the outflows) will not match. However, if they estimate the cash flows fairly accurately, they can plan for the deficit periods.

A cash flow statement, just like the budget, is also a look into the future. It takes the individual income and expense items and separates them by period, usually by month, but sometimes by quarter. The cash flow statement need not be complicated and is usually fairly subjective.

Looking first at income, when will the kids be ready for market? How many? And what will they be worth? The sale of breeding stock can also be planned. When will they likely be sold? Cull nannies probably will be disposed of after weaning. These items can be totaled for each month.

Moving on to expenses, and beginning with the first item on the list of budget expenditures, when will concentrates be fed? What about hay? The same reasoning can be applied to animal health and labor. Utilities (like telephone service) might reasonably be divided equally throughout the year.

Once the farmers and pastoralists know what the expected income and expense totals are on a monthly basis, they can use this information to keep track of their budget, item by item. As they proceed through the year, they may find that their original budget needs adjustment. At other times, they receive a warning that they are letting certain items get out of hand.

Table 11.3 presents a division of one revenue and four expense categories for the first four months of the year, taken from the budget values shown in Table 1. Note that the percentages allocated for each particular month are also given, so that the cash flow entries can be checked against the totals shown in the budget.

Table 11.3. Cash flow statement form.

Particulars	Months						Total
	Jan	Feb	Mar	Apr	…..	Dec	100%
Revenues							
Sale of market animal							
Costs							
Variable costs							
Concentrate							
Animal health							
Supplies							
Overhead							
Total cost							

Once the monthly figures for each revenue and expense item have been estimated, a cash flow summary can be prepared. Table 11.4 shows the components of a cash flow summary.

Table 11.4. Cash flow summary.

Particulars	Months						Total
	Jan	Feb	Mar	Apr	….	Dec	100%
Beginning Cash Balance							
Add in revenues							
Less expenses							
Surplus/Deficit							

The cash flow summary helps producers deal with their lender. By checking the surplus/deficit line, they can estimate when they will need additional money, or when they are likely to have some to pay back. Just imagine, they go in to their lender and say, "I've been looking at my numbers and it looks like I'm going to be short by about ETB 2,000 in April, but I'll be ahead by around ETB 5,000 by June.”

11.3. Specialization in Sheep and Goat Production

Without market facilities, areas must maintain diversified activities to produce their own food, shelter, tools and other needed goods. In the presence of a market, however, an individual can specialize in one activity and sell the surplus in order to purchase other needed goods.

There are two measures that are commonly used to determine whether an individual or a country is "best" at a particular activity: absolute advantage and comparative advantage. An individual (or country/ region/ locality) possesses an **absolute advantage** in the production of a good if the individual (or country/region/locality) can produce more than other individuals (or country/region/locality) can.

Opportunity cost is the value of the next best alternative. For example, suppose a farmer had a choice of rearing sheep and/or goats, or producing crops. Since she or he chose goat rearing, her or his opportunity cost of rearing goats is the sheep rearing or crop production that can give him or her the highest return. The individual is likely to specialize on the basis of a **comparative advantage** in that activity for which he or she has some special resource or ability and can produce at lowest opportunity cost.

A comparative advantage exists when an individual or country can produce a good, relative to the price of other goods, more cheaply than another individual or country. In livestock production, comparative advantage is often the result of agro-ecological conditions particular to a country, making it suited to certain specialized activities.

The agro-ecological basis for production results in-country comparative advantage, whereby all areas with that common agro-ecological base share the ability to produce the good relatively more cheaply than another area. Ethiopia is a country with diversified agro-ecologies suitable for production of different crops and livestock. These crops and livestock can be found in the range of the agro-ecologies. For example, sheep and goats are found across the range of different agro-ecologies. But, there are differences in the dominance of sheep and goats in these different areas. In pastoral areas, the number of goats is more than double that of sheep. The number of sheep in the highlands is by far greater than the number of goats.

A business person residing in the pastoral area has a comparative advantage of producing goats. He can specialize in goat production and purchase other necessary items such as grain from other producers in the mid-altitude.

Specialization enhances economic growth. If each country specializes in the types of production for which they are best suited, the total amount of goods and services produced in the world economy will increase.

Table 11.5. Production possibilities of wheat and mutton for Country A and Country B.

Proportion (%) of land devoted to:		Production (‘000 t)			
		Country A		Country B	
Wheat	Mutton	Wheat	Mutton	Wheat	Mutton
100	0	90	0	25	0
50	50	45	30	12	25
0	100	0	60	0	50

In this very simplistic example, countries A and B produce both wheat and mutton. The two countries have an equal amount of productive land. Country A, however, has more favorable agro-ecological conditions than B for both mutton and wheat. Table 11.5 shows the relative production potential of both countries for different proportions of land devoted to each product.

The trade-off ratio between wheat and mutton for country A is 3/2 (i.e., 90/60 under complete specialization; 100% of land devoted to each) while for country B it is ½ (i.e., 25/50). The trade-offs for the two countries can be expressed as:

	Wheat	*Mutton*
Country A:	1 t	2/3 t
Country B:	½ t	1 t

Note that country A can produce more of either wheat or mutton than country B. Thus, Country A has an absolute advantage for both wheat and mutton over country B. However, when we consider the trade-off ratios between wheat and mutton for individual countries, we find that to produce 1 t of mutton, country A has to give up the production of 3/2 t of wheat, and Country B only ½ t of wheat. Therefore, Country B has a comparative advantage in the production of mutton and Country A has a comparative advantage in the production of wheat.

The important point is that both countries would benefit if they could trade with each other in the item for which each has a comparative advantage.

If we look at the total production of wheat and mutton in the two countries, we find four possible situations:

	Total production ('1000 t)
1. Countries A and B devote half of their land to each product	45 + 30 + 12 + 25 = 112
2. Both countries specialize in wheat	90 + 25 = 115
3. Both countries specialize in mutton	60 + 50 = 110
4. Country A specializes in wheat and Country B in mutton	90 + 50 = 140

The largest amount of production results from each country specializing in the product for which it has a comparative advantage. Both countries will, however, end up with more of one good than they need and none of the other. So, for the benefits from comparative advantage to be realized, trade must occur.

Specialized activities lead to trade. The gains from trade will be the value of additional production made possible through specialization and trade.

The exact gains from trade will depend on the market prices of the goods with and without trade. This concept applies equally to individuals, who use their comparative advantage to specialize in one task, selling their products to trade for the other goods they need.

You have to advise farmers and pastoralists to produce those commodities in which they have comparative advantage and trade.

Ethiopia, as a country, has comparative advantage in livestock trade due to the relatively huge numbers of exportable surplus livestock resources, proximity to the export markets, presence of substantial demand for livestock and meat in the strategic markets, liberalization of the trade, and government support to the export trade.

11.4. Sheep and Goat Marketing

11.4.1. Market and marketing concepts

Market, in its physical or conceptual term, is a place where exchange takes place. Marketing is the performance of all business activities involved in the flow of goods and services from the point of initial production until they are in the hands of the ultimate consumer.

Marketing involves the transformation of goods in space, time and form from producers to consumers. These transformation processes should be efficient, i.e., accomplished at the lowest possible cost consistent with consumer preferences and incomes.

The marketing system must provide information flows from the consumer back to the producer through the processing, transportation and storage functions. The producer responds to the price signals by producing commodities in relative quantities dedicated by prices and costs. The efficient marketing system responds by providing goods and services over time and space and in the form consumers want at the lowest possible cost.

11.4.2. Types of sheep and goat market

Sheep and goat markets can be classified as primary, distributive and terminal depending on the purpose of animal buyers.

Primary markets are markets in which the majority of the animals are bought for reproduction and resale. Example, markets in remote rural areas.

Distributive markets are markets in which the majority of the animals are bought for resale and consumption. Example, markets in small towns. Figure 11.1 shows the Adillo distributive market in the Southern Region.

Terminal markets are markets in which the majority of the animals are bought for consumption. Example, markets in big towns and cities like Addis Ababa and Nazareth.

Figure 11.1. Adillo sheep market during Ethiopian New Year.

11.4.3. Marketing systems: functions, agents, enterprises and channels

A marketing system is comprised of a number of elements: the particular products (e.g., live sheep and goats) and their characteristics being transferred from producer to consumer; the characteristics of participants (e.g., the producer, the trader, and the consumer); the functions or roles that each participant performs in the market; and the locations, stages, timetable and physical infrastructures involved.

11.4.3.1. Marketing functions

Marketing functions can be classified as follows:

- **Exchange functions** involve finding a buyer or a seller, negotiating price and transferring ownership (but not necessarily physical transfer).
- **Physical functions** enable the actual flow of commodities through space and time from producer to consumer and their transformation to a form desirable to the consumer. They are:
    - assembling;
    - transport and handling;
    - storage;
    - processing and packaging; and
    - grading and standardization.
- **Assembling** or concentrating the product at convenient points allows its economical transport (i.e., getting enough animals together to transport cheaply).
- **Storage** allows the commodity to be held until peak season demand, thereby stabilizing supply.
- **Processing** transforms the commodity into the products desired by the consumers.
- **Grading and standardization** allow the consumer to be more confident of the characteristics of the good being purchased.
- **Facilitation** functions:
    - financing and risk-bearing,
    - market information,
    - demand and supply creation, and
    - market research.

Financing and risk-bearing are two important facilitating functions. The owner of goods at any marketing stage must sacrifice the opportunity to use the working capital needed to buy those goods elsewhere, or the owner must borrow that capital. In either case, capital must be provided by the trader or by some lending source. Regardless, cost is involved. Further, there is an implicit cost in the risk of losing all or part of that capital through theft, spoilage, mortality or changing market conditions. No stage of the market chain could function without the willingness to provide the capital and to bear these costs.

Marketing functions create marketing environment whose elements are as follows:

- Market and facilities — including the entire physical infrastructure upon which a market may depend.
- Market information and intelligence — including informal and formal communication systems and standard weights and grades on which market information depends.
- Institutional environment — including the government policy environment, regulations and supporting legislation.

11.4.3.2. Marketing agents

Marketing agents or participants involved in sheep and goat trades are producers, country buyers, wholesalers, commission agents, brokers, processors and retailers. Country buyers often carry out the initial task of assembling animals from dispersed farms or local rural markets. These buyers may be farmers, shopkeepers, or some cooperative or government buying agency.

- **Wholesalers** transfer goods from producer and country buyers to retailers or other wholesalers.
- **Commission agents** act on behalf of wholesaler for a percentage of the price paid. Although they act in the same way as wholesalers, the risk remains with the owner of the goods.
- **Brokers** offer an intimate knowledge of the market and act to bring buyers and sellers together. They are paid a negotiated price.
- **Processors** transform the animals either partially or completely into the form to be consumed.
- **Retailers** present the animals to the consumer in the manner, location and form desired, e.g., butchering.

11.4.3.3. Marketing enterprises and channels

Enterprises of four types normally fulfill the roles of middlemen. These are:

- Independent, locally-based private enterprises: example LUNA, ELFORA, SAFI and MODJO slaughter houses.
- Cooperatives.
- Marketing boards and other state enterprises.
- Transnational companies — companies operating in countries other than that of their headquarters.

A marketing channel describes the movement of a product or commodity from the site of production to the place of consumption. It may include transportation, handling and storage, ownership transfers, processing, and distribution. Figure 11.2 shows a hypothetical sheep and goat marketing channel. Reduction in a marketing chain enhances the income of the producer by cutting unnecessary market margins received by market agents.

