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# AGE 402

## HUSBANDRY OF RUMINANT ANIMALS


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**Course code: AGE 402**

**Course title: Husbandry of Ruminant Animals**

**Course credit load: 2 Units**

# Series 1: Fundamentals of Ruminant Animal Husbandry

- **Part 1.1: Definition, Classification, and Economic Importance**
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## Introduction

Ruminant animals, particularly cattle, sheep, and goats, form the backbone of livestock farming in Nigeria. They provide meat, milk, hides and skins, draught power, manure, and social capital. Understanding the basic concepts of ruminant animal husbandry, from the definition of what a ruminant is, through the terminology used by livestock farmers, to the reproductive parameters that determine herd productivity, is the essential foundation for all the management topics covered in subsequent Series. This Series establishes that foundation.

We begin by defining and classifying ruminants, describe their economic importance in Nigeria, introduce the standard livestock terminology used in describing cattle, sheep, and goats, explain how animals are aged by their teeth, cover the key reproductive parameters and care of the young, and conclude with an overview of the beef, dairy, and small ruminant industries in Nigeria. All subsequent Series build on the concepts introduced here.

## Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 1.1** define ruminant animals and list their distinguishing characteristics (Linked to Part 1.1),
- **SLO 1.2** classify ruminants and give examples of species important in Nigerian agriculture (Linked to Part 1.1),
- **SLO 1.3** explain the economic and social importance of ruminant animals in Nigeria (Linked to Part 1.1),
- **SLO 1.4** use correct livestock terminology for cattle, sheep, and goats and explain its importance in animal husbandry (Linked to Part 1.2),
- **SLO 1.5** age cattle, sheep, and goats using dentition and describe the external body parts (Linked to Part 1.2),
- **SLO 1.6** describe the reproductive parameters of cattle, sheep, and goats including puberty, oestrous cycle, gestation, and breeding ratios (Linked to Part 1.3),
- **SLO 1.7** describe the process of parturition and the care of the young ruminant (Linked to Part 1.3), and

- **SLO 1.8** describe the structure and challenges of the beef, dairy, and small ruminant industries in Nigeria (Linked to Part 1.4).

# 1.1 Definition, Classification, and Economic Importance

## 1.1.1 Definition and characteristics of ruminant animals

A ruminant is an even-toed hoofed mammal (order Artiodactyla) that digests plant-based food by initially softening it within the animal's first stomach (the rumen), then regurgitating the semi-digested mass known as cud and chewing it again; this process is called rumination or chewing the cud. Ruminants are characterised by: a complex multi-compartment stomach (rumen, reticulum, omasum, and abomasum); the ability to digest cellulose through microbial fermentation in the rumen; the absence of upper incisor teeth (they have a dental pad instead); even-toed hooves (two functional toes per foot); and the regurgitation and re-chewing of feed (rumination) after initial ingestion.

These characteristics enable ruminants to convert low-quality fibrous feeds (grass, crop residues, browse, straw) that non-ruminant livestock (pigs, poultry) cannot utilise into valuable animal products, making them uniquely suited to the feed resources available in Nigerian farming systems. The rumen supports a complex community of bacteria, protozoa, and fungi that produce enzymes (cellulases and hemicellulases) to break down plant cell wall fibre; in return the microorganisms receive a warm, stable environment and a continuous supply of fermentable substrates. Rumen microbes also synthesise B vitamins and microbial protein that the animal can absorb further along the digestive tract.

Fill in the blank: Ruminants digest fibrous feed through microbial _____ in the rumen; the microorganisms produce enzymes that break down cellulose and hemicellulose in plant cell walls.

## 1.1.2 Classification and examples of ruminant species

Ruminants belong to the suborder Ruminantia (excluding camelids, which ruminate but belong to a separate group). The major families of ruminants are: Bovidae (cattle, sheep, goats, buffalo, bison); Cervidae (deer and related species); Giraffidae (giraffe); and Camelidae (camels, llamas, alpacas; these are pseudo-ruminants with a three-compartment stomach). In Nigerian agriculture, the economically important ruminants are cattle (Bos indicus: zebu cattle and Bos taurus: taurine cattle), sheep (Ovis aries), goats (Capra hircus), and to a lesser extent West African dwarf cattle, buffalo (Syncerus caffer used for draught in very limited areas), and camels (in the far north).

Cattle are the most numerous large ruminants in Nigeria, with a national herd estimated at approximately 20 million head. Sheep and goats are even more numerous, with approximately 40 million sheep and 75 million goats, placing Nigeria among the top five countries globally for small ruminant populations. These numbers reflect the adaptability of small ruminants to Nigerian farming conditions: they can be kept in small numbers, require minimal capital, produce output rapidly (short generation interval), and serve as a savings and insurance asset for smallholder farm families.

Fill in the blank: Nigeria's national ruminant herd includes approximately 20 million cattle, 40 million _____, and 75 million goats, placing Nigeria among the top five countries globally for small ruminant populations.

| Species | Scientific Name | Family | Approximate Nigerian Population | Primary Products |
|---|---|---|---|---|
| Cattle | *Bos taurus* / *Bos indicus* | Bovidae | ~20 million | Meat, milk, hides, draught |
| Sheep | *Ovis aries* | Bovidae | ~34 million | Meat, wool, milk, skins |
| Goat | *Capra hircus* | Bovidae | ~76 million | Meat, milk, skins |
| West African Dwarf Cattle | *Bos taurus brachyceros* | Bovidae | ~1 million | Meat, milk, draught |
| Camel | *Camelus dromedarius* | Camelidae | ~0.3 million | Meat, milk, hides, draught |

Table 1.1: Classification of economically important ruminant animals in Nigeria

## 1.1.3 Economic and social importance in Nigeria

Ruminant animals contribute to the Nigerian economy and rural livelihoods in multiple ways. Meat production: beef, mutton, and chevon (goat meat) are the most widely consumed meats in Nigeria; cattle are slaughtered at abattoirs supplying urban butcheries and restaurants, while small ruminants are slaughtered locally at eid-el-kabir (during which millions of rams and bulls are sacrificed) and other ceremonies. Milk production: the Fulani cattle keepers (pastoralists) produce fresh milk (fura de nono) and fermented milk products marketed along migration routes and in urban centres; commercial dairy farming is small-scale but growing. Hides and skins: Nigeria is a major exporter of hides and skins (particularly from Kano, Sokoto, Kaduna, and Maiduguri), feeding the leather industry.

Social and cultural importance: livestock is a form of social currency; cattle are given as bride price (bride wealth) in many northern Nigerian cultures; small ruminants are sacrificed at naming ceremonies, weddings, and funerals; and herd size is a measure of social status among pastoral Fulani communities. Agricultural importance: ruminants provide draught power (oxen for cultivation) in the north; manure for soil fertility improvement; and income diversification for crop farmers. The pastoral and agropastoral livestock sector is estimated to contribute 5 to 8 per cent of Nigeria's GDP directly, with indirect contributions through leather, traction, and organic fertiliser significantly higher.

Fill in the blank: Livestock contributes 5 to 8 per cent of Nigeria's GDP; cattle are important as a form of _____ price (bride wealth) in northern Nigerian cultures and as social capital among Fulani pastoral communities.

*Pilot questions 1.1*

1. Define a ruminant animal and state four characteristics that distinguish ruminants from non-ruminant livestock.
2. Explain how the multi-compartment stomach of ruminants enables them to utilise feed resources unavailable to pigs and poultry.

3. Name the three main ruminant species kept in Nigeria and give the estimated national population of each.
4. State six ways in which ruminant animals are economically important in Nigeria.
5. Explain the social and cultural significance of ruminant animals in Nigerian communities.

## 1.2 Livestock Terminology and Ageing

### 1.2.1 Common livestock terms for cattle, sheep, and goats

Precise livestock terminology is essential for communication in animal husbandry; using the wrong term can cause confusion in records, trade, and management instructions. For cattle: bull (intact male); steer (castrated male); heifer (young female that has not yet calved); cow (mature female that has calved at least once); calf (young bovine of either sex up to weaning); yearling (bovine between 1 and 2 years old); ox or oxen (castrated male used for draught); dam (the mother of a calf); sire (the father of a calf). For sheep: ram (intact male); wether (castrated male); ewe (female); lamb (young sheep up to weaning or one year); hogget (sheep between one and two years old); flock (group of sheep).

For goats: buck or billy (intact male); wether (castrated male); doe or nanny (female); kid (young goat up to weaning or one year); herd (group of goats). General terms: parturition (act of giving birth); calving (cattle giving birth); lambing (sheep giving birth); kidding (goats giving birth); colostrum (first milk after parturition, rich in immunoglobulins); weaning (separation of the young from its mother and transition to solid feed); dry period (period between the end of lactation and the next calving); service (act of mating); conception rate (percentage of females that conceive after mating or insemination). Students are expected to use these terms correctly in all written and oral assessments in this course.

Fill in the blank: A _____ is a castrated male bovine used for draught power; a heifer is a young female bovine that has not yet calved; a steer is a castrated male bovine not used for draught.

## 1.2.2 Ageing by dentition

The age of cattle, sheep, and goats can be estimated by examining the teeth, particularly the incisors in the lower jaw. Ruminants have no upper incisors; they have a dental pad in place of upper incisors and 8 lower incisors (4 pairs: 2 centrals, 2 medials, 2 laterals, and 2 corners). The incisors erupt progressively as temporary (milk) teeth are replaced by permanent (adult) teeth. For cattle: at birth, the calf has temporary incisors; the first pair of permanent incisors (centrals) erupts at approximately 18 to 24 months; the second pair (medials) at 30 months; the third pair (laterals) at 36 months; and the fourth pair (corners) at 42 to 48 months, giving a full mouth of 4 pairs of permanent incisors. An animal with all 4 pairs of permanent incisors is described as a "full mouth" and is approximately 4 years old.

For sheep and goats, the eruption sequence is similar but faster: the first permanent pair erupts at approximately 12 to 15 months; a full mouth is reached at approximately 3 to 3.5 years. After reaching full mouth, age estimation becomes less precise; wear patterns (smooth, rounded, or missing teeth) indicate advanced age. Dentition-based age estimation is important for buying and selling livestock (older animals command different prices from young ones), for management decisions (culling old animals, selecting breeding stock), and for making reproductive records. A practical skill required of every animal husbandry student is being able to open an animal's mouth, examine the incisors, and give an approximate age.

Fill in the blank: A cattle with all four pairs of permanent incisors (described as a "_____ mouth") is approximately 4 years of age; the first pair of permanent centrals erupts at 18 to 24 months.