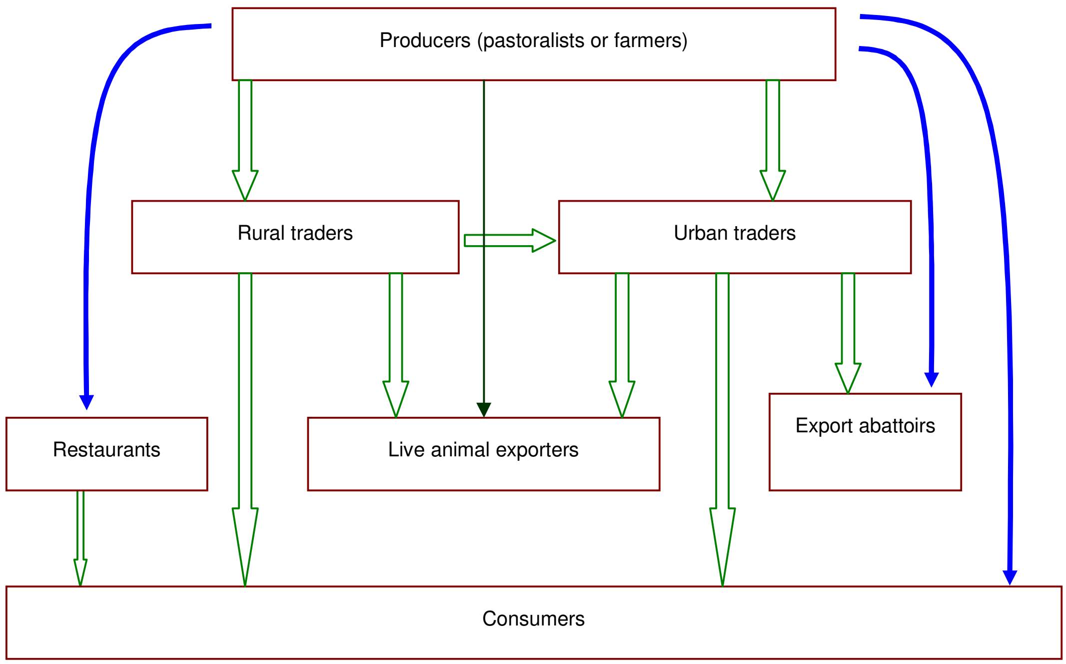


Figure 11.2. A hypothetical sheep and goat market channel.

An example market structure and route of sheep and goats from Bulbula market

Price of sheep and goats at the Bulbula market, East Shoa Zone, depends on age, color, source, sex, and condition of the animal. More goats are supplied to the market than sheep, as male goats 13–30 kg are in demand by abattoirs for export to the Middle East. At the same time, the price of goats is relatively higher than that of sheep. Sheep are supplied from the highlands of Arsi Zone (Assassa). The surrounding farmers also buy more breeding female goats than sheep because they say that goats are better suited to the environmental conditions in the area.

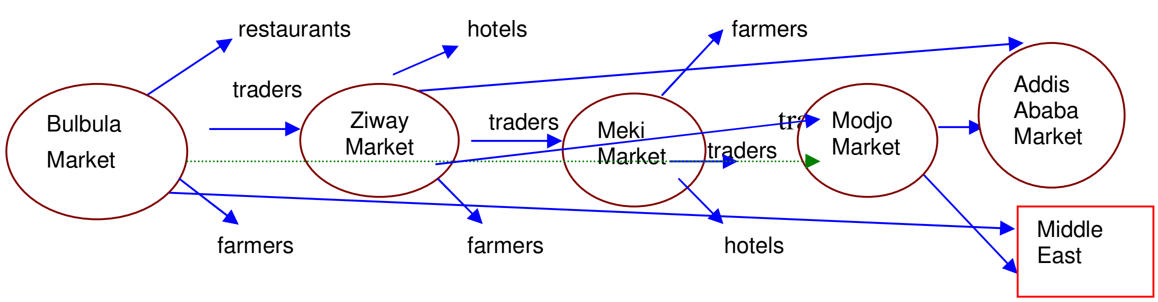


Figure 11.3 Market routes and channels of sheep and goats (Adami Tulu area).

11.4.4. Marketing margin, a measure of market efficiency

A common means of measuring market efficiency is to examine **marketing margins.** This is an attempt to evaluate economic or **price efficiency.**

The overall marketing margin is simply the difference between the farm gate price and the price received for retail sale. That difference can then be considered to be the cost of marketing and all that is entailed in getting the animals from the producer to the consumer in the desired form.

The question to be evaluated is whether the marketing services being provided are "worth" the cost of this margin.

Marketing margins can be calculated for different levels of the market, so that:

$$\textit{Marketing Margin} = P_1 - P_2$$

where, P_1 = the price at one level or stage in the market.
P_2 = the price at another level.

There are several types of marketing margins, based on the market level being considered.

The **wholesale margin** is the difference between the price paid by the wholesale trader (or the processor) and the farm gate or producer price.

The **retail margin** is the difference between the price the retail trader pays and the retail price he charges to consumers.

When the margin is expressed in monetary terms, it is called the price spread. Expressed as a percentage, it is known as the percentage margin.

The mark-up is the price spread between two levels in the market divided by the selling price expressed as a percent.

Example

A rural goat producer sells a 25 kg goat to a trader for ETB 150. The trader sells the goat to a butcher in an urban area for ETB 200. The retailer in turn sells the goat meat to his consumers for ETB 30/kg. If the carcass weighs 50% of the live goat weight and the skin from goat is sold for ETB 10, then:

Retail price	=	[(25 × 50/100) × 30] + 10 = 385
Wholesale margin	=	trader price – producer price
	=	200–150 = 50
Retail margin	=	retail price – trader price
	=	385-200 = 185
Total price spread	=	wholesale margin + retail margin
	=	50 + 185 = 235
Percentage margin	=	wholesale margin / wholesale buying price × 100
	=	(50/150) × 100 = 33%
Retail mark-up	=	retail margin / retail selling price × 100
	=	(185/200) × 100 = 92.5%

In an efficiently operating market, the competitive environment should keep the marketing margin to a minimum. Market prices should then reflect two elements: the actual costs of marketing plus **normal profit margin**. A normal profit is one which provides returns to investment comparable to available rates of interest plus some compensation for the risk borne by the marketer.

At different stages in the marketing system, the “product” (e.g., animal or meat) is sold and bought. Normally, at each successive stage, the price per unit bought or sold is higher and we say that **value has been added.** This refers to the fact that some marketing service has been provided, whether transport, processing or one of the other marketing functions, and the value of that service is now included in the product price (and presumably the desirability of the product has been likewise increased). Again, at each successive stage, it can be split into two categories: the part which is reflected in the real additional costs of adding value and the part which reflects the extra “profit” made.

Some of the additional costs incurred at each marketing stage are obvious; for example, taxes and market fees, transport costs (e.g., hiring a truck or paying trekkers accompanying the goats or sheep), feed purchases for the animals, any interest paid on a loan taken to finance the purchase, and animal upkeep.

Some approaches to estimating market margins

The commonly used approaches to determine marketing margins are to:

- Sample the price of uniform products at each market stage cross-sectionally at one point in time across a variety of market agents.
- Sample prices of uniform products at each market stage through time (time-series), relying on data from a smaller number of sources. This means in different months or years.
- Examine gross receipts and expenses of marketers at each stage, and divide by number of units traded.

11.4.5. Market demand and supply

The price of sheep and goats is determined by the interplay of demand and supply which may vary weekly, seasonally as well as for particular religious festivals and holidays.

Under a given supply situation, prices may vary among sheep and goats within a market day arising from differences in animal characteristics (sex, age, body condition, color, and breed type) and a buyer’s skill, bargaining ability, access to price information and purpose of buying (reproduction, resale or consumption).

11.4.5.1. Demand for sheep and goat

Demand is the quantity of a good that buyers are willing and able to buy at a given price over a time period, other things held constant. Demand describes the behavior of buyers at every possible price and reflects their preferences.

Domestic demand

Because of population growth and recent preference change towards goat meat, the demand for mutton and goat meat is escalating (Table 11.6). Now it is common to find goat meat restaurants in towns and cities.

Table 11.6. Domestic demand forecast – (population figures in tens of millions).

Category	2002	2003	2004	2005	2006	2007
Human population in millions	70	72	73	75	77	79
Local low land consumption:						
Beef ('000)	32200	33120	33580	34500	35420	35340
Mutton ('000)	9800	10080	10220	10500	10780	11060
Goat meat ('000)	9800	10080	10220	10500	10780	11060
Livestock equivalent ('000 heads):						
Cattle	293	301	305	314	322	330
Sheep	980	1008	1022	1050	1078	1106
Goats	1089	1120	1135	1167	1198	1229
Camels	53	54	54	55	55	55
Highland demand for cattle ('000 heads)	92	93	94	95	97	98
Total domestic demand ('000 heads):						
Cattle	385	394	399	409	419	428
Sheep	980	1006	1022	1050	1078	1106
Goats	1089	1120	1135	1167	1198	1229
Camels	53	54	54	55	55	55

Source: Belachew and Jamberu, 2003.

International demand for meat and live animals

Meat

The world meat import stood at 2,759,192 t for the year 2000. Out of this, beef and veal constituted 67% while mutton and goat meat accounted for 31 and 2%, respectively.

The annual meat import by African countries is estimated at 86,043 t with a value of 92 million dollars. The percentage share is 39 and 61% for beef and mutton, respectively.

Bahrain, Egypt, Iran, Jordan, Kuwait, Oman, Qatar, Saudi Arabia, Syria, United Arab Emirates and Yemen together have a total population of 207 million people with annual growth rates of 2.2 percent. Their annual meat demand is estimated at 206,846 t and valued at 399 million dollars. Of this, beef and veal account for 48% while the share of mutton and goat meat is 46 and 6%, respectively.

Live animals

The world demand for live animals stood at 26,477,214 head in the year 2000. Out of this number, cattle accounted for 31.5%, and sheep and goats together for 68%.

African countries imported 3.2 million head of live animals at a value of 480 million dollars in the year 2000. Sheep and goats accounted for 74% of the total. The share of cattle and camels stood at 25 and 1%, respectively.

The Middle East countries have, on average, an annual estimated import of 12 million head of live animals (cattle, sheep, goats and camels). The total import value is estimated at 656 million dollars.

The major import animals are sheep, accounting for 83% of the total, followed by goats (14%). Cattle and camels constitute 3%.

There is a great demand for hides, skin and wool in the marketplace. Ethiopian tanneries, on the other hand, are running at less than full capacity due to poor supply and quality issues. There is a need to improve the hides and skins sector from quality and quantity standpoints. Processors must use techniques that satisfy the international market. Further information can be found in Chapter 10.

11.4.5.2. Supply of sheep and goats

Supply is the relationship that exists between the price of animals and the quantity supplied in a given time period, other things held constant. It is important to distinguish between supply and the quantity supplied. Supply describes the behavior of sellers at every possible price. The quantity supplied is only meaningful in the context of a particular price.

Exportable surplus is annual off-take minus domestic consumption. Table 11.7 shows estimated exportable surplus. From the table, estimates of 1.237 million sheep and 4.287 million goats were available for export in 2007.

Table 11.7. Livestock available for export ('000 heads).

Category	2004	2005	2006	2007
Annual off-take:				
Sheep	2275	2297	2319	2343
Goats	5364	5412	--	5516
Domestic consumption:				
Sheep	1022	1050	1078	1106
Goats	1135	1167	1198	1229
Available for export (surplus):				
Sheep	1253	1247	1241	1237
Goats	4229	4245	4263	4287

Source: Belachew and Jamberu, 2003.

11.4.6. Synchronizing sheep and goat production and sales plans

Most farmers and pastoralists in Ethiopia are not market oriented. They sell sheep and goats when they need money. Especially in pastoral areas, people sell animals during the dry season. At this time, the price is low due to over supply. In the wet season, immediately when the pastoralists get lush pasture for their cattle, they stop supplying sheep and goats to markets. This has created serious problems for export abattoirs in getting the required type and quantity of animals on a regular manner. The pastoralists also do not benefit for they sell their sheep and goats at a time when prices are low due to very high supply of animals.

Planning sales when market prices are high is very important for farmers and pastoralists to earn more money. Abattoirs will also have a steady supply of animals for export. To develop a synchronized production and sales plan, knowledge of "what the buyer wants" is essential. The major buyers are export abattoirs, live animal exporters, restaurants and individual consumers. To develop a synchronized production and sales plan, the producers have to identify the type of meat each group generally likes to consume and when. Other considerations include:

- Sheep or goats, age or weight of animal, restrictions on feeding prior to slaughter, restrictions on slaughter itself (Halal, Kosher), special preparation of carcass (singeing or scalding), preference in coloring of animal (pure white, black, etc.)?
- Are there special times of the year when there will be a greater demand, such as holidays?
- What are the dates of those holidays?
- What type of meat do they want for each holiday?

Then make a table of the information found for goats and another for sheep.

Table 11.8. Goat meat chart.

Group	Time goat is eaten	Description of animal wanted	Live weight	Special slaughter	Special carcass	Special feeding
Eastern Orthodox Christians	Easter Christmas	Unweaned, 4–12 weeks old, plump.	15–20 kg	None	None	All milk
Muslims	Eid al-Adha Festival of Sacrifice	Lean, male or female, yearling "one tooth" (two permanent teeth), unblemished, uncastrated.	25–35 kg	Halal	None	No pork products (lard or bone meal) must not use these within 40 days of slaughter
	Regular eating and some other holidays	Lean, male or female, kid, under a year old (with milk teeth only)	25–35 kg			

Table 11.9. Holiday dates.

Holiday	2008	2009	2010
Eid al-Adha Festival of Sacrifice	December 8	November 28	November 17
Muharramn/ Islamic New Year	January 10	---	December 8
Mawlid al-Nabi Prophet's Birthday	March 20	March 9	February 26
Start of Ramadan/ month of fasting	September 2	August 22	August 11
Eid al-Fitre Festival of Fast Breaking	October 2	September 21	September 10
Passover/Pesach Jewish holiday	April 20-27	April 9-16	March 30-April 6
Rosh Hashanah Jewish holiday	September 30	September 19	September 9
Channukkah Jewish holiday	December 22-29	December 12-19	December 2-9
Western Roman Easter	March 23	April 12	April 4
Eastern Orthodox Easter	April 27	April 19	April 4
Christmas	December 25	December 25	December 25

11.4.7. Marketing facilities and information network

There are many animals that could be sold, but it is difficult to get them to market because of the lack of transportation and the poor condition of roads. Diseases can also spread in the market places resulting in loss of production or sale price.

Many markets have no scales. It is difficult to assess the value of animals and set prices without knowing the weight. Farmers can use a tape measurement to determine the weight of their animals before they go to market as described in the Management chapter.

Farmers can also determine the meat value of their animals through simple body condition scoring techniques. These techniques can be learned quickly and easily and will enable the farmer to argue for better prices.

Because of the lack of information on prices, farmers may not receive a price that reflects the true value of the animals. Farmers often do not know what prices are being paid in other markets, which puts them at a disadvantage with traders.

In many countries, the government lists livestock prices on the radio and in newspapers daily so that current prices are known. This prevents dishonesty. In areas without electricity, some towns buy a hand crank or battery-powered radio, assigning a person to listen to the livestock reports. Farmers then check for these prices before going to market, so they know the going rates for sheep and goats.

If farmers know the weight and condition of their animals, and they know the market price, they have bargaining power. If a single farmer cannot get higher prices from traders, then farmers have the option of forming a cooperative and bargaining as a group.

11.4.8. Contractual arrangements in sheep and goat production and marketing

A contract is an agreement between two or more parties to carry out obligations agreed on by all parties. There are two types of contracts: informal and formal contracts. An informal contract is a contract made between two or more parties without the involvement of a legal entity. This is typically a verbal contract. A formal contract is a written contract agreed on and signed by all parties with the involvement of a legal entity.

Farmers and pastoralists can sign contracts with processors and traders to increase production and also to avoid marketing risks. Written contracts should clearly indicate the responsibility of the sellers and buyers so that both will be protected from loss. The contract should address the responsibilities of all parties and state the penalties levied for breaking the contract.

Transferable Messages

1. As a development agent, you can assist farmers and pastoralists in developing contracts with traders and processors that clearly lists the responsibilities of each party.
2. You also have to assist farmers in producing higher quality animals to increase profits for themselves and for the exporter for the coexistence and further development of the business.

11.5. Introduction to Cooperatives

11.5.1. Cooperatives — definition, values and principles

A cooperative is an autonomous association of persons united voluntarily to meet their common economic, social and cultural needs and aspirations through a jointly owned and democratically controlled enterprise. Cooperatives are based on the values of self-help, self-responsibility, democracy, equality, equity and solidarity. In the tradition of their founders, cooperative members believe in the ethical values of honesty, openness, social responsibility and caring for others.

There are seven principles or guidelines by which cooperatives put their values into practice. These are:

1. ***Voluntary and Open Membership:*** Cooperatives are voluntary organizations, open to all persons able to use their services and willing to accept the responsibilities of membership, without gender, social, racial, political or religious discrimination.

2. ***Democratic Member Control:*** Cooperatives are democratic organizations controlled by their members, who actively participate in setting their policies and making decisions. Men and women serving as elected representatives are accountable to the membership. In primary cooperatives, members have equal voting rights (one member, one vote) and cooperatives at other levels are also organized in a democratic manner.

3. ***Member Economic Participation:*** Members contribute equitably to, and democratically control, the capital of their cooperative. At least part of that capital is usually the common property of the cooperative. Members usually receive limited compensation, if any, on capital subscribed as a condition of membership. Members allocate surpluses for any or all of the following purposes: developing their cooperative, possibly by setting up reserves, part of which at least would be indivisible; benefiting members in proportion to their transactions with the cooperative; and supporting other activities approved by the membership.

4. ***Autonomy and Independence:*** Cooperatives are autonomous, self-help organizations controlled by their members. If they enter into agreements with other organizations, including governments, or raise capital from external sources, they do so on terms that ensure democratic control by their members and maintain their cooperative autonomy.

5. ***Education, Training and Information:*** Cooperatives provide education and training to their members, elected representatives, managers and employees so they can effectively contribute to the development of their cooperatives. They inform the general public — particularly young people and opinion leaders — about the nature and benefits of cooperation.

6. ***Cooperation among Cooperatives:*** Cooperatives serve their members most effectively and strengthen the cooperative movement by working together through local, national, and international structures.

7. ***Concern for Community:*** Cooperatives work for the sustainable development of their communities through policies approved by their members.

11.5.2. Agricultural marketing cooperatives

Cooperatives can be classified as agricultural and non-agricultural. Non-agricultural cooperatives can be further classified as industrial, housing, saving and credit, and consumers' cooperatives. Agricultural cooperatives can be classified as agricultural marketing cooperatives, agricultural saving and credit cooperatives.

Objectives of marketing cooperatives

The objectives of marketing cooperatives are to:
- reduce the number of middlemen;
- enhance bargaining power;
- provide market information; and
- provide storage facilities, e.g., a temporary holding center for sheep and goats.

Importance of agricultural cooperatives

- Agricultural cooperatives play great roles in agricultural development by improving production and marketing of agricultural inputs and products. They reduce production, marketing and processing costs by way of providing farm inputs, transportation facilities and processing plants at reasonable prices.

- Dividend payment: from the total profit of the society, a payment, or dividend, is distributed to members based on participation.
- Improved services: cooperatives may provide financial, postal, telephone and electricity services to members.
- More market power due to greater size, brand identification, quality control, etc.
- Assured source of supply: reduced dependence on external sources and guaranteed supply of inputs.
- Provide education, training, and information to members, board directors, cooperative officials and managers.
- Contribute to national capital formation through mobilizing resources and savings.
- Extend democratic principles as all members have equal rights in decision making.

11.5.3. Cooperative structure

There are three cooperative structures.

- Primary cooperative societies:
  - Formed at village or *kebele* levels.
  - Only individual membership is allowed.
  - Market members' products, supply farm inputs at reasonable costs, and provide members with financial services.
- Center or district cooperative societies:
  - Operate in a district or cover a wide area in a district.
  - Also called unions.
  - Engage in buying and selling of agricultural products and extending credit facilities to primary cooperatives.
- Regional cooperative societies:
  - Apex level cooperatives which serve the state as a whole.
  - Both primary and union cooperatives are members of these cooperatives.
  - Basic functions include interstate trade, import–export, procurement and distribution of inputs and consumer goods, dissemination of market information and granting of credit facilities, etc.

Cooperatives have the potential to improve marketing efficiency. They can reduce marketing costs. For example, a village livestock marketing cooperative could coordinate the production schedules of small farmers so that sufficient animals reach market age at the same time allowing truck transport to markets that would lower per unit transport costs.

Cooperatives can also be used to counteract imperfect competition among buyers by creating greater bargaining power among producers. Typically, they are used to distribute credit or subsidized inputs.

In order to be successful in the long run, a cooperative must be able to carry out marketing functions with lower cost or effort than other available alternatives. If this ability is not perceived by members, cooperatives are likely to break down. The ownership of cooperatives, by definition, lies in the hands of those who use its services (and who are thus entitled to any profits).

Farmers in a cooperative have the possibility to sell directly to brokers by pooling animal numbers. Groups of animals could also be sold directly to retailers (grocery stores).

One or two people act as market coordinators, negotiate the price with the broker, let the others know what type of animal the broker wants, and set a final date for the roundup of animals. Everyone brings their animals. The animals are then weighed, transported and delivered as one group.

Many farmers do not have a way to get their animals to market. If they form a co-op, they can through time buy trucks together and ship their animals as a group. They can pay for the truck by hauling goods/products of other people and charging transportation fees. Someone has to be a driver and someone has to organize and pay the bills.

11.6. Credit Facilities

- Finance is the life blood of any business.
- There are two major sources of finance: savings and credit.
- Savings can play a minimal role as the majority of our farmers and pastoralists are capital-starved due to the vicious circle of poverty (Figure 11.4).

Credit may play a major role in financing crop and livestock production activities. There are three financial institutions in Ethiopia providing financial services to the public: conventional financial institutions, non-conventional formal financial institutions, and informal financial institutions.

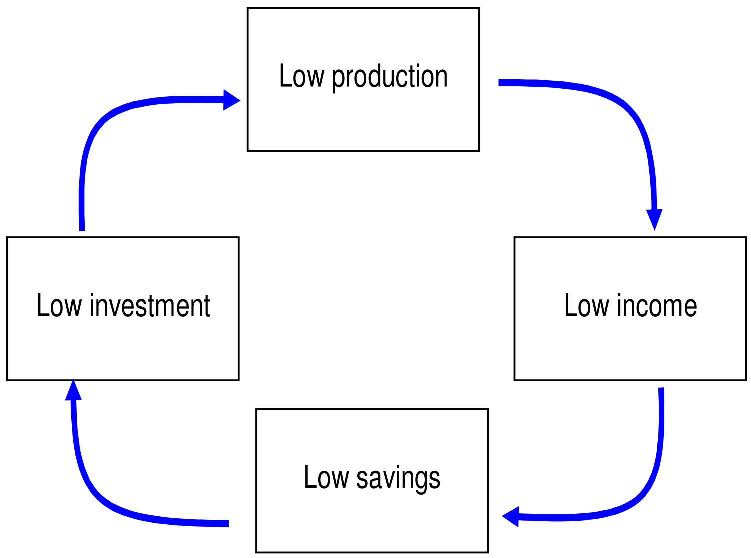


Figure 11.4. Vicious circle of poverty.