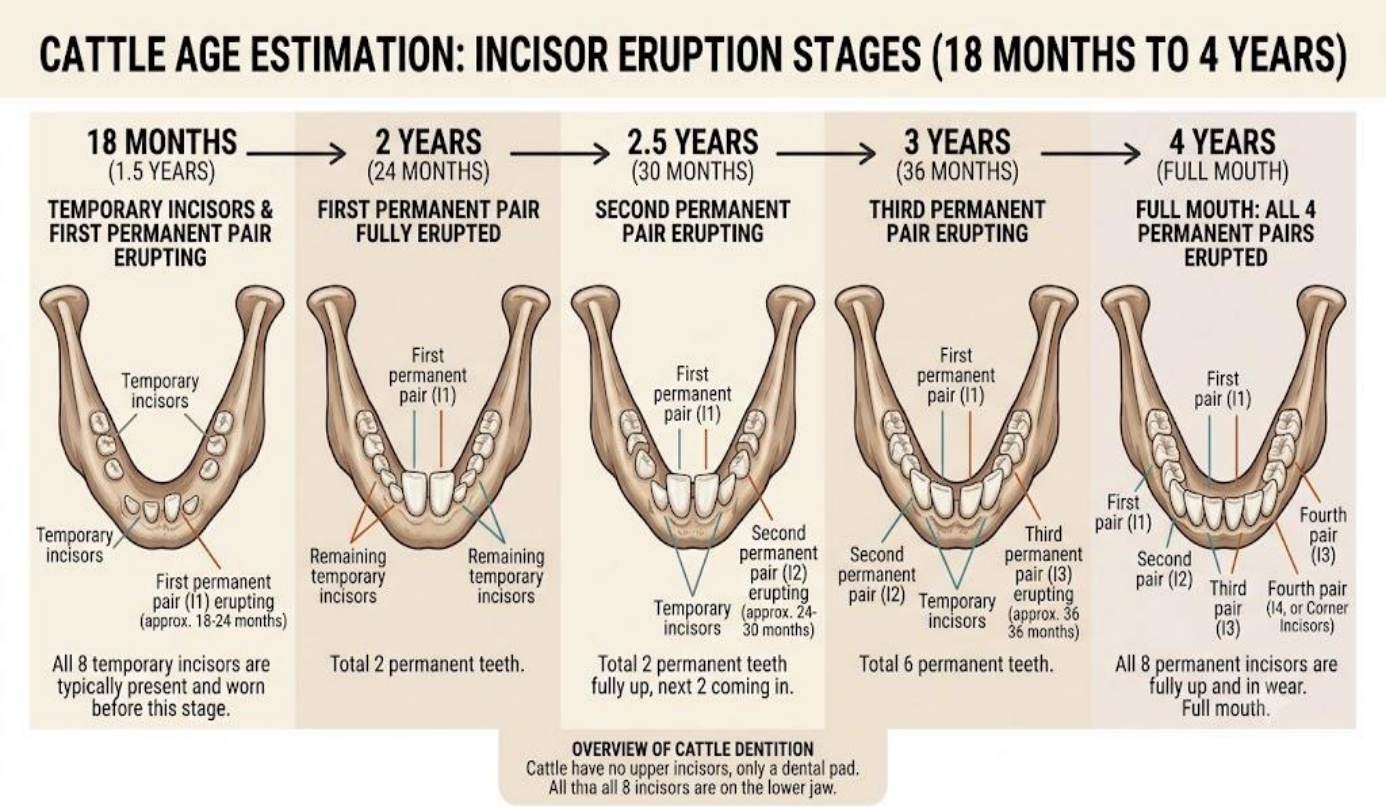


Figure 1.1: Diagram showing the progressive eruption of permanent incisors in cattle from 18 months to 4 years (full mouth)

### 1.2.3 External body parts and conformation

Knowing the names of the external body parts of ruminants is essential for accurate description in records, veterinary communication, and showing/judging livestock. The main body regions and parts of cattle are: head (poll, forehead, face, muzzle, eye, ear, horn); neck (crest, throat, dewlap); forequarters (shoulder, point of shoulder, brisket, foreleg: knee, pastern, hoof); barrel (back, loin, ribs, belly, flank); hindquarters (rump, pin bones, thurl, round, thigh, stifle, hock, hindleg: fetlock, pastern, hoof); udder and teats (in females); and tail head, tail, and switch. The withers is the highest point of the back, just behind the neck; height at the withers is the standard measurement of body height.

Conformation refers to the physical structure and form of an animal and indicates its capacity for production and soundness. Good beef conformation includes: a rectangular, deep body; well-developed hindquarters (the site of the most valuable cuts); a broad, level back; short, strong legs

set squarely under the body; and good muscling throughout. Good dairy conformation emphasises: a wedge-shaped body wider at the hindquarters than the front; angular frame; a large, capacious udder with evenly placed teats; and a pronounced backbone and prominent hip bones (indicating energy mobilisation for milk production). Conformation faults (sickle hocks, poor feet, pendulous udder, uneven teats) reduce the productive life and market value of an animal.

Fill in the blank: The _____ is the highest point of a ruminant's back, just behind the neck; body height is measured at this point from the ground.

*Pilot questions 1.2*

1. Give the correct livestock term for each of the following: an intact male sheep; a female goat; a young bovine before first calving; a castrated male bovine used for draught; the act of cattle giving birth.
2. Explain how to age a cow by its dentition, stating the age at which each pair of permanent incisors erupts.
3. A farmer is buying a ram at a market. The ram has two pairs of permanent incisors. Estimate the animal's approximate age.
4. Name five external body parts of cattle and state one practical use of knowing body part terminology.
5. Distinguish between beef conformation and dairy conformation in cattle.

## 1.3 Reproductive Parameters and Management

### 1.3.1 Reproductive cycle and puberty in ruminants

Puberty is the age at which an animal first becomes sexually mature and capable of reproduction. In cattle, puberty occurs at approximately 8 to 12 months in improved exotic breeds and 15 to 24 months in Nigerian zebu and indigenous breeds; heifers should not be bred until they have reached at least 60 to 65 per cent of their mature body weight to avoid stunting growth and difficult calving. In sheep, puberty occurs at approximately 5 to 7 months; ewes are usually first

mated at 7 to 9 months. In goats, puberty occurs at 4 to 6 months; does are first mated at 7 to 10 months. Rams and bucks mature slightly later than females of the same breed.

The oestrous cycle is the recurring cycle of hormonal and physiological changes that culminates in ovulation and the period of sexual receptivity (heat or oestrus) in the female. Cattle have an oestrous cycle of approximately 21 days (range 18 to 24 days); sheep approximately 17 days; goats approximately 21 days. The duration of heat (standing oestrus) is approximately 12 to 18 hours in cattle, 24 to 36 hours in sheep, and 24 to 48 hours in goats. Detection of heat is critical for timely mating or insemination; signs include restlessness, standing to be mounted, swollen and reddened vulva, and clear mucous discharge. The gestation period (length of pregnancy) is approximately 280 to 285 days in cattle; 147 to 155 days in sheep; and 148 to 155 days in goats.

Fill in the blank: The oestrous cycle of cattle is approximately _____ days; standing oestrus lasts approximately 12 to 18 hours, making timely heat detection critical for successful mating or insemination.

| Species | Puberty Age (months) | Age at First Mating (months) | Oestrous Cycle Length (days) | Duration of Heat (hours) | Gestation Period (days) | Litter Size |
|---|---|---|---|---|---|---|
| Cattle | 12–18 | 24–30 | 18–24 | 12–30 | ~280 | 1 |
| Sheep | 6–8 | 12–18 | 16–17 | 24–36 | ~150 | 1–3 |
| Goat | 5–7 | 10–15 | 18–21 | 24–48 | ~150 | 1–3 |

Table 1.2: Reproductive parameters of cattle, sheep, and goats

## 1.3.2 Mating systems and breeding ratios

The mating system is the method by which males and females are brought together for reproduction. Natural service involves allowing a male (bull, ram, or buck) to run with the females and mate naturally; it is the most common system in Nigerian village and pastoral production. Hand mating (controlled mating) involves the farmer introducing the male to the female only when she is in heat and supervising the mating; this gives more control over parentage records and reduces male injury from aggressive females. Artificial insemination (AI)

uses stored semen from superior bulls or rams to inseminate females; it is increasingly used in commercial and government cattle breeding programmes in Nigeria to spread the genetics of proven bulls rapidly.

The breeding ratio is the number of females per male that can be served in one breeding season. For bulls: 25 to 30 cows under natural service (pasture or paddock mating); up to 50 cows with hand mating; one superior bull via AI can serve thousands of cows. For rams: 30 to 50 ewes per ram in a flock. For bucks: 20 to 30 does per buck. Overloading a male leads to reduced conception rates, physical exhaustion, and injury; underutilising a male increases the cost of production. The breeding season is year-round in most Nigerian ruminant breeds (cattle, West African Dwarf sheep and goat are not strongly seasonal), though conception rates may vary with rainfall and feed availability.

Fill in the blank: Under natural service, a bull can serve approximately 25 to 30 cows in a season; a ram can serve _____ to 50 ewes per season; over-loading a male reduces conception rates and risks injury.

### 1.3.3 Pregnancy, parturition, and care of the young

Pregnancy diagnosis in cattle can be done by rectal palpation at 6 to 8 weeks post-service (feeling the embryo and foetal membranes through the rectal wall), ultrasonography (as early as 3 to 4 weeks in cattle), or progesterone assay of milk or blood. In sheep and goats, ultrasonography is the most reliable method; visual signs (increased abdominal girth, udder development, and behavioural changes) become apparent from mid-pregnancy. Heavily pregnant females should be provided with extra nutrition (steaming-up) during the last 6 to 8 weeks of pregnancy to build body reserves for lactation and to prevent pregnancy toxaemia (twin lamb disease), which occurs when energy demand exceeds intake in multiple-bearing ewes.

Parturition (calving, lambing, or kidding) should be supervised if possible. Signs of imminent parturition: the udder fills and teats become turgid 2 to 3 days before; the vulva softens and becomes oedematous; the pelvic ligaments relax. Normal parturition proceeds in three stages: cervical dilation (3 to 6 hours in cattle, shorter in sheep and goats); delivery of the foetus (30 minutes to 2 hours in cattle); and expulsion of the foetal membranes (within 6 to 8 hours in

cattle; retention beyond 12 to 24 hours is abnormal and requires veterinary attention). The new-born should receive colostrum within the first 6 hours of life to absorb maternal immunoglobulins before intestinal permeability closes at approximately 24 to 36 hours. Failure to absorb colostral immunoglobulins is a major cause of new-born mortality.

Fill in the blank: The new-born ruminant must receive _____ within the first 6 hours of life to absorb maternal immunoglobulins before intestinal permeability closes at 24 to 36 hours post-birth.

*Pilot questions 1.3*

1. State the age at puberty and the recommended age at first mating for cattle, sheep, and goats.
2. Describe three signs of oestrus in a cow and explain why timely heat detection is critical.
3. Distinguish between natural service, hand mating, and artificial insemination as mating systems.
4. Describe the three stages of parturition in cattle.
5. Explain why colostrum is critical for the survival of the new-born ruminant.