11.6.1 Conventional financial institutions

These are the National Bank of Ethiopia (NBE), the Commercial Bank of Ethiopia (CBE), the Development Bank of Ethiopia (DBE), the Construction and Business Bank (CBB), and private banks (example, Dashen, Nib). These banks are operating in urban areas and require collateral to advance loans. Thus, they are less important for smallholder farmers and pastoralists.

11.6.2. Informal financial institutions

Informal finance sources are commonly credit given by relatives and friends, traders, neighbors, local moneylenders and indigenous rotating savings groups. The most noticeable rotating savings groups are *Iqqub, Iddir*, and *Mahiber*.

Informal sources of credit appear to have considerable appeal to rural communities because of their characteristics such as accessibility, speed of transaction, small loan size, availability of loans for consumption, minimal and flexible collateral requirements, flexible repayment arrangements, privacy of information, freedom of utilization of borrowed money, i.e., absence of control and restrictions on the use of the loan.

Local money lenders are the most important rural financial markets. They charge interest ranging between 50 and 120%. Loans obtained from friends and relatives are generally interest-free. Traders provide loans on the basis of commission or profit share.

11.6.3. Non-conventional formal financial institutions

These are institutions giving microfinance to the disadvantaged poor through loans, savings, and other basic financial services. Most microfinance institutions are non-governmental organizations committed to assisting some sectors of the low-income population. Other microfinance institutions are credit unions, cooperatives, government owned projects and programs. There are about 27 microfinance institutions registered under the National Bank of Ethiopia delivering financial services to over 1.7 million clients.

Credit enables the poor to use their human and productive capital more profitably and to build up their asset base. In addition to credit, savings and insurance services are used by the poor to plan for future lump-sum needs and to reduce their exposure to income changes or unforeseen expenses. Saving services are available through some informal relationships, such as rotating savings, credit associations and mutual insurances, which have the tendency to be erratic and insecure.

Microfinance institutions are very good alternatives since they provide financial services at a reasonable cost without demanding collateral from the borrower's side.

To benefit from micro-credit, a pre-existing level of ongoing economic activity, entrepreneurial capacity and managerial talent is needed, i.e., microfinance is designed to benefit the economically active or able poor.

Additionally, the client that may benefit from credit is the one who:

- is healthy;
- has skill;
- is confident and has a minimal financial base;
- can undertake different activities;
- is honest, has integrity and is prompt;
- is stable, has a low degree of mobility; and
- has client discipline.

Client discipline means that poor people take responsibility for their decisions, agreeing to and making on-time payments of their principal and an amount of interest that will cover the full cost of the service.

Timeliness, cost (interest rate) and accessibility are the major issues to be considered when selecting one or a mix of institutions for credit service.

11.7. Sheep and Goat Business Plan

- A business plan is a document that clearly and concisely defines the goals and objectives of a business, outlining the methods for achieving them.
- The business plan is the most essential document involved when starting, building and managing a successful business and it is an effective tool for raising the necessary capital as well as capturing the interest of investors. Many businesses fail due to lack of planning and preparation.
- The two business plan guidelines developed by Business Development Service of Ethiopia are: Business Plan 1 (for micro- and small enterprises) and Business Plan 2 (medium-sized enterprises).
- Business Plan 1 describes the type of business, how and where it functions, and all financial and managerial aspects. The business format includes the following basic components:

- personal data;
- work premises at the disposal of the operator;
- yearly sales plan;
- equipment owned and to be purchased;
- yearly raw material requirements;
- yearly operating expenses;
- yearly production/service plan; and
- yearly profit and loss statements.

- Business plan outline for micro-enterprises — Ethiopian application

Business plan

1. Full name of the business operator: ....

2. Address:
   Woreda .... Town ....
   Kebele .... House No. ....

3. Type of the plan/work/business in which the operator is/to be engaged:
   ....

4. Year of the plan: from .... to ....

5. Work premises at the disposal of the operator:
....
....

Specify, if there is any problem:
....
....

6. Yearly sales plan:

Ser. No.	Product/service to be sold, marketed/year	Unit	Quantity	Unit price	Total price	Remark
	Total sales					

Months during which sales are expected to be high:
....
....

7. Equipment currently owned by the operator:

Ser. No.	Type of equipment	Unit of measure	Quantity	Unit cost	Total cost	Remark
	Total cost of equipment					

8. Equipment to be purchased by the operator:

Ser. No.	Type of equipment	Unit of measure	Quantity	Unit cost	Total cost	Remark
	Total cost of equipment					

9. Yearly raw material requirement:

Ser. No.	Type of raw material	Unit	Quantity	Unit price	Total price	Remark
	Total yearly raw material cost					

Source of raw material ....

10. Other yearly operating expenses (e.g., labor costs, sales expenses, depreciation, taxes, etc.):

Ser. No.	Types of expense	Amount of expense in Birr	Remark
	Total expense		

11. Yearly production/service plan:

Ser. No.	Types of production/ service to be produced or rendered	Unit	Quantity	Unit cost	Total cost	Remark
	Total cost					

12. Financial plan:

Capital requirements	Equity	Loan	Total
Investment capital:			
1. Machinery + equipment 2. Furniture + fixture 3. Business premises 4. Any other initial and significant outlay			
Working capital:			
1. Salary/wage 2. Raw material and/or supplies 3. Rent 4. Maintenance 5. Business promotion 6. Other cash out of the business to meet short-term and recurrent expenditure			
Total:			

13. Yearly profit and loss plan:

Profit + Loss Statement Format:

	Particular (in Birr)	Amount (in Birr)
I	*Receipts*	
II	*Expenses*	
	Operating expenses of costs	
	Total operating expenses	
Fixed expenses or costs		
	Total fixed costs	
III	*Net cash income*	
IV	*Net operating income*	
V	*Net farm income*	

Transferable Message

1. As an extension agent, you can play an important role by advising farmers and pastoralists. You can change the current practice of selling a few small ruminants in times of need, into planned, long-term marketing of livestock to increase farm income and enhance family and community financial security.
2. Sharing information, including financial information, is a good way to learn. You can provide market training programs for farmers and traders to teach them what laws and regulations apply to marketing.
3. You can train farmers and pastoralists to analyze and respond to market demands such as knowing the animal size, weight and quality preferences of their customers.
4. You can train farmers and pastoralists to read and to do simple mathematics through informal, adult education.
5. You can train a few people from each cooperative on how to do basic accounting so they can apply for and repay loans.
6. You can provide training in running a small business.

Exercises

1. What is a sheep and goat enterprise analysis?
2. How can you help a farmer or pastoralist conduct a profitability analysis of sheep and goat raising as a business venture?
3. What is specialization? How can you advise farmers or pastoralists to specialize in sheep and goat production?
4. What is marketing? How intense is the problem of sheep and goat marketing in your area?
5. How can cooperatives solve sheep and goat marketing problems in your area?
6. Is cash constraining farmers and pastoralists in you area? What sources of credit are available in the area?
7. Is there a microfinance institution in the vicinity? Do people take loans for sheep and goat production?

Glossary

Average daily gain: Kilo of live weight gained per day.

Budget: An estimate of the receipts and expenses of a proposed plan.

Capital: The livestock, dead stock (buildings, machinery, stored products, etc.) and money necessary for carrying on a business.

Cost of gain: Total of all costs divided by the total weight gained.

Depreciation: The loss in value of capital items due to age and wear and tear.

Enterprise: A section or department of a farm.

Fixed costs: Costs which do not vary with the size of an enterprise and cannot be avoided by discontinuing production.

Gross margin: The difference between the value of total production and variable costs.

Interest: A payment made in return for the use of borrowed capital.

Man-day: The work of one person for one day.

Man-hour: The work of one person for one hour.

Market price: Local sale value.

Mortgage: A loan obtained by offering land or buildings as security.

Opportunity cost: The value of the return which would have been obtained if a productive resource had been employed in the best alternative way.

Profit: The gain from a business activity. The excess of total production over cost.

Valuation: A statement of the value of capital on a farm.

Variable costs: Costs which vary with the size of enterprise and can be avoided by discontinuing production.

References

Ahmed, A. 2003. Microfinance and pastoralism. Proceedings of the Third National Conference on Pastoral Development in Ethiopia. Pastoralism and Sustainable Economic Development, 23–24 December 2003, Addis Ababa, Ethiopia.

Solomon Desta, Getachew Gebru, Solomon Tezera and Coppock, D.L. 2003. Linking Small Ruminants with Markets: A case study from Southern Ethiopian Rangelands.

Belachew Hurrissa and Jemberu Eshetu. 2003. Challenges and opportunities of livestock marketing in Ethiopia. Yilma Jobre and Getachew Gebru (eds). Challenges and Opportunities of Livestock Marketing in Ethiopia. Proceedings of the 10th Annual Conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, August 22–24, 2002. ESAP, 2003. Addis Ababa, Ethiopia. pp 1–13.

Ibrahim, H. 1998. Small ruminant production techniques. ILRI Manual 3. ILRI (International Livestock Research Institute), Nairobi, Kenya.

Andargachew Kebede. 1990. Sheep marketing in the central highland of Ethiopia. MSc Thesis, Alemaya University of Agriculture School of Graduate Studies, July 1990, Dire Dawa, Ethiopia.

Merkel, R.C. and Subandriyo. (eds.). 1997. Sheep and Goat Production Handbook for Southeast Asia. viii 214+ pp.

Sahs, R. and Doye, D. 2007. Goat farm budgeting. In: T.A. Gipson, R.C, Merkel, K.A. Williams, and T. Sahlu (eds.). Meat Goat Production Handbook. Langston University. pp. 327–334.

Simon, M. 2007. Farm business planning. In: T.A. Gipson, R.C, Merkel, K.A. Williams, and T. Sahlu (eds.). Meat Goat Production Handbook. Langston University. pp. 313–326.

CHAPTER TWELVE

Sheep and Goat Meat Characteristics and Quality

Amha Sebsibe

Objectives

1. To describe meat quality related problems affecting the market.
2. To highlight strategies for improving small ruminant meat yield and quality.

Expected outputs

1. Knowledge of meat quality related problems shared to stakeholders (extension workers, producers, processors, etc.).
2. Increased awareness on methods of improving meat yield and quality.

12.1. Introduction

Ethiopia is home to 24 million sheep and 23 million goats, and meat production is the most important function of these animals in the country. There is high demand for live animals as well as meat from small ruminants by consumers in the Middle East and North and West African countries. There is also a high domestic demand for small ruminant meat, particularly during religious festivals. The country exported 12,000 tons of small ruminant meat in 2005/6. The goal for ruminant meat export in 2008 is 30,000 tons, of which 33% is expected to be from small ruminants.

The proximity of Ethiopia to consumers in Middle Eastern countries and their taste preference for our indigenous animals are advantageous for the Ethiopian meat export market. However, the international market for meat is becoming increasingly competitive and meat traders must adopt improved practices in production, processing and packaging of meat to maintain and grow market share. Strict quality control measures to meet specific export-market demands also need to be implemented. Hence, considerable training and extension will be essential in assisting various stakeholders to meet market requirements and maximize the foreign exchange generated from the growing meat industry.

12.2. Meat Production and Carcass Composition

12.2.1. Meat production

The annual national mutton and goat meat production is 77 and 62 thousand metric tons, respectively, largely because of the high average off-take rates estimated to be about 30% from sheep and 36% from goats. Sheep and goats, respectively, contribute some 21 and 16.8% of the total ruminant livestock meat output.