## 1.4 The Beef, Dairy, and Small Ruminant Industries

### 1.4.1 The beef cattle industry in Nigeria

The Nigerian beef industry is built largely on extensive pastoral and agropastoral production systems dominated by the Fulani ethnic group, who herd zebu cattle (primarily White Fulani, Sokoto Gudali, and Red Bororo breeds) across vast ranges in the north. Cattle are raised primarily on natural pastures and crop residues, with little supplementary feeding; they are sold as finished steers at markets or driven to abattoirs in major cities. The Kano and Lagos abattoir complexes are the largest in Nigeria. Most Nigerian cattle are slaughtered at relatively low body weights (180 to 220 kg carcass weight) and advanced ages (4 to 6 years) compared with improved beef production systems globally, reflecting the lack of finishing operations and the use of cattle primarily as store animals and walking banks rather than meat production units.

Feedlot finishing (fattening young steers or bulls on high-energy diets for 90 to 180 days before slaughter) is practised at small to medium commercial scale around major cities and during the Ramadan period (when beef demand spikes). The Nigerian beef industry faces challenges including: low off-take rate from the national herd; seasonal price volatility (beef is cheapest during eid-el-kabir when many animals are slaughtered simultaneously); inadequate abattoir infrastructure; poor cold chain (most beef is sold fresh, not chilled); and farmer-herder conflict over grazing land. Government and private sector initiatives to improve beef production include restocking programmes, feedlot development, and rangeland management projects.

Fill in the blank: Most Nigerian beef cattle are slaughtered at 4 to 6 years at carcass weights of 180 to 220 kg; feedlot _____ involves feeding young steers on high-energy diets for 90 to 180 days before slaughter to increase carcass weight and quality.

## 1.4.2 The dairy industry in Nigeria

Nigeria's dairy industry is dominated by informal milk production and marketing by Fulani pastoralists. Fresh milk (collected twice daily by hand-milking) is sold in calabashes or plastic containers, or processed into wara (soft cheese), nono (soured milk), and fura de nono (fermented milk with millet balls) at roadsides and in markets. Indigenous Fulani cattle (White Fulani, Sokoto Gudali) produce approximately 2 to 5 litres of milk per day over a lactation of 150 to 200 days; much of the potential milk yield is suckled directly by the calf and never collected for sale. Commercial dairy farming using exotic or crossbred dairy cattle (Holstein-Friesian, Jersey, or Friesian x White Fulani crosses) exists at government-owned farms (NAPRI Shika, Agricultural Development Farms) and a small number of private commercial farms, primarily around Kaduna, Kano, Vom, and Lagos.

The commercial dairy sub-sector faces severe challenges: insufficient numbers of improved dairy cows; inadequate cool chain for fresh milk; poor veterinary services; high cost of imported dairy cattle genetics; competition from cheap imported powdered milk; and limited market infrastructure for processed dairy products. Nigeria imports approximately 1.3 billion litres of liquid milk equivalent per year at a cost of over USD 1 billion. The Federal Government's National Dairy Policy and various state government dairy development programmes aim to

reduce import dependence by expanding the commercial dairy herd and building milk processing capacity.

Fill in the blank: Nigeria imports approximately 1.3 billion litres of liquid milk _____ per year; indigenous Fulani cattle produce only 2 to 5 litres per day while improved exotic cows can produce 15 to 30 litres per day.

### 1.4.3 The sheep and goat industry in Nigeria

Sheep and goat production in Nigeria is characterised by smallholder ownership (1 to 10 animals per household), scavenging on village wastes and communal grazing, and minimal input use. West African Dwarf sheep and goats (the dominant breeds in the south and Middle Belt) and Sahel/Uda/Yankasa sheep and Red Sokoto/Maradi goats (dominant in the north) are kept under semi-intensive and extensive systems. Small ruminants are important as a readily realisable financial asset: they can be sold quickly to meet cash needs, require little capital, and reproduce rapidly. The demand for small ruminants peaks during eid-el-kabir (Eid al-Adha), when millions of rams are required for ritual slaughter, driving seasonal price spikes.

Commercial small ruminant production (intensive pen-fattening of lambs, kids, and rams) is growing around major Nigerian cities. Key challenges include: high kid and lamb mortality (30 to 50 per cent in the first month of life under traditional management); endemic diseases (contagious ecthyma, PPR, fascioliasis); inadequate veterinary extension; predation; and theft. The export potential of Nigerian goat products (particularly dried and smoked goat meat) to the Nigerian diaspora in Europe and North America is an emerging opportunity. Research programmes at NAPRI and NIHORT continue to work on improving the productivity of Nigerian small ruminant breeds.

Fill in the blank: Kid and lamb mortality under traditional management in Nigeria is estimated at 30 to _____ per cent in the first month of life; major causes include inadequate colostrum uptake, diarrhoea, and pneumonia.

| Challenges | Opportunities |
|---|---|
| **Inadequate veterinary services** | Growing urban meat and milk demand |

| | |
|---|---|
| **Farmer–herder conflict** | Eid-el-Kabir seasonal demand for small ruminants |
| **Poor infrastructure** | Leather industry demand for hides and skins |
| **High young-stock mortality** | Diaspora market for processed goat products |
| **Cheap imported dairy products** | Government dairy development programmes |
| **Low offtake rates** | |

Box 1.1: Challenges and opportunities in the Nigerian ruminant livestock industry

*Pilot questions 1.4*

1. Describe the dominant production system for beef cattle in Nigeria and explain its main limitations.
2. Explain what feedlot finishing is and state two benefits it offers over traditional beef production.
3. Describe the dairy industry in Nigeria and explain why it cannot meet domestic demand.
4. State four challenges facing the Nigerian small ruminant industry.
5. Explain why small ruminants are particularly valuable as a financial asset for Nigerian smallholder farm families.

## Series Summary

This Series introduced the fundamentals of ruminant animal husbandry. We defined ruminants (even-toed mammals with a multi-compartment stomach that practice rumination) and described their unique ability to digest fibrous feeds through rumen microbial fermentation. We classified the main ruminant species in Nigeria (approximately 20 million cattle, 40 million sheep, 75 million goats) and explained their economic and social importance (meat, milk, hides, draught, manure, bride price, sacrifice). We introduced standard livestock terminology for cattle, sheep, and goats; explained age estimation by dentition (permanent incisor eruption from 18 months in cattle to full mouth at 4 years); and described external body parts and conformation.

We covered the reproductive parameters of cattle, sheep, and goats (puberty, oestrous cycle length, heat duration, gestation period), the three mating systems (natural service, hand mating, AI), and recommended breeding ratios. We described the three stages of parturition and the

critical importance of colostrum within the first 6 hours of birth. Finally, we surveyed the beef industry (pastoral and agropastoral systems, feedlot finishing, low offtake, abattoir challenges), the dairy industry (Fulani pastoral informal, small commercial sector, 1.3 billion litre import deficit), and the small ruminant industry (smallholder scavenging systems, eid-el-kabir demand, high kid and lamb mortality). By completing this Series, you should be able to achieve all eight Series Learning Outcomes (SLO 1.1 to SLO 1.8).

## Glossary of Terms

- **Abomasum:** the fourth and true stomach compartment of a ruminant, where enzymatic digestion similar to that in a simple-stomach animal occurs.
- **Artificial insemination (AI):** the introduction of collected and stored semen into the female reproductive tract by artificial means; allows rapid genetic improvement and disease control.
- **Bull:** an intact (uncastrated) male bovine.
- **Buck (billy):** an intact male goat.
- **Calving:** the process by which a cow gives birth.
- **Chevon:** meat from goats; also called goat meat.
- **Colostrum:** the first milk produced after parturition, rich in immunoglobulins (maternal antibodies), vitamins, and nutrients; essential for the passive immunity and survival of the new-born.
- **Conformation:** the physical structure and form of a livestock animal; indicates its capacity for production and soundness.
- **Cow:** a mature female bovine that has calved at least once.
- **Dam:** the mother (female parent) of a calf, lamb, or kid.
- **Dental pad:** the firm, fleshy structure in the upper jaw of ruminants that replaces the upper incisor teeth; used in conjunction with the lower incisors to prehend (grasp) feed.
- **Doe (nanny):** a female goat.

- **Dry period:** the period between the end of one lactation and the next calving during which the cow's udder is not being milked.
- **Ewe:** a female sheep.
- **Feedlot finishing:** the intensive feeding of cattle (or small ruminants) on high-energy diets in a confined facility for a defined period before slaughter to increase weight and carcass quality.
- **Full mouth:** a term describing a ruminant that has all four pairs of permanent incisors; indicates an age of approximately 4 years in cattle and 3 to 3.5 years in sheep and goats.
- **Gestation period:** the length of pregnancy from conception to parturition; approximately 280 to 285 days in cattle, 147 to 155 days in sheep, and 148 to 155 days in goats.
- **Heifer:** a young female bovine that has not yet calved.
- **Kid:** a young goat up to weaning or one year of age.
- **Kidding:** the process by which a doe (female goat) gives birth.
- **Lamb:** a young sheep up to weaning or one year of age.
- **Lambing:** the process by which a ewe (female sheep) gives birth.
- **Oestrous cycle:** the recurring cycle of hormonal and physiological changes in the female reproductive system culminating in ovulation; approximately 21 days in cattle and goats, 17 days in sheep.
- **Oestrus (heat):** the period of sexual receptivity in the female ruminant during which she will accept mating; 12-18 hours in cattle, 24-48 hours in sheep and goats.
- **Ox (plural oxen):** a castrated male bovine trained for draught work.
- **Parturition:** the process of giving birth; also called calving (cattle), lambing (sheep), or kidding (goats).
- **Puberty:** the age at which an animal first becomes sexually mature and capable of reproduction.
- **Ram:** an intact male sheep.

- **Rumination:** the process of regurgitating partially digested feed (cud) from the rumen and re-chewing it to break it into smaller particles for further fermentation; the defining behaviour of ruminants.
- **Sire:** the father (male parent) of a calf, lamb, or kid.
- **Steer:** a castrated male bovine not used for draught.
- **Steaming-up:** the practice of providing extra nutrition to a heavily pregnant female in the last 6-8 weeks of pregnancy to build body reserves for lactation.
- **Wether:** a castrated male sheep or goat.
- **Withers:** the highest point of the back of a ruminant, just behind the neck; the standard point from which body height is measured.

## Concept Check Questions [Series 1]

Objective Questions

1. Ruminants digest fibrous feeds through microbial _____ in the rumen, allowing them to utilise cellulose that non-ruminants cannot digest. (Linked to SLO 1.1)
2. Nigeria has approximately 20 million cattle, 40 million sheep, and _____ million goats in its national herd. (Linked to SLO 1.2)
3. A cattle with all four pairs of permanent incisors (described as a "_____ mouth") is approximately 4 years old. (Linked to SLO 1.5)
4. The oestrous cycle of cattle is approximately _____ days, and standing oestrus lasts 12 to 18 hours. (Linked to SLO 1.6)
5. The new-born ruminant must receive _____ within the first 6 hours of life to absorb maternal immunoglobulins before intestinal permeability closes. (Linked to SLO 1.7)

Short-Answer Questions

6. State four characteristics that distinguish ruminants from non-ruminant livestock. (Linked to SLO 1.1)
7. Give the correct term for each: intact male sheep; female goat; young bovine before first calving; castrated male used for draught; act of a cow giving birth. (Linked to SLO 1.4)
8. Describe the three stages of parturition in cattle. (Linked to SLO 1.7)
9. Distinguish between natural service, hand mating, and AI, and state the recommended breeding ratio for bulls under natural service. (Linked to SLO 1.6)
10. State four challenges facing the Nigerian beef cattle industry. (Linked to SLO 1.8)

Long-Answer Questions

11. Describe the definition, classification, economic importance, and social significance of ruminant animals in Nigeria. (Linked to SLOs 1.1, 1.2, 1.3)
12. Describe the reproductive parameters of cattle, sheep, and goats, covering puberty, oestrous cycle, heat signs, gestation, mating systems, and parturition; and explain the care of the new-born ruminant. (Linked to SLOs 1.6, 1.7)
13. Describe the structure, challenges, and opportunities of the beef, dairy, and small ruminant industries in Nigeria. (Linked to SLO 1.8)

## Answers to Concept Check Questions [Series 1]

Objective Questions

1. Fermentation.
2. 75.
3. Full.
4. 21.
5. Colostrum.

Short-Answer Questions

6. Any four: multi-compartment stomach (rumen, reticulum, omasum, abomasum); ability to digest cellulose through rumen microbial fermentation; absence of upper incisor teeth (dental pad instead); even-toed hooves; regurgitation and re-chewing of cud (rumination); rumen microbes synthesise B vitamins and microbial protein.
7. Intact male sheep: ram; female goat: doe or nanny; young bovine before first calving: heifer; castrated male used for draught: ox; act of a cow giving birth: calving.
8. Stage 1 (cervical dilation): 3 to 6 hours in cattle; the cervix dilates and the foetus positions itself for delivery. Stage 2 (delivery of the foetus): 30 minutes to 2 hours; the foetus passes through the birth canal and is expelled. Stage 3 (expulsion of foetal membranes): normally within 6 to 8 hours; retained placenta beyond 12 to 24 hours is abnormal and requires veterinary attention.
9. Natural service: the male runs with the females and mates naturally; most common in Nigerian pastoral systems; breeding ratio: 25-30 cows per bull. Hand mating: the male is introduced to an individual female in heat under supervision; gives better parentage records. AI: stored semen from superior males used to inseminate females; one bull can serve thousands of cows; allows rapid genetic improvement.
10. Any four: low off-take rate from the national herd (cattle kept as walking banks, not primarily as meat production units); cattle slaughtered at low weights and advanced ages; seasonal price volatility around eid-el-kabir; inadequate abattoir infrastructure; poor cold chain for fresh beef; farmer-herder conflict over grazing land; inadequate feedlot and finishing operations.

Long-Answer Questions

11. Definition: a ruminant is an even-toed hoofed mammal that digests fibrous plant food by rumination (re-chewing cud) and rumen microbial fermentation. Characteristics: multi-compartment stomach (rumen, reticulum, omasum, abomasum); cellulose digestion by rumen microbes producing cellulases; no upper incisors (dental pad); even-toed hooves; rumination. Classification: Bovidae (cattle, sheep, goat, buffalo, bison); Cervidae (deer); Giraffidae (giraffe); Camelidae (pseudo-ruminants: camels, llamas). Nigerian species: cattle (Bos indicus zebu and Bos taurus taurine; ~20 million); sheep (Ovis aries; ~40 million); goats (Capra hircus; ~75 million). Economic importance: meat (beef, mutton, chevon); milk (fura de nono, wara, nono); hides and skins (leather export from Kano, Sokoto, Kaduna); draught power (oxen for cultivation in north); manure (soil fertility); 5-8% GDP contribution. Social importance: cattle as bride price

(bride wealth) in northern cultures; small ruminants sacrificed at naming ceremonies, weddings, funerals; herd size as social status indicator among Fulani pastoralists.

12. Puberty: cattle 8-12 months (exotic) to 15-24 months (zebu/indigenous); sheep 5-7 months; goats 4-6 months. First mating: cattle heifers at 60-65% mature body weight; sheep ewes 7-9 months; does 7-10 months. Oestrous cycle: cattle 21 days; sheep 17 days; goats 21 days. Heat duration: cattle 12-18 hours; sheep 24-36 hours; goats 24-48 hours. Heat signs in cattle: restlessness; standing to be mounted by other cattle; swollen reddened vulva; clear mucous discharge; reduced milk production; off feed. Gestation: cattle 280-285 days; sheep 147-155 days; goats 148-155 days. Mating systems: natural service (male with herd, 25-30 cows/bull); hand mating (supervised individual service); AI (stored semen, one bull serves thousands). Parturition stages: Stage 1 (cervical dilation, 3-6 hrs); Stage 2 (foetal delivery, 30 min-2 hrs); Stage 3 (placental expulsion, within 6-8 hrs; retention beyond 12-24 hrs needs vet). Care of new-born: ensure colostrum within first 6 hrs to absorb maternal immunoglobulins before intestinal permeability closes at 24-36 hrs; failure = major cause of new-born mortality; disinfect navel with iodine; identify (tag/brand); weigh and record; ensure warmth; monitor for suckling.
13. Beef industry: dominated by Fulani pastoralists (White Fulani, Sokoto Gudali, Red Bororo zebu breeds) on extensive ranges in north; natural pastures and crop residues, minimal supplementary feeding; slaughter at 4-6 years at 180-220 kg carcass weight (low compared with improved systems); feedlot finishing (90-180 days on high-energy diet) practised near cities and during Ramadan; challenges: low off-take, seasonal price volatility, poor abattoir infrastructure, no cold chain, farmer-herder conflict. Dairy industry: dominated by informal Fulani pastoral milk (fresh milk, wara cheese, nono, fura de nono); indigenous cows 2-5 L/day, 150-200 day lactation; commercial dairy at government farms (NAPRI Shika, Vom) and private farms around Kaduna, Kano, Lagos using Holstein-Friesian crosses (15-30 L/day); challenges: insufficient improved cows, no cool chain, expensive imported genetics, cheap imported powdered milk competition; Nigeria imports 1.3 billion litres milk equivalent per year; National Dairy Policy targets import substitution. Small ruminant industry: smallholder (1-10 animals) scavenging and communal grazing; WAD sheep and goats (south and Middle Belt); Yankasa/Uda/Sahel sheep and Red Sokoto/Maradi goats (north); important as readily realisable financial asset; eid-el-kabir peak demand; challenges: 30-50% kid/lamb mortality in first month (inadequate colostrum, diarrhoea, pneumonia); PPR; PPR; fascioliasis; inadequate vet extension; commercial pen-fattening growing around cities.

## Answers to Pilot Questions [Series 1]

Part 1.1

1. A ruminant is an even-toed hoofed mammal that digests plant-based food by initially softening it in the rumen, then regurgitating the partially digested mass (cud) and re-chewing it, a process called rumination. Four distinguishing characteristics: (1) multi-compartment stomach (rumen, reticulum, omasum, abomasum) rather than the single stomach of pigs and poultry; (2) ability to digest cellulose through rumen microbial fermentation using cellulase enzymes produced by rumen bacteria, protozoa, and fungi; (3) absence of upper incisor teeth, replaced by a dense dental pad used with the lower incisors to grasp forage; (4) even-toed hooves (two functional toes per foot) and the behaviour of rumination (chewing the cud) after initial ingestion of feed.
2. The multi-compartment stomach of ruminants, particularly the rumen, harbours a dense community of bacteria, protozoa, and fungi that produce cellulase and hemicellulase enzymes, breaking the beta-1,4-glycosidic bonds of cellulose and hemicellulose in plant cell walls. Pigs and poultry lack these enzymes and cannot break down plant cell wall fibre; feed components like grass, crop residues, straw, and browse pass through their simple stomachs largely undigested and are therefore not suitable as major dietary components. Ruminants ferment these fibrous feeds in the rumen into volatile fatty acids (mainly acetate, propionate, and butyrate), which are absorbed through the rumen wall and used as the primary energy source. This ability means ruminants do not compete with humans or monogastric livestock for grain-based feeds and can convert land unsuitable for crops into animal protein.
3. Cattle (Bos indicus and Bos taurus): approximately 20 million head; the most important large ruminant in Nigeria. Sheep (Ovis aries): approximately 40 million head. Goats (Capra hircus): approximately 75 million head; Nigeria is among the top five countries globally for goat population.
4. Any six: (1) meat production (beef, mutton, chevon constitute the majority of meat consumed in Nigeria); (2) milk production (fresh milk, wara, nono, fura de nono produced by Fulani pastoralists and commercial dairy farmers); (3) hides and skins production (raw material for Nigeria's significant leather export industry, particularly from Kano, Sokoto, and Kaduna); (4) draught power (oxen provide cultivation traction in the north, reducing human drudgery); (5) manure production (farmyard manure improves soil fertility and reduces the need for chemical

fertilisers); (6) savings and investment (livestock is a form of savings that can be liquidated at any time; cattle are used as bride price and as expressions of wealth); (7) contribution to GDP (5-8% direct contribution from livestock sector).

5. Cattle serve as bride price (bride wealth) in many northern Nigerian cultures: a prospective groom's family negotiates and pays a bride price in cattle to the bride's family, making cattle ownership essential for marriage and social advancement. Among Fulani pastoral communities, herd size is a direct indicator of social status, wealth, and respect; a Fulani man with a large herd commands greater authority in his community. Small ruminants (sheep and goats) are sacrificed at major social events: rams are slaughtered at eid-el-kabir (Eid al-Adha) as an act of religious devotion; goats and sheep are slaughtered at naming ceremonies, weddings, and funerals across all ethnic groups in Nigeria, providing both communal meat and demonstrating the host's generosity. The cultural and social demand for livestock is an important driver of livestock prices and production incentives.

Part 1.2

1. Intact male sheep: ram; female goat: doe or nanny; young female bovine before first calving: heifer; castrated male bovine used for draught: ox (plural oxen); act of a cow giving birth: calving.
2. Ageing cattle by dentition: examine the lower incisor arcade (ruminants have no upper incisors, only a dental pad). A young calf has 8 temporary (milk) incisors. Permanent incisors erupt progressively, replacing the temporary ones, as follows: first permanent pair (central incisors) erupts at approximately 18 to 24 months; second permanent pair (medials, adjacent to the centrals) at approximately 24 to 30 months; third permanent pair (laterals) at approximately 30 to 36 months; fourth permanent pair (corner incisors) at approximately 42 to 48 months. When all four pairs of permanent incisors are present (described as "full mouth") the animal is approximately 4 years old. After full mouth, further ageing relies on the degree of wear, which is less precise.
3. The ram has two pairs of permanent incisors. In sheep, the permanent incisor eruption sequence parallels that in cattle but is faster: the first pair erupts at approximately 12 to 15 months; the second pair at approximately 18 to 24 months. A ram with two pairs of permanent incisors is therefore approximately 18 to 24 months old, or approximately 1.5 to 2 years of age. This would be described as a "two-tooth" or "two-permanent-tooth" ram.