While contributing significantly to meat production in Ethiopia, present production levels of sheep and goats are far below their potential. Productivity per animal is reported to be very low. Annual meat production is estimated at 3–3.5 kg per animal per year in the population and 8–10 kg per animal slaughtered. These values are very low when compared with those in neighboring countries that have small ruminant populations 50–75% less than Ethiopia. A major cause contributing to such low meat yield is that animals are commonly slaughtered at immature body weights, 18–20 kg for sheep and 16–18 kg for goats.

Performance of some indigenous small ruminant breeds

Wide variability exists among Ethiopian small ruminant breeds with respect to potential growth rates and mature weight. Further, most Ethiopian breeds have undergone little selection for improved meat production and true breed potentials are not known. Horro rams have shown capability for post-weaning growth rates of approximately 150 g/day, which would enable them to reach a mature body weight of 45–50 kg at one year of age. Afar rams attain average mature bodyweights of approximately 40 kg, but post-weaning growth rates have been reported to be less than 100 g/day with supplementary feeding. The maximum post-weaning growth rate of Menz (small-sized breed) ram lambs under improved on-station management appears to be less than 100 g/day. The Awassi × Menz crossbred ram, however, was 40% heavier in yearling bodyweight under supplementary feeding than purebred Menz. Middle Rift Valley goats grazing natural pastures and supplemented with a concentrate had an average growth rate of 72 g/day. The growth rates indicated are unlikely to be achieved under natural grazing systems, and animals usually take extended periods of time to reach marketable weight. However, if properly fed, most Ethiopian small ruminant breeds could meet the current live weight requirement of some export markets in the Middle East.

Meat consumption

The domestic meat demand is believed to increase with increasing literacy and family income. Meat consumption is often an indicator of the economic status of a country or an individual. People with a higher social or economic status demand a greater amount of high-quality meat products. The per capita consumption of meat in developed/industrialized countries is much higher compared with developing countries. Countries whose population consumes the least amount of meat are located in Africa and Asia. The ten lowest-ranking countries in meat consumption consume 3–5 kg per capita per year. In Ethiopia, the average annual meat consumption per capita is estimated to be 8 kg/year. Consumption of meat in the USA is 124 kg per capita per year (340 g/day). The global average meat consumption is 38 kg (104 g/day).

12.2.2. Carcass composition

A carcass is made up of various proportions of muscle, bone and fat. The ideal carcass can be described as one that has a minimum amount of bone, a maximum amount of muscle and an optimum amount of fat. Market requirements differ in size of carcass and level of fatness acceptable. A certain proportion of fat is desirable to reduce drying out of the carcass. On the other hand, too much fat is undesirable.

Muscle: Water makes up 74% of the total muscle weight. The remainder of the muscle is protein, lipid, minerals and some vitamins.

Bone: Bone provides the rigid support to which the muscles are attached. The hard, calcified cells give bone the strength needed to support the weight of the animal.

Fat: Fat is basically a food or energy reserve for the animal and is laid down in special cells in various sites of the body. The various fat depots found on a carcass are subcutaneous, intermuscular, intramuscular and miscellaneous. Subcutaneous fat is the fat immediately under the skin and lies on the outside surface of the carcass. Subcutaneous fat minimizes drying out of the underlying meat. Since fat has low water content, it is unsuitable as an environment for microorganisms to grow and effectively acts as a protective layer around the meat. Intermuscular fat lies in pockets between the muscle, frequently surrounding blood vessels and nerves, serving a protective, cushioning role. Intramuscular fat lies within the muscle between the bundles of muscle fibers and its content can vary from 1–15% of total muscle weight, depending upon the level of fatness. A high content of intramuscular fat is known as marbling, a common feature in feedlot and heavy-weight cattle, but seldom seen in sheep or goats. The miscellaneous fat depots include kidney, scrotal and gut fats.

Major factors affecting carcass composition

Weight: Carcass weight is a main factor affecting the composition of the carcass and is closely related to age at slaughter. As animals mature, they normally gain weight resulting in a heavier carcass. Much of the weight gain of a mature animal is fat rather than muscle. Thus, at heavier live weight, an animal’s carcass will have lower proportions of muscle and bone and a higher proportion of fat.

Age: Increases in age, independent of changes in weight, tend to have little influence on the carcass composition of sheep. Normally, as animals age they gain weight that is largely made up of fat. It is this increase in weight that results in an increase in fatness.

Sex: At all weights, females tend to be fatter than ram lambs under similar management.

Breed: Some breeds mature earlier than others and the main breed differences in carcass composition are related to the rate of fat deposition during the later stages of growth. To achieve a similar level of fatness with breeds of different maturity types, it is necessary to market earlier maturing lambs at lighter weights than later maturing lambs.

Conformation: The conformation of a carcass refers to its shape. Carcasses that are short in the leg and plump or ‘blocky’ in appearance are said to have ‘good’ conformation. Carcasses with a longer ‘leggy’ appearance are said to be of ‘poor’ conformation. Carcasses having good conformation generally contain more fat and less protein than those of poor conformation.

Nutrition: The effect of nutrition on carcass composition is not a simple one as it involves the interactions among level of intake, the composition of the feed, and nutrient needs of the animal. As more food energy is required to produce a kilogram of fat than a kilogram of muscle, one has to be conscious of the type of market targeted during the feeding operation.

Transferable Message

The characteristics of a superior carcass are: high proportion of muscle (lean), low proportion of bone and an optimal level of fat cover.

12.3. Meat and Indicators of Meat Quality

Meat is one of the most nutritious foods that humans can consume, particularly in terms of supplying high-quality protein (essential amino acids), minerals (especially iron) and essential vitamins. Meat is defined as all animal tissues suitable as food for human consumption. This includes all processed or manufactured products prepared from animal tissues. The majority of meat consumed comes from domestic and aquatic animals, but a number of lesser known species and products are continuously added to the list. Meat is subdivided in to the following categories.

Red meat: The largest category in terms of volume of consumption. Includes beef, mutton, goat meat, pork, etc.

Poultry meat/white meat: Meat from domestic birds, e.g., chicken, turkeys, ducks, etc.

Seafood: This category includes fish, lobsters, oysters, etc., from both fresh and saltwater habitats, wild or farm-raised.
Game meat: Meat from wild game or traditionally non-domesticated animals, e.g. rabbit, llama, camel, eland, impala, deer, game birds, etc.

Meat quality in this chapter focuses on eating quality. Eating quality comprises palatability, wholesomeness, and being free of pathogens and toxins. Factors influencing the palatability of meat include tenderness, flavor and juiciness. Each of these criteria is again dependent on many factors, including animal age and physiological state, gender, fat and connective tissue, the biochemistry of the post-mortem muscle and the effect of genetics on tissue character and metabolism. Consumers often tend to evaluate meat quality on the basis of tenderness, juiciness and flavor of cooked meat. Juiciness and tenderness are influenced by the cut of meat and how long the meat is cooked (grilled or fried). The longer meat is fried, the more liquid is lost and the tougher it becomes. The more tender the meat, the more rapidly juices are released by chewing and the less residue remains in the mouth after chewing. The following are some of the important parameters/indicators of meat quality.

12.3.1. Meat pH

A key determinant of meat quality is pH. The ultimate pH is determined 24 hours post-slaughter, using a pH meter. Good quality meat usually has a pH of 5.4–5.7. The muscle of a living animal has a pH of 7.1. The extent to which pH is lowered after slaughter depends on the amount of glycogen in the muscle prior to the animal's death.

The pH value determines environmental microbial balance. Low pH has a bacteriostatic effect on the meat. Accordingly, meats with pH values above 6 are generally considered unsuitable for storage because of the favorable development of proteolytic microorganisms.

12.3.2. Meat color

Meat color is an important parameter in meat quality. It can be measured numerically using a colorimeter or subjectively. Several factors affect meat color such as species/breed, age, sex, cut of meat, surface drying of the meat and surface spoilage. Meat color is largely determined by the content of myoglobin and its derivatives. It is normal for meat to change color depending on the presence or absence of air. For instance, exposed meat changes color due to reactions occurring between myoglobin and oxygen. Meat color changes in response to both the quantity of myoglobin it contains, and chemical changes in the myoglobin itself. The more myoglobin in the meat, the darker the color exhibited. Older sheep contain more muscle myoglobin and hence have darker meat than lambs.

Color is also greatly affected by muscle pH. At a high pH, muscle has a closed structure and, hence, appears dark and the meat tends to be tough. Meat color is also affected by diet.

Meat can also become discolored before reaching a retail outlet if too much drying occurs. Hence, butchers prefer carcasses to have at least some fat cover (subcutaneous fat) evenly distributed over the carcass because it aids in maintaining quality and an attractive appearance by preventing the meat from drying.

12.3.3 Meat tenderness

Tenderness appears to be the most important sensory characteristic of meat and a predominant quality determinant. It can be evaluated by mechanical devices and/or a taste panel. Factors affecting meat tenderness include breed, nutrition, age, and muscle location.

Breed: Meats vary greatly in tenderness. There is variation among species and among animals within a species. Variation among animals reared in the same environment and slaughtered at the same age, weight, and degree of finish suggests a genetic cause for some tenderness variation. In beef, there is a heritability value of 60% for tenderness suggesting that heredity may be a major influence. This is expected to be similar in sheep and goats.

Nutrition: Nutrition influences tenderness principally through its effects on the amount and type of fat in the meat. Deposition of fat among the muscle fibers (marbling) as the animal grows and matures on a high-energy ration can improve tenderness.

Age: Meat generally becomes less tender as animals age. As an animal matures and the size of each muscle fiber increases, there would be an expected decrease in tenderness.

Muscle location: “Exercise muscles” are usually less tender than support muscles, i.e., the more a muscle is used, the stronger it becomes, and therefore the tougher the cut of meat will be.

12.3.3.1. Some methods of improving meat tenderness

Aging: Post-mortem aging of red meat is the time-honored practice of naturally improving palatability. Tenderness is improved when proteases or enzymes break apart the muscle fibers and reverse the effects of rigor mortis on the carcass. These effects occur largely during the first 3–7 days post-mortem. Aging also changes the flavor of the meat.

Freezing: Freezing increases tenderness apparently because muscle fibers are ruptured by ice formation and connective tissue components are stretched and ruptured. Lowering meat temperature to about -23°C (-10°F) apparently causes consistent increases in tenderness, but lower temperatures do not cause further tenderizing.

Electrical stimulation of the carcass: Electrical stimulation is a widely used method of improving the tenderness of mutton and beef. Electrical stimulation causes the carcass muscle to contract violently and hastens the conversion of muscle to meat. The pH level drops more rapidly and rigor mortis sets in more quickly than in non-stimulated carcasses. Electrical stimulation protects against cold shortening and may improve meat tenderness, color, and appearance. Due to the enhanced quality of meat and reduced costs, electrical stimulation has become widely practiced in recent years in commercial slaughter houses as a method of tenderizing lamb and goat carcasses. On the other hand, electrical stimulation may result in increased protein denaturation resulting from an accelerated rate of glycolysis and high temperature.

The meat from spent animals is generally tough and poor in palatability due to high content of connective tissue. Electrical stimulation can be used to make the meat from these animals acceptably tender for use as table meat.

Transferable Message

Depending on the market, aim to produce carcasses with tender meat. Well-fed animals slaughtered while young will yield tender meat.

12.3.4. Chemical composition

The approximate composition of meat is about 75% water, 19% protein, 2.5% lipid, 0.65% minerals and some vitamins. Many goat breeds have lower carcass fat than sheep and deposit more fat in the abdominal cavity. However, the relatively higher mean carcass fat in some Ethiopian goat breeds (Table 12.1) would be useful in reducing chilling losses and improving quality. Figure 12.1 shows the fat cover of well-fed goats.