4. Any five: poll (top of the head); muzzle (the lips and nose); dewlap (fold of skin hanging from the throat and brisket area); withers (highest point of the back behind the neck; point of height measurement); flank (the side of the animal between the ribs and the hindquarters); hock (the large joint in the hind leg, equivalent to the human ankle); udder (the milk-producing gland of the female); brisket (the chest floor between the forelegs); rump (the upper area of the hindquarters from the hip bones to the tail). Practical use of body part terminology: accurate communication with veterinarians (locating the site of an injury, disease lesion, or injection); recording identification and description of individual animals in farm records; evaluating conformation at livestock shows and markets; describing the location of external parasites or lesions in health monitoring.
5. Beef conformation: a good beef animal has a rectangular, blocky, deep body; well-developed, rounded hindquarters (the primary site of high-value beef cuts: rump, round, sirloin); a broad, level back; wide, thick loin; short, strong legs set squarely under the body; deep chest and full brisket; heavy muscling throughout with a smooth, well-filled topline. Dairy conformation: a good dairy animal has a wedge-shaped or triangular body profile, wider at the hindquarters than at the front; angular frame with prominent bones (indicating lean, energy-mobilising type); well-attached, capacious, symmetrical udder with four evenly placed teats of uniform size; prominent backbone and visible hip bones; long, lean neck; large, open nostrils and bright eyes. The key conceptual difference is that beef conformation emphasises muscle development and meat yield, while dairy conformation emphasises the capacity for high feed intake, efficient conversion of feed to milk, and udder structure that supports sustained high milk production.

Part 1.3

1. Cattle: puberty at 8-12 months (exotic improved breeds) or 15-24 months (Nigerian zebu and indigenous breeds); first mating recommended at 15-18 months (exotic) or 24-30 months (zebu) when the heifer has reached at least 60-65% of her expected mature body weight. Sheep: puberty at 5-7 months; first mating recommended at 7-9 months. Goats: puberty at 4-6 months; first mating recommended at 7-10 months. Early mating before adequate body development leads to dystocia (difficult birth), stunted growth, and poor lifetime productivity.
2. Three signs of oestrus in a cow: (1) standing to be mounted (the cow stands still and accepts mounting by other cows or a bull; the most reliable single sign of oestrus, known as "standing heat"); (2) restlessness and bellowing (the cow in heat moves around the pen or pasture more than

usual, vocalises frequently, and may mount other cows herself); (3) physical signs (the vulva becomes swollen, reddened, and moist; a clear, stringy mucous discharge is visible from the vulva; the tail area and rump may be dirty from mounting by other cattle). Timely heat detection is critical because the window for successful insemination or mating is very narrow: standing heat in cattle lasts only 12 to 18 hours, and ovulation occurs approximately 10 to 14 hours after the end of standing heat; if the animal is missed, the farmer must wait another full 21-day cycle, losing 3 weeks of reproductive time and production potential.

3. Natural service: the bull, ram, or buck is allowed to run with the females in the same paddock or pasture; he detects females in heat by smell (flehmen response) and mates them without farmer intervention; widely used in Nigerian pastoral and smallholder systems because it requires no farmer skill or intervention; disadvantage: parentage records may be uncertain, the male may overwork himself, risk of venereal disease transmission, and the farmer cannot control the timing of matings. Hand mating (controlled service): the farmer observes females for signs of heat and brings the male to the female only when she is in oestrus; the mating is supervised; the male is returned to his pen after mating; this system keeps cleaner parentage records, reduces risk of injury, and allows better utilisation of a high-quality male. Artificial insemination (AI): semen is collected from superior males (often at distant semen collection centres), extended, frozen in liquid nitrogen, and transported to the farm; a trained AI technician thaws the semen and deposits it in the female's reproductive tract using a long metal or plastic pipette during oestrus; AI enables one superior bull to serve thousands of cows; it allows import of improved exotic genetics without importing live animals, and it prevents transmission of venereal diseases.
4. Three stages of parturition in cattle: Stage 1 (preparatory stage or cervical dilation): lasts 3 to 6 hours; the uterine muscles begin contracting, the cervix dilates progressively to allow passage of the foetus, and the foetus rotates into the correct position (anterior presentation: forefeet first, head resting on forelegs); the cow shows restlessness, switching her tail, getting up and lying down repeatedly; signs are similar to colic. Stage 2 (expulsion of the foetus): lasts 30 minutes to 2 hours; the amniotic sac may appear at the vulva; the cow strains forcefully with each uterine contraction; the forelegs, then the head, then the rest of the foetal body are expelled; veterinary assistance (calving aid, manual correction of malpresentation) should be sought if stage 2 exceeds 2 hours without progress. Stage 3 (expulsion of the foetal membranes or afterbirth): normally within 6 to 8 hours after calving; uterine contractions expel the placenta; manual removal of the placenta within 6 hours is not recommended as this may cause haemorrhage and uterine damage; retention beyond 12 to 24 hours is abnormal and requires veterinary treatment (often with antibiotics and prostaglandins).

5. Colostrum is critical for the survival of the new-born ruminant for three reasons: (1) Passive immunity: the new-born ruminant is born without circulating immunoglobulins (maternal antibodies do not cross the ruminant placenta) and is therefore completely vulnerable to infection; immunoglobulins (IgG, IgM, IgA) in colostrum can be absorbed directly across the intestinal wall into the bloodstream only during the first 24 to 36 hours of life, when the gut is permeable to large protein molecules; after this window closes, immunoglobulins are digested like any other protein and no longer provide systemic immunity; the first 6 hours of life are critical because gut permeability and colostrum immunoglobulin concentration are both highest at this time. (2) Nutrition: colostrum contains 2 to 3 times more protein, more fat, more vitamins (especially A, D, and E), and more minerals than mature milk, providing concentrated nutrition for the new-born that needs to sustain itself after birth. (3) Gut development: colostrum contains growth factors and hormones (insulin, IGF-1) that stimulate the development and maturation of the intestinal epithelium of the new-born, preparing it for efficient digestion of subsequent milk and eventually solid feed.

Part 1.4

1. Dominant production system: the Nigerian beef industry is built on extensive pastoral and agropastoral production dominated by the Fulani ethnic group who move their zebu cattle herds (White Fulani, Sokoto Gudali, Red Bororo) seasonally across large areas in the north following rainfall and pasture availability; cattle are grazed on natural pastures and crop residues with no or minimal supplementary feeding; they are not specifically managed as meat production units but serve as a form of savings and social capital. Main limitations: low carcass yield (cattle slaughtered at 4-6 years of age at carcass weights of only 180-220 kg); low reproductive efficiency (long calving intervals; high calf mortality); inadequate animal health services on the range; inadequate water and pasture during the dry season; high cost and risk of driving cattle long distances to abattoirs (weight loss, injury, theft); seasonal price volatility at eid-el-kabir; and farmer-herder conflict over arable land.
2. Feedlot finishing is the intensive feeding of cattle (or small ruminants) on high-energy diets (grain, molasses, agricultural by-products such as brewery waste, cotton seed cake) in a confined facility (feedlot pen) for a defined period (90 to 180 days) before slaughter. Two benefits over traditional production: (1) Increased carcass weight and quality: feedlot-finished cattle reach slaughter weight faster and at a heavier, more uniform carcass weight (300-350 kg versus 180-

220 kg from pasture systems); the diet produces more intramuscular fat (marbling) and firmer, better-quality meat that commands premium prices in high-end restaurants and export markets. (2) Reduced slaughter age: feedlot cattle can be slaughtered at 18-24 months rather than 4-6 years, significantly improving the efficiency of beef production per unit of land and total feed consumed.

3. Nigeria's dairy industry is dominated by informal milk production by Fulani pastoralists who milk indigenous zebu cattle (White Fulani, Sokoto Gudali) by hand twice daily and sell fresh milk, wara (soft cheese), nono (soured milk), and fura de nono along migration routes and at urban markets; indigenous cows produce only 2 to 5 litres per day over a lactation of 150 to 200 days, and much of this is suckled by the calf and never collected. A small commercial dairy sector uses exotic and crossbred dairy cattle (Holstein-Friesian, Jersey, Friesian x White Fulani) at government farms (NAPRI Shika, Vom) and private farms around Kaduna, Kano, and Lagos; these cows produce 15 to 30 litres per day. The industry cannot meet domestic demand because: the total number of improved dairy cows is very small relative to the population; there is no cold chain for fresh milk in most of Nigeria, causing rapid spoilage; the cost of importing and maintaining exotic dairy genetics is high; cheap imported powdered milk (subsidised in the countries of origin) undercuts domestic fresh milk prices; and the lack of processing capacity limits the development of value-added dairy products.
4. Any four challenges: (1) high kid and lamb mortality (30-50% in the first month of life) due to inadequate colostrum intake, neonatal diarrhoea, pneumonia, and hypothermia; (2) endemic diseases: PPR (Peste des Petits Ruminants), contagious ecthyma (orf), fascioliasis (liver fluke), trypanosomiasis, and foot rot significantly reduce productivity and cause mortality; (3) inadequate veterinary and extension services: most smallholder goat and sheep keepers have no access to routine vaccination, deworming, or veterinary consultation; (4) predation and theft: particularly for free-ranging animals; (5) inadequate feeding: scavenging animals during the dry season when vegetation is scarce leads to poor body condition, reduced conception rates, and low birth weights; (6) lack of improved breeds and genetic resources for smallholders.
5. Small ruminants are particularly valuable as a financial asset for Nigerian smallholder families for five reasons: (1) rapid capital appreciation: sheep and goats reproduce faster than cattle (shorter gestation, earlier puberty, frequent twinning in some breeds), meaning a small initial investment grows rapidly into a larger flock; (2) easily liquidated: a goat or sheep can be sold quickly at any local market without the logistical challenges of transporting a large animal; (3) divisible: unlike a cow (which represents a large indivisible sum), a family can sell one or two goats to meet a small cash need without losing the entire herd; (4) modest capital requirement: a

single ewe or doe costs far less than a cow, making small ruminant ownership accessible to the poorest farm families; (5) seasonal premium: market prices for rams and bucks spike dramatically before eid-el-kabir, rewarding farmers who time their sales appropriately with a significant profit margin over rearing cost.