Table 12.1. Chemical characteristics of goat meat from different breeds.

Characteristics %	Australian Capretto goats	South African indigenous goat	Boer goat	Ethiopian goats
Moisture	75.2	69.8	69.4	67.0
Protein	18.9	24.8	22.8	20.1
Fat	3.25	7.9	10.5	12.6
Ash	1.10	0.97	0.95	1.19

Among the goat carcasses shown in Figure 12.1 (#1357 and #1355 — Long-eared Somali, #1258 and #1317 — Central Highland and #1283 and 1311 — Afar), the second (#1258) and fifth (#1317) have less fat cover than the others, particularly around the buttock area. This is mainly due to breed differences.

12.3.5. Fatty acid composition

Studies have shown that fatty acid composition of muscle and adipose lipid tissue is influenced by breed, the quality and quantity of feed consumed, age/bodyweight, sex and level of fatness. Fatty acid composition in turn affects the nutritive value and the sensory characteristics of meat.

Animal fat has been the subject of much interest and debate because of health risks related to excess consumption of animal fat. Fat, however, is not only a concentrated source of energy for the body, but also improves meat palatability as it affects texture, juiciness and flavor as well as being important for meat preservation. When eaten, fat is also a carrier of the fat soluble vitamins A, D, E and K and the essential fatty acids. It is also important in growth and in the maintenance of many body functions. Fatty acids are the major components of lipids. Today, it is accepted that both the amount and the structure of the fatty acids consumed play a major role in maintaining human health.

Through research over the last decades, the scientific community has accepted that saturated fatty acids (SFA) tend to increase cholesterol levels in plasma while polyunsaturated fatty acids (PUFA) tend to decrease it. The SFA, such as lauric (C12:0), myristic (C14:0) and palmitic acids (C16:0) are hypercholesterolemic, while the saturated stearic (C18:0), and unsaturated oleic (C18:1), linoleic and linolenic present a hypocholesterolemic action. The SFA C10:0 also does not raise blood cholesterol levels. Myristic has four times the hypercholesterolemic effect of the others. Compared to intensively fed Jebel (Oman) goats at similar slaughter body weight, Ethiopian goats had a 2.4-times lower concentration of myristic fatty acid.

All unsaturated fatty acids and stearic fatty acid are categorized as desirable fatty acids (DFA). The average percentage of DFA in goat meat was estimated between 61 and 80%; the mean DFA of some Ethiopian goats is 70%. These demonstrate the potential of Ethiopian goats for the production of high-quality meat.

Figure 12.1. The fat cover of well-fed goats.

12.3.6. Cooking loss

Breed significantly affects cooking loss and the values range 34.1–39% for Capretto and 32.5–51.5% for Chevon. Higher cooking loss (62.2%) is reported for Nanjiang yellow goats. The average cooking losses of some Ethiopian indigenous goats (29%) are lower than Australia Capretto goats (35%) at similar slaughter weight. In general, the lower the cooking loss, the better the juiciness of the meat. This is another valuable quality trait observed in some Ethiopian indigenous sheep and goats useful in market promotion efforts.

12.4. Factors Affecting Meat Quality On-farm

12.4.1. Genetic factors

Many physical properties of meat are greatly influenced by genetic factors. Tenderness is reasonably inheritable. Sheep and goat producers can make improvements to the end-quality of meat by careful selection of breeds, and strains within a particular breed.

12.4.2. Age and weight

Meat quality changes markedly with the animal's age or weight at slaughter. Hence, appropriate slaughter weights should be identified for various breeds to get better dressing percentage, meatiness and quality. Postponing the slaughter age permits a better exploitation of growth potential, but the parallel increase of the carcass fat content and the subsequent worsening of the feed conversion index reduces potential economic returns.

12.4.3. Feed factors

The general feeding practice by traditional sheep and goat producers is to graze all livestock together on communal or privately owned grazing land. All animals are subjected to similar constraints imposed by grazing inadequate and overgrazed pastures. Culling unproductive animals is not practiced. The majority of indigenous sheep and goats from this system of management are marketed at average live weights of 20 kg, have low mean dressing percentages of less than 50% and poor carcass fat cover. Efforts are needed to help producers provide optimum nutrition to marketable animals to improve live weight at slaughter, the proportion of carcass contents and total edible meat produced.

A higher plane of nutrition promotes earlier fattening while a lower level results in a delayed or slower fattening process. Fatness varies a great deal with the husbandry method and genotype of the animal. Therefore, to attain the high or low fat levels a particular market may demand, farmers can accordingly vary feeding regimes and husbandry methods.

As indicated in 12.3.2 above, meat color is affected by diet. Research has shown that bulls fed forage-based, restricted diets had less glycogen, a higher muscle pH, and darker muscle color than bulls fed concentrates *ad libitum*. The same applies to sheep and goats.

12.4.4. Sex

Meat quality differences between sexes of animals is not fully understood, but is believed to be caused by differing levels of sex hormones circulating in the blood. Young rams have meat that tends to be relatively darker and tougher than that of female animals of similar age. Moreover, at similar age, ewe lambs are fatter than ram lambs.

12.5. Pre-Slaughter Management

There are a variety of environmental conditions which can cause stress in animals before slaughter. These include extremes in temperature, humidity, light, sound, and confinement. Other stressors are excitement, fatigue, pain, hunger, and thirst, all of which affect meat quality.

Observations made in some export abattoirs demonstrated that there is a lack of strong abattoir policy with respect to rest and related management of slaughter animals. In some cases, the conditions of transportation of animals to the abattoir by the middlemen and other suppliers have also been observed to be unsatisfactory.

To understand the effects of stress on final meat quality, it is important to understand the relationship of glycogen and lactic acid to pH decline in meat after slaughter. An animal which has not been stressed will have normal levels of glycogen in its body. When the animal is slaughtered, the metabolic process continues but oxygen no longer circulates. In the absence of oxygen, the breakdown of glycogen/glucose results in a build up of lactic acid, which then causes a drop in pH of the meat.

If at slaughter the animal has adequate glycogen reserves, and the slaughter and the storage processes are appropriate, glycolysis and the concomitant increase in lactic acid results in a pH fall from about 7.2 to about 5.5. An ultimate pH of 5.5 is desirable and is associated with light-colored, palatable meat. However, if pre-mortem glycogen reserves are low due to some stress, the glycogen will be depleted before a pH level of 5.5 is attained.

The final quality of meat is greatly affected by the rate of pH decline in the meat after slaughter. If the animal's glycogen is depleted before slaughter, the pH may not drop quickly enough after slaughter because of insufficient lactic acid production. In this case the meat will be very dry and dark in color. This condition is known as Dark, Firm, Dry (DFD) meat. An additional problem with this type of meat is that it is more susceptible to spoiling since it lacks the lactic acid which normally helps retard growth of microorganisms.

At the other extreme, if there was a great lactic acid build-up before slaughter, the pH of the meat declines too quickly after slaughter and a Pale, Soft, Exudative (PSE) condition may develop. As suggested by the name, the affected meat is pale, soft, and fluid may drip from the surface.

The following are some of the major pre-slaughter factors resulting in stress and subsequent poor meat quality.

Distance and conditions of travel to the abattoir: Traveling long distances exerts substantial stress on animals which could lead to greatly reduced glycogen levels.

Nutrition and fasting: The rate of glycogen repletion is particularly slow in animals that have been on poor quality diets and/or that have been fasted long periods prior to slaughter.

Mixing strange animals prior to transportation or slaughter: This can lead to fighting while establishing a new social order.

Physical activity: Too much physical exertion prior to transport or slaughter can increase stress.

Transportation-related problems and precautions: These include the following:

- Loading and unloading are often the most stressful parts of the transport process and it is imperative that proper thought and planning be given to the procedure to avoid using excessive force. For instance, one of the most common mishandling practices involves deep and extensive bruising along the back of the animals caused by lifting the live animal by the hair or wool. If the sheep must be lifted during the loading and unloading operations, the workman should embrace the lamb by extending both arms through the flank region under the body. When caught from the rear they should always be grasped by the hind leg and never by the wool.
- Animals should not be overcrowded. This helps prevent injury and unnecessary suffering.
- The journey should be made in a careful manner avoiding sudden stops and starts, fast-turning and unnecessary delays.
- Lambs and kids may travel for 9 hours before a minimum rest period of 1 hour followed by a further maximum of 9 hours. Adult sheep and goats may travel for 14 hours before a minimum rest period of 1 hour, followed by a further maximum of 14-hours travel.
- Feed and water should be available during the rest periods.
- Animals normally lose weight during transport. It is possible in many cases to restore some, if not all, of this loss with adequate rest. In South Africa, the resting of adult Merino sheep for 24 hours with feed and water after rail transport for more than 3 days had beneficial effects on carcass yield.

12.5.1. Animal husbandry in the lairage

Minimizing stress in the period immediately before slaughter is important for economic reasons related to meat quality as well as for animal welfare. Animals must be handled carefully at all times with minimal use of force.

- Most lairages in the abattoir should have solid non-slip floors suitably sloped for adequate drainage. They must be well-lit and ventilated. During the pre-slaughter period in the lairage, animals must be kept under conditions which prevent any further contamination of feet, hides, fleeces or skins.
- The attitude of the attendant in the abattoir can be all-important to the calm and efficient operation of the facility. Persons experienced in animal husbandry know instinctively where to stand when moving stock and can carry out their task using only encouraging noises and the occasional tap or wave of a stick.

Inexperienced operatives, however, frequently excite, confuse and antagonise the animals making handling difficult.

- Animals should receive ample drinking water during their stay in the lairage as this serves to lower the bacterial load in the intestine and facilitates the removal of skin during the dressing of the carcass.
- Stock should not be held for more than a day in the lairage and must not be slaughtered in sight of other stock.

12.5.2. Fasting during the holding period

Small ruminants should be held without feed but with access to water for 12–24 hours prior to slaughter. Withholding feed results in greater ease of evisceration and minimizes the migration of ingested bacteria from the gastrointestinal tract into the blood stream. This helps in lengthening the period of time carcasses can be held without spoilage after slaughter.

Transferable Messages

Proper handling of animals before slaughter can greatly reduce their discomfort and stress, thereby improving meat quality. This includes:

1. Proper feeding.
2. Rest.
3. Proper techniques for moving and transporting animals.

12.6. Post-Slaughter Factors

To produce quality meat, appropriate temperature, airflow and relative humidity must also be employed in the chillers.

12.7. Meat Safety — Producer Responsibilities

The production of meat for direct consumption or export consists of two main phases. The on-farm production is referred to as *pre-harvest* while *post-harvest* refers to practices of livestock slaughter and subsequent meat processing. The farmer or pastoralist has no control over post-harvest procedures. Conversely, the abattoir and meat processors have no control, except that exerted through market channels, on the product they receive for processing. The responsibility of delivering an animal that can yield high quality, and high value, edible product belongs to the producer.

There are three main hazards that occur in food, i.e., biological (microbial contamination), chemical (toxins or drug residues), and physical (foreign material in food, e.g., glass or plastic). Livestock producers must eliminate as many of these hazards as possible.

- *Biological hazards* are minimized by maintaining the health of the animal, including providing vaccinations and proper health care. Animal pens and corrals should be well maintained to prevent injury to animals that could allow entry of disease organisms.
- *Chemical hazards* of most concern in meat are drug residues. Only drugs approved for use in small ruminants should be used and then only under supervision of an animal health official. Withdrawal times (the time needed for a drug to clear an animal's system) for both meat and milk products have been set for most drugs. These should be followed and no animal should be slaughtered or milk consumed during the withdrawal period. These rules must be followed for animals sold for export as well as those slaughtered for village or home consumption. Chemical contamination can also come from animals eating feed with

fertilizer, pesticide, or herbicide residue. Be careful when using chemicals and do not feed grain, hay, or grass that may have been contaminated.

- *Physical hazards* are not common in meat animals coming off farm. However, broken needles are one example of a physical hazard that can be prevented on-farm. Care should be taken when injecting animals. ***All injections (subcutaneous, intramuscular, and intravenous) should be given in the neck area in front of the shoulder. Never inject an animal in the rear leg.*** Injection site lesions (areas of toughened scar tissue resulting from an injection) can form in muscle. After slaughter, this portion of the meat must be cut out and discarded. This affects animal price and negatively affects the small ruminant meat industry, particularly the export market.

Transferable Messages

Livestock raisers have a responsibility to provide animals to market that produce safe, wholesome meat. They should strive to:

1. provide proper care to animals;
2. use all drugs correctly and follow withdrawal times;
3. be careful when using fertilizers and other chemicals to not contaminate animal feed; and
4. never inject in the rear muscle.

12.8. Carcass classifications and grading

In many countries, animal carcasses are classified and graded based on quality. Animals yielding carcasses of higher quality receive a premium in the marketplace while animals with inferior carcasses are discounted. Producers, then, have an incentive to raise and produce animals that yield superior meat. Through meat labeling, consumers know the quality of the meat they purchase and pay higher prices for premium quality cuts.

Classifying refers to dividing animals according to kind, sex, age and weight while grading is the process of sorting the classified animals into sub-groups based on the relative merit of the meat produced. In other words, classification is the grouping together of carcasses having similar features while grading separates meat into groups based upon quality characteristics.

Classification and grading of carcasses are important marketing tools and also the means of clearly communicating carcass and meat quality characteristics back to the producer and to the consumer. Objective classification and grading is the responsibility of a central authority. The objective, in general, is to easily predict, with acceptable accuracy, carcass and meat features from easily accessible and related characteristics and to communicate these to the marketer, processor and consumer. Meat yield, muscle content and fatness are the most important characteristics sought in carcasses.

12.8.1. Advantages of classifying and grading

- Producers can receive a premium for animals producing high-quality meat.
- Establishes consistent quality and uniformity within a group.
- Reduces purchasing risks; consumers benefit by paying a fixed price for a specified grade.
- No time is wasted by bargaining, thus consumers tend to buy graded animals for a fixed price.
- Provides a quick, cheap and easy method of comparing individual animals under differing management system, seasons or environments.

12.8.2. Meat grading in different countries

The grading method and system practiced in different countries varies depending on the objectives of the system and on the degree of uniformity that exists among types and species of animals. In many countries, quality is measured by third-party evaluation. As an example, the US and Australia use a grading system based on marbling, age and sex of slaughter animals. In South Africa, the grading system is based on external fat covering and age of the animal. Countries have established the system that best allows consistency of product for their consumers.

In Ethiopia, there is no grading system for live animals or meat. Therefore, proper market research and adequate consultation involving the various stakeholders should be conducted to determine the important factors to be considered. In the domestic market, there is a similar unit price for all meat, i.e., both tender and less tender cuts are sold at similar prices. Regarding the export market, whole carcasses are sold at a similar price per kilogram. In neither case do producers have any incentive to raise animals producing high-quality carcasses.

Example — the USA sheep meat grading program

In the USA, consumers can be assured of receiving a wholesome product and good quality meat by looking for the United States Department of Agriculture (USDA) grade shield on raw meat packages. The shield is a guide to the quality of meat and also an assurance that the meat is wholesome because only meat that has first passed inspection may be graded. The USDA's quality grading program is voluntary and paid for by user fees.

Sheep meat in the USA is classified as either lamb or mutton. Lamb is produced from animals less than a year old. Meat from older sheep is called yearling mutton or mutton. Lamb meat grades are Prime, Choice, Good, and Utility. Lamb meat graded as Prime or Choice is usually labeled in stores. Lower grades of lamb and mutton (Good, Utility, and Cull) are seldom marked with the grade if sold at retail. Grades for yearling mutton are the same as for lamb, except that mutton does not qualify for the Prime grade and the Cull grade applies only to mutton.

USDA Prime: Prime grade lamb is very high in tenderness, juiciness, and flavor. It has moderate marbling, which enhances both flavor and juiciness.

USDA Choice: Choice grade lamb has slightly less marbling than Prime, but still is of very high quality. Choice chops and roasts also are very tender and juicy, and have choice flavor.

The following pictures are graded beef. They are displayed to help you observe the differences in marbling used while grading.

USDA Prime USDA Choice

Figure 12.2. USDA's quality grades.

12.9. The Meat Industry and Export Market Specifications

Strengthening the meat export market would provide a means of reducing poverty levels, particularly in rural Ethiopia. Animal production would be stimulated and producers would have a larger number of outlets for their animals. Initially, production would be stimulated in the traditional sector, which is the major source of animal production. When meat quality begins to be taken into account in live animal pricing, livestock producers will have an economic incentive to produce high-quality animals. This will result in improved livestock nutrition and management.

The export abattoirs currently operating, those expected to come into operation in the near future and their locations are shown in Table 12.2.

Table 12.2 Export abattoirs currently operational or expected to come into operation in the near future.

Abattoirs' name	Location	Abattoirs' number	Status
ELFORA, HELIMEX	Debre Zeit	2	Functional
Modjo Modern, Mojo Luna	Mojo	2	Functional
Organic	Mojo	1	Future
Mewashe	Metehara	1	Functional
Bahirdar, Kombolcha, Mekele	Bahirdar, Kombolcha, Mekele	3	Future

The annual slaughter capacity of the existing abattoirs is 2.5 million small ruminants with a possibility of expansion to attain a maximum capacity of 4.5 million. However, only a small amount of their existing capacity is currently used.

Some of the major importing countries of small ruminant meat and/or live small ruminants are the United Arab Emirates, Saudi Arabia and Yemen. Saudi Arabia also imports meat by-products such as liver, kidney, heart, tongue, small intestine and brain.

12.9.1. Potential and actual volume of export

The estimated annual potential for export is 72,000 metric tons of meat. Recently, the volume of small ruminant meat exported was 12,000 tons and a comparable amount or more is the export goal for 2008.

12.9.2. Major preference of breeds in the export market

According to the abattoirs, among sheep breeds, the Black Head Somali and Afar are preferred. The Borana, Somali and Afar are the preferred goat breeds. However, during periods of high demand from different importers, mainly during holiday and festival periods, other breeds of small ruminants are also slaughtered and exported. There are some complaints concerning highland sheep and goats due to the alleged darkening of meat during storage. This problem is being investigated so that both the highland and the lowland small ruminant breeds could be made to contribute to alleviating the constraints related to the consistent and uniform supply for the export market.

12.9.3. Export market specifications

The specifications indicated in Table 12.3 show the product type and weight category required by some countries. However, the other important consideration such as the sanitary and phytosanitary requirements of the World Organization for Animal Health (OIE) and the importing countries must also be considered.

Table 12.3. Meat preference of different importing countries.

Consumers	Product specification
Middle East (Saudi Arabia and Dubai)	Skin-off carcass mutton: 8–12 kg; goat: 5–7.5 kg
Malaysia	Skin-off, lean carcass, <10 kg
Malaysia	Skin-off, lean carcass, 20 kg
Malaysia	Boneless lean meat
Taiwan	Skin-on, lean, 14–16 kg goat carcass
Europe	Kid, skin-off, lean, 5–12 kg carcass

12.10. Opportunities and Constraints of Meat Marketing

The following are some of the important opportunities and challenges/constraints influencing the meat industry in Ethiopia, particularly the export sector.

12.10.1. Opportunities

- Proximity to Middle East countries and their preference to the taste of Ethiopian animals.
- High and increasing demand. The annual total meat demand of the Middle East countries is about 207 thousand tons of meat and 12 million head of sheep, goats, cattle and camels. Considering population sizes, purchasing power and level of meat imports, there is also a potential market in the following African countries: Algeria, Angola, Benin, Cote d'Ivoire, the Democratic Republic of Congo (DRC), the Gabon, Egypt, Mauritius and South Africa. These countries annually import 82% of the total meat imported to the continent. There is also a possibility of expansion to Asian markets such as Malaysia, which require halal-slaughtered, frozen, skin-off carcasses with less stringent hygienic regulations. The carcass weight categories are less than 12 kg, 12–18 kg, and greater than 18 kg. Currently in Ethiopia, at least the former weight category can be targeted.
- High livestock population and diverse genotypes.
- Diverse agro-ecologies.
- Increasing number of export abattoirs.
- The expansion of agro-industries and the increase of by-product feeds.

12.10.2. Constraints/challenges

- Inadequate research and extension programs in the production, processing and marketing of meat.
- Inadequate knowledge and technologies to make optimal use of local animal feed resources in diets.
- Livestock diseases and inadequate veterinary support services. There are frequent import bans mainly due to the stringent health requirements of some importers.
- Inadequate application of HACCP (Hazard Analysis and Critical Control Point) procedures.
- Lack of constant and uniform animal supply.
- Inadequate infrastructures on transportation routes and markets.
- Lack of marketing information and cooperative systems for the marketing of animals.
- Lack of a grading system to provide incentives to producers and to assist in the development of meat exports. In most markets, there are no weighing facilities, and animals are subjectively sold according to appearance and size.
- Inadequate knowledge at different levels of stakeholders (producers, dealers, meat handlers, consumers, etc). A consumers' forum should be established. The importance of packaging should be taught to the meat sellers.
- Contraband trade around the lowland borders of the country. East African livestock trade is characterized by illicit trade between neighboring countries and the inflow stocks are used either for domestic consumption (Kenya), or for re–export and domestic consumption (Somalia) or re-export alone (Djibouti).

Illicit trade seriously affects Ethiopia. Data from the Livestock Marketing Authority (LMA, 2001) revealed that an estimated 1,150,000 sheep and goats and 300,000 skins outflow every year from Ethiopia through illicit cross–border trade.

- Lack of an integral connection between the stakeholders involved in the production chain.
- Inadequate market promotion and study tours to potential importing countries.
- Lack of efficient air transport for export of fresh and chilled meat.
- Some markets are also dominated by influential personalities.

Transferable Messages

1. Appropriate breeds and technologies and targeting of markets have to be used to increase animal off-take as well as productivity per animal with acceptable quality and safety, and to ensure a constant and uniform supply of meat.
2. Attention should be given to the establishment of disease-free zones for livestock export.

Glossary

Aging: refers to holding of carcasses at certain temperature to allow naturally present enzymes to tenderize the meat.

Ante-mortem: Before death.

Antioxidant: A compound that prevents oxidation. Used in mixed feeds to prevent rancidity or loss of vitamin potency.

Capretto: A suckling goat only a few weeks old.

Carcass: The major portion of a meat animal remaining after slaughter. It varies among animals, but usually the head, the skin, internal organs and the shanks have been removed.

Chevon: The meat of an older, weaned meat goat.

Chilled meat: Meat kept between 0 and 4^{o}C in a chiller or refrigerator usually 24 hours post-slaughter.

Conformation: The structure or shape of an animal or its carcass, or a cut from the carcass.

Dressing percent: Carcass weight divided by live weight and multiplied by 100. Usually the cold carcass weight is used.

Fatty acids: A basic unit of fats. They are lipids that can be directly utilized as a source of energy by most body cells.

Hypercholesterolemic: Fatty acids that may increase cholesterol level.

Hypocholesterolemic: Fatty acids that may reduce cholesterol level.