## References and Attributions [Series 1]

Textual References (Books and External Sources)


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Figures, Plates, Tables, and Boxes

- Table 1.1: Classification of ruminant species in Nigeria Attribution: AI generated. Suggested OER search string: "ruminant animals Nigeria cattle sheep goat classification economic importance OER table".
- Figure 1.1: Cattle dentition and age estimation diagram Attribution: AI generated. Suggested OER search string: "cattle age dentition incisors permanent eruption stages diagram OER".
- Table 1.2: Reproductive parameters of cattle, sheep, and goats Attribution: AI generated. Suggested OER search string: "reproductive parameters cattle sheep goats puberty oestrous cycle gestation table OER".
- Box 1.1: Challenges and opportunities in the Nigerian ruminant livestock industry Attribution: AI generated. Suggested OER search string: "Nigerian ruminant livestock industry challenges opportunities beef dairy small ruminants OER box".

**Course code: AGE 402**

**Course title: Husbandry of Ruminant Animals**

# Series 2: Breeds, Characteristics, and Digestive Anatomy of Ruminants

- **Part 2.1: Cattle Breeds**
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  - Sub Part 2.1.2: Exotic cattle breeds and their use in Nigeria
  - Sub Part 2.1.3: Crossbreeding for breed improvement
- **Part 2.2: Sheep and Goat Breeds**
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- **Part 2.3: Digestive Anatomy of Ruminants**
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- **Part 2.4: The Physiology of Digestion**
  - Sub Part 2.4.1: Feed intake, prehension, and rumination
  - Sub Part 2.4.2: Fermentation products and their utilisation
  - Sub Part 2.4.3: Digestive disorders and their prevention

## Introduction

Knowing the breeds of ruminants available to Nigerian farmers, their characteristics, and their suitability to local conditions is fundamental to making sound management decisions. Equally important is understanding the digestive anatomy that makes ruminants unique: the four-compartment stomach enables them to convert fibrous feeds that other livestock cannot digest, but it also creates specific nutritional and health constraints that the manager must understand. This Series covers Nigerian and exotic breeds of cattle, sheep, and goats; the general characteristics of ruminants; the anatomy and function of the ruminant digestive tract; and the physiology of digestion including fermentation, fermentation products, and common digestive disorders.

The breed and anatomy content of this Series directly underpins the feeding, nutrition, housing, and health topics of Series 3, 4, and 5. A student who can identify the major Nigerian breeds, understand why crossbreeding is practiced, and explain what happens in each stomach compartment is equipped to understand why specific management practices are recommended.

## Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 2.1** describe the major indigenous cattle breeds of Nigeria and state their characteristics and production uses (Linked to Part 2.1),
- **SLO 2.2** describe the major exotic cattle breeds used in Nigeria and explain the objectives of crossbreeding (Linked to Part 2.1),
- **SLO 2.3** describe the major sheep and goat breeds of Nigeria and state their characteristics (Linked to Part 2.2),
- **SLO 2.4** list the general characteristics that distinguish ruminant animals from other livestock (Linked to Part 2.2),
- **SLO 2.5** describe the anatomy and function of each compartment of the ruminant stomach (Linked to Part 2.3),

- **SLO 2.6** explain rumen microbiology and the role of the rumen microbiome in digestion (Linked to Part 2.3),
- **SLO 2.7** describe the physiology of feed intake, prehension, and rumination (Linked to Part 2.4), and
- **SLO 2.8** explain the main digestive disorders of ruminants and describe how they are prevented (Linked to Part 2.4).

## 2.1 Cattle Breeds

### 2.1.1 Indigenous Nigerian cattle breeds

Nigeria's indigenous cattle breeds are all of the zebu (Bos indicus) type, characterised by a prominent neck hump, pendulous dewlap, large drooping ears, and adaptation to heat, tick infestation, and trypanosomiasis in the sub-humid zone. The White Fulani (Bunaji) is the most numerous breed, raised by the Fulani across the north for both beef and milk; it has a white coat, black muzzle, and lyre-shaped horns. The Sokoto Gudali (Adamawa Fulani) is a more compact, heavier breed found in Sokoto, Zamfara, and Adamawa states, valued for its beef qualities. The Red Bororo (Rahaji) is a tall, slender, predominantly red-and-white breed kept mainly by pastoral Fulani for social prestige; its milk production is relatively high for an indigenous breed.

The Keteku (Muturu cross) and Ndama are West African short-horn taurine (Bos taurus) breeds found in the tsetse-infested forest and sub-humid zones of south-western Nigeria. The Ndama, originally from Guinea, is the most important trypanotolerant breed in West Africa; its ability to survive and maintain productivity in tsetse-infested areas without intensive trypanocidal treatment makes it highly valuable where sleeping sickness and nagana are endemic. The West African Dwarf cattle (Muturu) is a small taurine breed of the Niger Delta and forest zone; it is trypanotolerant but has very low productivity. Understanding which breeds are adapted to which environments is essential for selecting the right breed for any farm location in Nigeria.

Fill in the blank: The _____ cattle breed, originally from Guinea, is the most important trypanotolerant breed in West Africa; it can survive and remain productive in tsetse-infested areas without intensive trypanocidal treatment.

### 2.1.2 Exotic cattle breeds and their use in Nigeria

Exotic cattle breeds are those originating outside Nigeria, imported primarily for their superior milk or beef production potential under improved management. Dairy breeds used in Nigeria: the Holstein-Friesian (black and white; highest milk-yielding breed globally, 8,000 to 12,000 litres per lactation under temperate conditions; adapted to cool climates; requires high-quality nutrition, excellent veterinary care, and heat mitigation in Nigeria); the Jersey (light brown; smaller frame; highest milk fat percentage among dairy breeds at 4.5 to 5.5%; heat-tolerant compared with Friesian; used in Nigeria for crossing and on-station trials); and the Brown Swiss (grey-brown; good milk yield with high protein content; more heat-tolerant and longer-lived than Friesian).

Beef breeds used in Nigeria: the Simmental (large, dual-purpose European breed; fast-growing and well-muscled; used for crossing with zebu to improve beef quality); the Hereford (red with white face; docile and efficient on pasture; used in feedlot crossing); and the Charolais (white, very large-framed European beef breed; imported through AI for crossbreeding programmes aimed at heavier carcass weights). Under pure exotic conditions in Nigeria, mortality from heat stress, tick-borne diseases, and nutritional deficiencies is high; exotic breeds are therefore used primarily for crossing with indigenous zebu breeds to produce crossbred animals that combine the production potential of the exotic parent with the adaptability of the zebu parent.

Fill in the blank: The _____ cattle breed is the highest milk-yielding dairy breed globally; under Nigerian conditions it requires high-quality nutrition, heat management, and excellent veterinary care to realise its production potential.

| Breed | Origin | Type | Production Category | Key Characteristic |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| White Fulani | Nigeria (Northern regions) | Indigenous | Beef/Dairy | Large frame, good milk yield, hardy in dry climates |
| Sokoto Gudali | Nigeria (Sokoto area) | Indigenous | Dairy | High milk production, tolerant to heat |
| Red Bororo | Nigeria (Fulani pastoralists) | Indigenous | Beef | Tall, long-horned, highly mobile, adapted to nomadic lifestyle |
| Ndama | West Africa (Guinea, Sierra Leone) | Indigenous | Dual-purpose | Trypanotolerant (resistant to tsetse fly), moderate milk and beef |
| Holstein-Friesian | Europe (Netherlands/Germany) | Exotic | Dairy | Very high milk yield, requires intensive management |
| Jersey | Europe (Channel Islands, UK) | Exotic | Dairy | High butterfat content in milk, smaller body size |
| Simmental | Europe (Switzerland) | Exotic | Dual-purpose | Large body size, good beef and milk production |

Table 2.1: Major cattle breeds used in Nigeria with their origin, type, and primary production use

### 2.1.3 Crossbreeding for breed improvement

Crossbreeding is the mating of animals from two different breeds to produce offspring (crossbreds or F1 hybrids) that combine desirable traits from both parents. In Nigerian cattle improvement, the most common crossbreeding strategy is crossing exotic dairy or beef bulls (usually through AI) with indigenous zebu cows. The F1 crossbred (50% exotic, 50% indigenous) typically shows heterosis (hybrid vigour) for production traits: milk yield, growth rate, and reproductive efficiency are often higher in the F1 than the average of the two parental

breeds. The F1 Friesian x White Fulani crossbred, for example, produces 6 to 10 litres of milk per day under adequate management, compared with 2 to 5 litres for the pure White Fulani.

Backcrossing (crossing the F1 back to the exotic breed) increases the proportion of exotic genes and production potential but reduces heat tolerance and disease resistance. The optimum exotic blood level for Nigerian conditions is generally considered to be 50 to 62.5 per cent (F1 to backcross 1), beyond which adaptability problems outweigh the production gains. Rotational crossbreeding (alternating between two or more breeds over successive generations) can maintain a permanent level of heterosis. Grade upgrading (repeatedly using exotic sires on indigenous cows and their female offspring over several generations) progressively increases the proportion of exotic genes in the herd. Government-supported breed improvement programmes (such as the National Livestock Breeding Policy) use AI to distribute improved semen widely at subsidised cost.

Fill in the blank: The F1 crossbred of Friesian x White Fulani produces approximately 6 to 10 litres of milk per day compared with 2 to 5 litres for the pure White Fulani, demonstrating the benefit of _____ (hybrid vigour) from crossbreeding.

## Pilot questions 2.1

1. Name three indigenous Nigerian cattle breeds, state one distinguishing characteristic of each, and identify their main production use.
2. Explain why the Ndama breed is important in southern Nigeria.
3. Name two exotic dairy breeds used in Nigeria and state one advantage and one disadvantage of each for Nigerian conditions.
4. Explain the objective of crossbreeding in Nigerian cattle improvement and state the optimum exotic blood level.
5. Explain what heterosis is and give one example from Nigerian cattle crossbreeding.

## 2.2 Sheep and Goat Breeds

### 2.2.1 Nigerian sheep breeds

The dominant sheep breeds of Nigeria are: the Yankasa, the most numerous, distributed across the Sudan savanna and Jos Plateau; it is medium-sized, brown or white with brown patches, earless or with small ears, horned in males and polled in females; kept primarily for meat but yields some milk. The Uda (Fulani long-legged sheep) is a large, long-legged breed of the Sahel zone, often bicoloured (black/white or brown/white); rams are horned with spiralled horns; primarily meat breed with some milk production. The Balami (White Sahel sheep) is the largest Nigerian sheep breed, predominantly white, found in Borno, Yobe, and Adamawa; valued for its large body size and white fleece (used locally for weaving).

The West African Dwarf (WAD) sheep is a small, short-legged, trypanotolerant breed of the forest zone and Niger Delta; it is the most important sheep breed in southern Nigeria; males are often dark with lighter undersides; it is highly prolific (frequently twins or triplets) and resistant to Haemonchus contortus, the primary sheep worm in the humid tropics. WAD sheep thrive on browse, household food scraps, and communal grazing without supplementary feeding, making them ideal for smallholder households in the south. The Ouda and Fulani Gudali are additional Sahel zone breeds of importance in north-eastern Nigeria.

Fill in the blank: The West African Dwarf sheep is the most important sheep breed in southern Nigeria; it is _____ to Haemonchus contortus and frequently produces twins or triplets under village management.

### 2.2.2 Nigerian goat breeds

The major Nigerian goat breeds are: the Red Sokoto (Maradi) goat, the most economically important Nigerian goat breed; it is medium-sized, characteristically red or reddish-brown in colour, short-coated, found across the north-west and north-central states; it produces very high-quality leather (Sokoto leather) highly valued in the tanning industry; its milk production is moderate and meat quality is good. The Sahel goat (White Borno) is a large, predominantly white breed of the Sahel and Sudan zones; long-legged and angular; kept for milk and meat by

nomadic pastoralists. The Kano Brown goat is a medium-sized brown breed of the kano and Katsina area; it is one of the heaviest Nigerian goat breeds.

The West African Dwarf (WAD) goat is the dominant goat breed of southern Nigeria and the Middle Belt; it is small and compact, trypanotolerant, highly hardy, and prolific; WAD goats are found in virtually every household in the south, scavenging on household and market waste. The Sokoto Red, Red Bororo, and WAD goat collectively account for most of Nigeria's goat population. Improved exotic goat breeds such as the Anglo-Nubian (large, Roman nose, pendulous ears; high milk yield and fat content) and the Boer goat (South African; fast-growing, heavily muscled; used for crossbreeding to improve meat production of Nigerian breeds) are used in government and research breeding programmes.

Fill in the blank: The _____ Sokoto goat is the most economically important Nigerian goat breed; it produces high-quality leather that commands premium prices in the international tanning industry.

| Breed | Ecological Zone | Key Characteristics | Primary Production Use |
|---|---|---|---|
| Yankasa | Northern Guinea savanna | White coat with black patches, medium size | Meat, skins |
| Uda | Semi-arid Sudan savanna | Long-legged, pied coat (white body, black/brown head and legs) | Meat, skins |
| Balami | Semi-arid northeastern Nigeria | Large body size, all-white coat | Meat, skins |
| West African Dwarf (WAD) Sheep | Humid forest zone | Small size, trypanotolerant | Meat, skins |
| Red Sokoto | Semi-arid northern Nigeria | Uniform red coat, medium size | Skins (leather), meat |

| | | | |
|---|---|---|---|
| Sahel Goat | Arid/semi-arid northern Nigeria | Tall, long-legged, hardy | Meat, milk |
| West African Dwarf (WAD) Goat | Humid forest zone | Small size, prolific, trypanotolerant | Meat, skins |

Table 2.2: Major sheep and goat breeds of Nigeria with their zone, characteristics, and primary use

### 2.2.3 General characteristics of ruminant animals

Beyond the ruminant features introduced in Series 1, ruminants share a number of general characteristics that distinguish them from other livestock and shape their management requirements. They have an even number of toes (two functional hooves per foot), a feature that places them in the order Artiodactyla. Their dentition is distinctive: 8 lower incisors and no upper incisors (a dental pad instead); a dental gap (diastema) between the incisors and molars; and upper and lower cheek teeth (premolars and molars) for grinding cud. Adult cattle have 32 teeth in total (8 incisors, 0 upper incisors, 12 premolars, 12 molars). Ruminants have four-chambered stomachs, are cloven-hoofed, and in most species both sexes may carry horns.

Other general features: ruminants are endotherms (warm-blooded) with a normal body temperature of 38.5 to 39.5 degrees Celsius in cattle and 38.5 to 40 degrees Celsius in sheep and goats; a body temperature above 40 degrees in cattle indicates fever or severe heat stress. The heart rate of a healthy cow is 60 to 80 beats per minute; the respiratory rate is 10 to 30 breaths per minute; rumen motility (sounds heard with a stethoscope on the left flank) is 1 to 3 contractions per minute. Normal faecal consistency is firm but moist in cattle and pellet-form in sheep and goats. These vital signs are used in clinical examination to detect disease and are essential knowledge for every animal husbandry student.

Fill in the blank: The normal body temperature of a healthy cow is _____ to 39.5 degrees Celsius; a temperature above 40 degrees indicates fever or severe heat stress requiring immediate management attention.

### Pilot questions 2.2

1. Name three Nigerian sheep breeds found in the northern zone and state one distinguishing feature of each.
2. Explain why the West African Dwarf sheep is the preferred breed for smallholder farming in southern Nigeria.
3. Describe the Red Sokoto goat and explain its economic importance to Nigeria.
4. State the normal body temperature, heart rate, and respiratory rate of a healthy cow.
5. State four general characteristics shared by all ruminant animals.

## 2.3 Digestive Anatomy of Ruminants

### 2.3.1 The rumen and reticulum

The ruminant stomach consists of four compartments: the rumen (reticulum), omasum, and abomasum. The rumen is the largest compartment, occupying the entire left side of the abdominal cavity; in an adult cow it has a volume of approximately 100 to 150 litres (about 85 per cent of total stomach capacity). Its inner wall is lined with papillae (small projections that increase the surface area for absorption of volatile fatty acids). The rumen acts as a large fermentation vat: ingested feed is mixed with saliva and subjected to microbial fermentation; the continuous contraction and mixing movements of the rumen (muscular contractions 1 to 3 times per minute) ensure uniform fermentation and passage of digesta.

The reticulum is the smallest compartment, located just behind the diaphragm; it has a honeycomb-like inner wall (characteristic of all ruminants) and communicates freely with the rumen, so the two are often referred to together as the reticulorumen. Its primary functions are: sorting ingesta (large undigested particles are returned to the rumen for further fermentation while small particles pass on to the omasum); regurgitation (the reticulum initiates the anti-peristaltic contractions that force a bolus of ingesta back up the oesophagus for re-chewing during rumination); and trapping of swallowed foreign objects (metal objects, wire, and nails that

cattle accidentally ingest settle in the reticulum and may cause hardware disease or traumatic reticuloperitonitis if they penetrate the wall).

Fill in the blank: The reticulum has a _____ inner wall; it initiates regurgitation of the cud for re-chewing and traps accidentally swallowed metal objects, which may cause traumatic reticuloperitonitis.

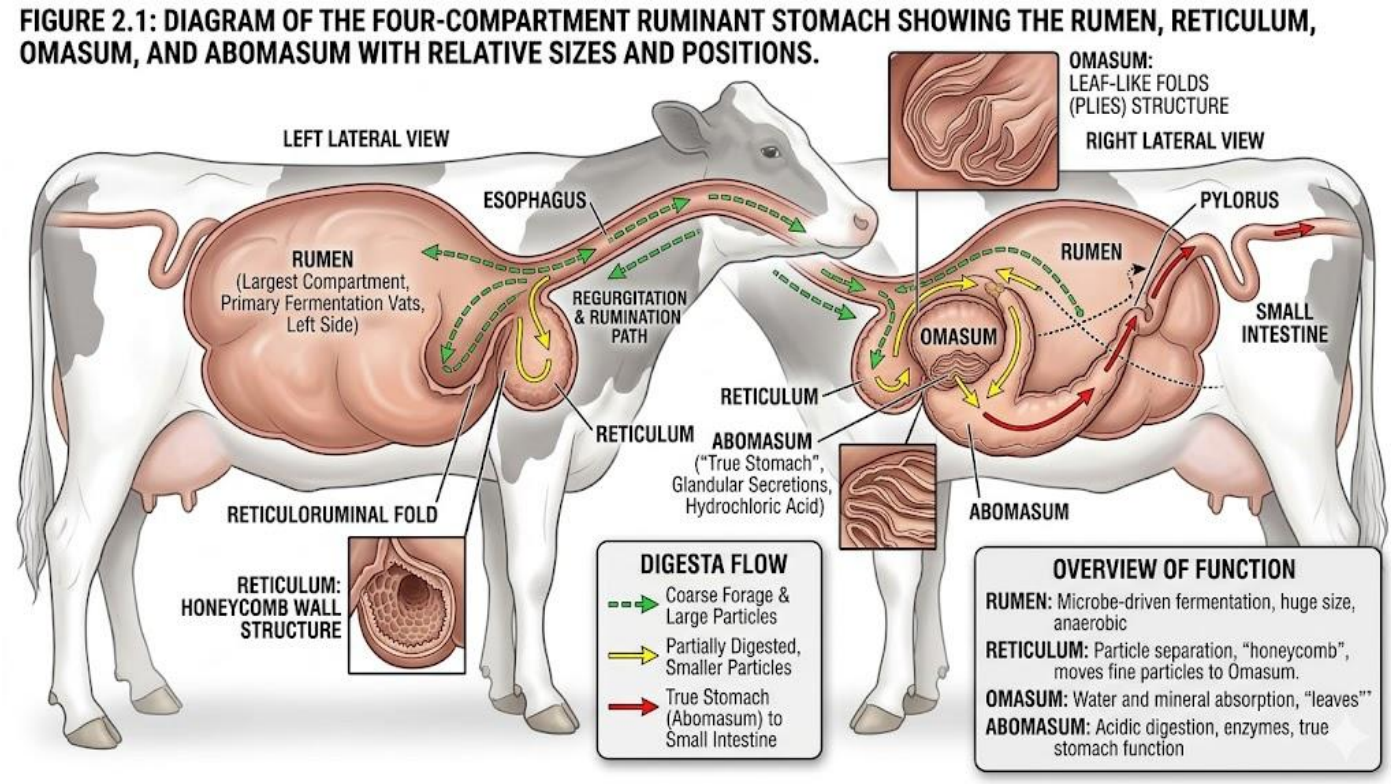


Figure 2.1: Diagram of the four-compartment ruminant stomach showing the rumen, reticulum, omasum, and abomasum with relative sizes and positions

## 2.3.2 The omasum, abomasum, and intestines

The omasum (also called the manyplies or psalterium) is a spherical compartment filled with numerous leaf-like laminae (folds); these greatly increase the surface area for absorption of water and electrolytes from the ingesta passing through. As a result, the material leaving the omasum has a much lower water content than the material entering from the reticulum. The omasum constitutes approximately 8 per cent of total stomach capacity in cattle. Its grinding action between the laminae further reduces particle size before the digesta passes into the abomasum.

The abomasum (the "true stomach") is the final compartment; it is the only one with a glandular mucosa that secretes digestive enzymes (pepsin) and hydrochloric acid, similar to the single stomach of a non-ruminant. Protein digestion begins in the abomasum. Microbial protein (synthesised in the rumen and reaching the abomasum as microbial cells) is digested here and provides a high-quality supplementary protein source for the animal in addition to any undegraded dietary protein that escapes rumen fermentation. The small intestine (duodenum, jejunum, ileum) is the primary site of enzymatic digestion and nutrient absorption; bile and pancreatic enzymes are secreted into the duodenum. The large intestine (caecum, colon, rectum) absorbs water and forms faeces.

Fill in the blank: The _____ is the true stomach of a ruminant; it has a glandular mucosa that secretes pepsin and hydrochloric acid for protein digestion, similar to the single stomach of a non-ruminant animal.