Lactic acid: A byproduct which results when glucose is broken down without a sufficient supply of oxygen. Post-mortem lactic acid build-up is an important factor in the pH decline in meat and has an impact on final meat quality.

Lairage: A place for keeping livestock temporarily in the abattoir.

Lipids: Lipids are organic molecules which are not soluble in water, including fats and cholesterol. Lipids are important constituents of cell walls and the starting materials for the synthesis of steroids.

Marbling: Small visible streaks of fat within a meat cut.

Myoglobin: A red iron-containing protein pigment in muscles that is similar to hemoglobin.

Post-mortem: After death.

Rigor mortis: Stiffening of muscles after slaughter.

References

Ameha Sebsibe. 2006. Meat quality of selected Ethiopian goat genotypes under varying nutritional conditions. Ph.D. Thesis. University of Pretoria, South Africa.

Belachew, Hurissa and Jemberu, E. 2003. Challenges and opportunities of livestock marketing in Ethiopia. In. Proceedings of the 10th Annual Conference of the Ethiopian Society of Animal Production. Addis Ababa, Ethiopia.

Ethiopian Agricultural Research Organization (EARO). 1999. Small Ruminant Research Program Strategy. EARO, Addis Abeba, Ethiopia.

Marinova, P., Shindarska, Z., Banskalieva, V. 1992. Deposition and composition of muscular tissue in lambs under different feeding levels and clenbuterol participation. In: Proceedings of the 38th International Congress of Meat Science and Technology, Clermot-Ferrand, France, Vol. 2, pp. 89–92.

Purchas, R.W. 1990. An assessment of the role of pH differences in determining the relative tenderness of meat from bulls and steers. Meat Sci. 27, 129–140.

Rhee, K.S. 1992. Fatty acids in meat and meat products. In: Fatty Acids in Foods and Their Health Implications. Chow, C.K., Marcel Deker, (eds), New York, pp. 65–93.

Scheeder, M.R.L., Casutt, M.M., Roulin, M., Escher, F., Dufey, P.A., Kreuzer, M. 2001.Fatty acid composition, cooking loss and texture of beef patties from meat of bulls fed different fats. Meat Sci. 58, 321–328.

Chapter Thirteen

Records and Record Keeping

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Objectives

1. To highlight the importance of record keeping in various aspects of sheep and goat production.
2. To describe the different kinds of records that are required in relation to sheep and goat production.

Expected Outputs

1. Understanding of the importance of record keeping.
2. Understanding of the major components of a record.
3. Ability to design a format for keeping records for sheep and goat production.

13.1. Objectives of Record Keeping

Record keeping is an essential part of good livestock and farm business management. Recording can be done most easily if animals have some form of identification. Thus, animal recording and identification are inseparable. There are two main objectives of animal identification and recording:

- To identify animals belonging to a particular owner; proof of ownership.
- To use as a management tool to:
  - undertake performance evaluation,
  - perform genetic selection,
  - keep proper health records,
  - accurately measure production and reproduction, and
  - perform other important management functions required to run an effective and efficient farm enterprise.

Establishment of a national livestock data-recording system is important for a uniform development of recording and analysis procedures. The national recording system should:

- be uniformly used throughout the country.
- be simple to implement and use.
- allow identification of the best and poorest management procedures.
- provide information necessary to make management decisions.
- provide data for research, policy development and extension.
- help in implementing genetic improvement programs.

Such national schemes can become successful if there is clear benefit to participating farmers. However, the need for record keeping could arise from its importance on a scale broader than a single farm. Effective, reliable and traceable identification and recording systems for live animals and animal products could enable national or international bodies to rapidly respond to disease outbreaks and biosafety concerns. This will help to identify the source or sources of the problem, understand its implications and take appropriate measures.

13.2. Types of Records

Sheep and goat production records should give details of individual ewe or doe performance over successive years on fertility, prolificacy, rearing or mothering ability and milk production directly or indirectly estimated through lamb/kid growth rate to a given age. If records are used for selection purposes, comparisons should be made between animals in the same flock to avoid confusion arising from differences in farm conditions or other environmental effects. Another option is to mathematically correct for known factors causing differences. As the number of animal records increases, their reliability to be used as a guide for breeding value of individual animals is increased.

On-farm records are essential in evaluating and improving the performance of sheep and goats within a farming system. Farmers should have a record book in which all records are kept. This should be stored in a place where it will not become soiled or wet, making the records useless. The format should be simple and readily understood by the farmer. KDA agents should make a sample record book that can be shown to farmers. This record book should be written in a language understood by farmers in the area and must contain any type of regional-specific records or information that needs to be kept.

Below is a list of records that may need to be kept under Ethiopian conditions. The value and relevance of the different types of records will vary with differing sheep and goat production systems.

- Lambing records, which include identity, dam ID, weight, date of birth, type of birth and sex.
- Growth or weight records kept periodically by recording the body weight of animals.

- Health records including morbidity, mortality, signs and symptoms, diagnosis, treatments and vaccinations, etc.
- Feed consumption: This is difficult to estimate on farms where animals graze, but for capital-intensive farm businesses, such as finishing or fattening operations, the amount of concentrate fed should be recorded to calculate profitability.
- Milk production records: recording once weekly may suffice as this is highly correlated with total milk production. Therefore, in dual-purpose sheep and goats, or even in meat types, a random sample of lactating females may be selected for recording their once-a-week milk production.
- Mating records: Sire, dam and progeny identification is important in breeding, sale, and culling decisions.
- Testes size: Recording testes size at one year of age can assist in sire selection. Testes size in males is related to ovarian activity (multiple ovulations) in females.
- Carcass yield or dressing percentage is a factor that has tremendous economic value, particularly in a community-based breeding program involving meat breeds. This information could be obtained from slaughterhouses/abattoirs.
- Hides and skins: For a crossbreeding program there may be a need to record skin quality aspects such as area of hide, skin thickness, elasticity, pigmentation and density of hair.

Final Message

1. Records are essential in sheep and goat production to optimize production and maximize profit.
2. In addition to its importance at the farm level, following a standard format at a national level could contribute to comparisons for various purposes. Entries for specific requirements of a farm can be added on the entries of the standard format.
3. Records should be simple to keep and easy to understand in order to be useful in achieving production and economic objectives.
4. Some measurements which need recording a few times in an animal's life (e.g., testes size) can have far reaching impacts on productivity.
5. In crossbreeding programs, production records can assist in determining if the activity has an overall benefit.
6. Records are important for cost-benefit analysis of sheep and goat production enterprises.

13.2.1. Examples of records

As noted above, there are different types of records that may be kept in a sheep and goat record book. Moreover, the formats of records should be simple and easy to understand. Examples of different types of records are presented in Tables 13.1 to 13.9.

Table 13.1. An example of breeding records.

Dam ID	Dam breed	Dam birth date: dd/mm/yy	Sire ID	Sire breed	Mating date: dd/mm/yy	Lambing/kidding date: dd/mm/yy	Remarks

Table 13.2. An example lambing/kidding record.

Individual dam and lamb/kid performance record															
Dam ID:						Dam birth date:					Dam weaning weight (kg):				
Sire ID:				Sire breed:				Dam ID:				Dam breed:			
Dam source:					Reason for culling:						Culling date:				
Comments:															
Pre-weaning performance							Weaning					Ewe/doe status			Remarks
Lamb/kid ID	Birth date	Sex	Birth type (S/T/M)	Sire ID	Sire breed	Birth wt. (kg)	Weaning date	Weaning wt. (kg)	Type of rearing	Wt. at marketing	Price (Birr)	Condition score	Pregnancy check	Preg. or Open	

Table 13.3. An example lamb or kid performance record.

Pre-weaning									At weaning							
Lamb/ kid ID	Birth date	Sex	Birth type	Dam ID	Dam breed	Sire ID	Sire breed	Birth wt. (kg)	Weaning date	Weaning wt. (kg)	Type of rearing	Weaning group	Wt. at marketing	Body condition score (1–5)	Lamb/kid price (Birr)	Remarks

Table 13.4. An example post-weaning performance record of lambs/kids.

Lamb/ kid ID	Birth date	Sex	Birth type	Birth wt. (kg)	Weaning date	Weaning wt. (kg)	Type of rearing	Weight No. ____		Weight No. ____		Weight No. ____		Remarks
								Date	Wt. (kg)	Date	Wt. (kg)	Date	Wt. (kg)	

Table 13.6. An example of record of milk production by milking (second row) or by lamb/kid suckling method.

Identification number	Date of birth	Date of lambing/ kidding	Date of milk recording	Method of milking	Milk produced	Body weight of lamb before suckling	Body weight of lamb after suckling	Weight difference	Remark
				Milking	100				
				Weigh suckle weigh		5.5	5.6.	0.1	

Table 31.7. An example animal health record.

Owner's name: ______________________
Peasant Association: ______________________
Woreda: ______________________

No.	Date of observation	Animal species	Number of animals of the same species in the flock	Number of sick animals	Number of animals that died	Major signs observed	Suspected disease	Measures taken	Remarks

Table 13.8. An example individual ewe/doe record.

Owner's name: ______________________
Region: ______________________
Woreda ______________________
Kebele ______________________

ID No.	Age	Date lambed/ kidded	Weight of lamb/kid	Type of birth	Parity	Date brought into the farm	Date removed/ culled	Reason for removal

Table 13.9. An example feed consumption / cost record.

Owner's name: ______________________
Region: ______________________
Woreda ______________________
Kebele ______________________

No.	Date	Type of feed	Consumption (kg)	Cost/kg	Total cost	Remarks

Table 13.10. An example income/expense record of a sheep/goat farm.

No.	Income		Expenses		Difference	Remarks
	Description of income	Amount	Description of expenses	Amount		

Exercises

1.	What is the prerequisite for record keeping in animal production?
2.	Name at least four types of records you keep in sheep and goat production.
	a.
	b.
	c.
	d.
	e.
	f.
3	Name at least 5 benefits of having a good sheep production record-keeping system:
	a.
	b.
	c.
	d.
	e.
	f.

References

Campher, J.P. 2004. Animal identification and recording systems in the Southern African Development Community (SADC): 1. Overview of the current situation. In: Pauw, R. et al. (eds). October 2004. Proceedings of a Workshop on Development of Animal Identification and Recording Systems for Developing Countries, 29 May 2004. ICAR Technical Series No. 9.

Meat and Livestock Commission (MLC). 1979. Sheep improvement services booklet. Performance Recorded Flocks. July 1979. 44pp.

Meyn, K., Mocquot, J.C. and Wickham, B. 2001. A prospective view of animal recording. In: Vares, T. et al. (eds). April 2001. Proceedings of a Workshop on the Role of Breeders' Organizations and State in Animal Identification and Recording in CEE Countries, Bled, Slovenia, 15 May 2000. ICAR Technical Series No. 5.

Ministry of Agriculture (MoA). 1985. Livestock sub-sector review (Draft Final). Annexes, Volume 3:10–14. Australian Agricultural Consulting and Management Company PTY. LTD. February 1984.

Mukhereje, T.K. 1991. Performance recording and productivity assessment in goats. In: Panandam, J.M., Sivaraj, S., Mukherjee, T.K. and Horst, P. (eds). Goat Husbandry and Breeding in the Tropics. Compiled papers presented in an international seminar carried out by German Foundation international for Development (DSE) at the Institute for Advanced Studies, University of Malaya, Kuala Lumpur.

Pollott, G.E. 1998. Goal-led livestock recording systems for low to medium input production systems. In: Trivedi, K.R. (ed.) International Workshop on Animal Recording for Smallholders in Developing Countries ICAR Technical Series No.1. Anand (India) 20–23 October 1997.

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