### 2.3.3 Rumen microbiology and fermentation

The rumen supports a dense and diverse community of microorganisms: bacteria (the most numerous at 10^10 to 10^11 cells per mL; species include Fibrobacter succinogenes, Ruminococcus flavefaciens, Butyrivibrio fibrisolvens, and Selenomonas ruminantium among hundreds of others); ciliate protozoa (10^5 to 10^6 cells per mL; engulf bacteria and starch granules, reducing the efficiency of microbial protein synthesis but contributing to fermentation of structural carbohydrates); anaerobic fungi (fewer in number but important for degrading the most resistant plant cell wall fractions); and methanogenic archaea (produce methane as a by-product of fermentation, representing an energy loss of 5 to 15 per cent of gross energy intake). The total microbial biomass in the rumen is enormous: a 600 kg cow carries approximately 3 to 4 kg of living microbial matter in its rumen at any time.

The rumen environment is maintained at: temperature 38 to 40 degrees Celsius; pH 6.0 to 7.0 (higher when the diet is forage-based, lower when high-grain diets are fed; pH below 5.5 causes rumen acidosis and microbial die-off); anaerobic conditions (oxygen is rapidly consumed by aerobic bacteria entering with feed; the rumen is essentially oxygen-free); and a near-constant supply of fermentable substrate from continuous feeding or the release of rumen contents. Saliva

(60 to 180 litres per day in cattle) plays a critical role in maintaining rumen pH through its bicarbonate and phosphate buffering capacity; reduced saliva (from inadequate roughage or reduced rumination) predisposes to acidosis.

Fill in the blank: The rumen pH ranges from 6.0 to 7.0; a pH below _____ causes rumen acidosis and microbial die-off; saliva from chewing roughage provides buffering that prevents pH from falling dangerously.

### Pilot questions 2.3

1. State the volume of the rumen in an adult cow and explain its primary function.
2. Describe the honeycomb reticulum, state its two main functions, and explain the condition it predisposes cattle to.
3. Explain the function of the omasum and state what it absorbs.
4. Describe the rumen microbiome, naming the four types of microorganisms present and their roles.
5. Explain why rumen pH is important and what happens when pH falls below 5.5.

## 2.4 The Physiology of Digestion

### 2.4.1 Feed intake, prehension, and rumination

Cattle prehend (grasp) forage by wrapping their tongue around it and pulling it against the lower incisors and dental pad to tear it; they do not bite feed as cleanly as horses (which have upper incisors). This tearing prehension means cattle graze less selectively than sheep and goats, which use their mobile lips and teeth to select specific plant parts. After prehension, feed is chewed briefly (mastication), mixed with copious saliva, and swallowed into the rumen. The reticulo-rumen contractions sort ingesta: large particles float on the rumen mat and are eventually regurgitated for rumination; small particles and liquid pass to the omasum. An adult cow may spend 6 to 8 hours per day grazing and 7 to 10 hours per day ruminating; adequate rumination time is a reliable indicator of animal welfare and proper rumen function.

Rumination (chewing the cud) involves: reticular contraction that initiates regurgitation; a bolus of ingesta travels up the oesophagus to the mouth; the liquid is swallowed immediately; the solid bolus is chewed approximately 40 to 60 times per bolus; the re-chewed material is re-swallowed into the rumen. Each rumination bout lasts 20 to 60 minutes and a cow may have 15 to 20 bouts per day. The primary purpose of rumination is to reduce particle size so that rumen microbes have a larger surface area to attack; secondary benefit is the production of additional saliva (which buffers rumen pH). Cessation of rumination is one of the earliest and most reliable clinical signs of systemic illness or severe rumen dysfunction.

Fill in the blank: A healthy cow spends approximately 7 to 10 hours per day _____ (chewing the cud); cessation of rumination is one of the earliest signs of systemic illness or severe rumen dysfunction.

### 2.4.2 Fermentation products and their utilisation

The principal products of rumen fermentation are volatile fatty acids (VFAs): acetate (acetic acid), propionate (propionic acid), and butyrate (butyric acid), produced in a ratio of approximately 65:20:15 on a forage-based diet. These VFAs are absorbed directly through the rumen wall into the bloodstream and are the primary energy source for the ruminant (providing 60 to 80 per cent of the animal's metabolisable energy). Acetate and butyrate are used primarily for body fat synthesis and mammary gland milk fat synthesis; propionate is the primary gluconeogenic precursor (it is converted to glucose in the liver), making it critically important for milk lactose synthesis and energy balance in high-yielding dairy cows.

The ratio of VFAs changes with diet composition: diets high in roughage (long fibre) produce high acetate:propionate ratios and high milk fat; diets high in rapidly fermentable starch (grain) produce lower acetate and higher propionate (increasing milk protein yield but reducing milk fat). Carbon dioxide and methane are produced as gaseous fermentation by-products; they are removed by eructation (belching) approximately once per minute. Failure to eructate normally causes accumulation of gas in the rumen (bloat). Microbial protein (synthesised as microbial cells from ammonia, peptides, and amino acids in the rumen) flows out with the digesta and is digested in the abomasum and small intestine, contributing high-quality protein to the animal.

Fill in the blank: The three main volatile fatty acids produced in the rumen are acetate, _____, and butyrate; propionate is the primary gluconeogenic precursor and is converted to glucose in the liver.

**FIGURE 2.2: DIAGRAM SHOWING RUMEN FERMENTATION PATHWAYS AND THE FATE OF VOLATILE FATTY ACIDS**

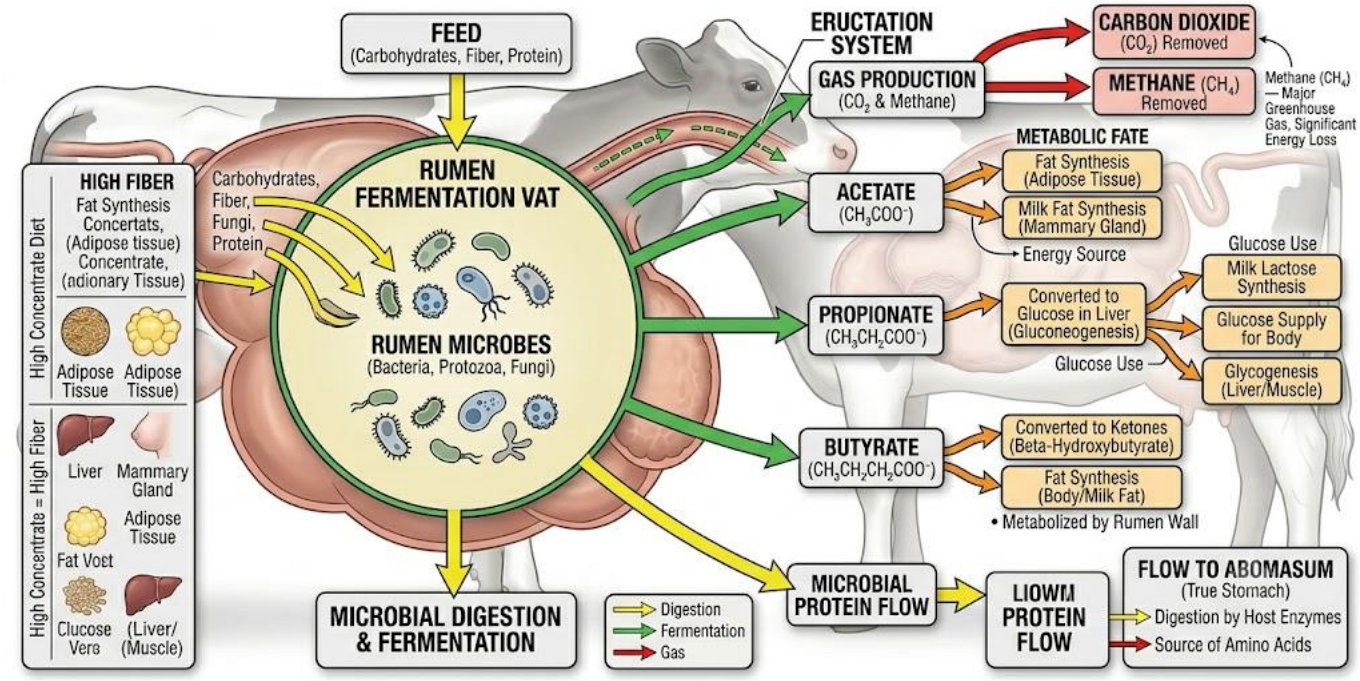


Figure 2.2: Diagram showing rumen fermentation pathways and the fate of volatile fatty acids

## 2.4.3 Digestive disorders and their prevention

Bloat is the accumulation of fermentation gas (free gas or foam) in the rumen, causing distension of the left flank and, if severe, respiratory distress and death. Frothy bloat (the most dangerous form) occurs when foam traps gas in the rumen, preventing eructation; it is caused by rapid ingestion of lush legume pastures (clover, alfalfa) or grain. Prevention: avoid sudden access to lush legume pastures; introduce animals gradually; supplement with antifoaming agents (poloxalene, vegetable oil). Treatment of acute frothy bloat: antifoaming drenches, passage of a stomach tube, or emergency trocarisation of the rumen. Free-gas bloat occurs when gas cannot escape due to physical obstruction of the oesophagus or rumen atony.

Ruminal acidosis (grain overload) occurs when a ruminant consumes excessive rapidly fermentable starch (grain), producing a rapid fall in rumen pH to below 5.0 due to accumulation of lactic acid; rumen microbiota shifts toward acid-producing bacteria; the animal becomes dull, refuses to eat, may show diarrhoea, and in acute cases dies from metabolic acidosis, dehydration, and laminitis. Prevention: introduce grain gradually over 2 to 3 weeks; maintain adequate long-fibre roughage (minimum 50 per cent of diet dry matter); use rumen buffers (sodium bicarbonate in feedlot diets). Hardware disease (traumatic reticuloperitonitis) results from sharp metal objects penetrating the reticulum wall; prevention: use magnets placed in the reticulum at herd entry. Pregnancy toxaemia (ketosis in cattle; twin lamb disease in sheep) results from energy deficiency in the last trimester; prevented by adequate steaming-up nutrition.

Fill in the blank: Rumen acidosis occurs when excessive _____ ferments rapidly, producing lactic acid that drops rumen pH below 5.0; prevention requires gradual introduction of grain and maintenance of adequate long-fibre roughage.

### Pilot questions 2.4

1. Describe how cattle prehend feed and explain the role of rumination in ruminant digestion.
2. Name the three main VFAs produced in the rumen, state their approximate ratio on a forage diet, and describe the metabolic fate of each.
3. Explain the difference between frothy bloat and free-gas bloat and state how each is prevented.
4. Describe rumen acidosis: its cause, signs, and prevention.
5. Explain what hardware disease is and how it is prevented.

## Series Summary

This Series covered the breeds, characteristics, and digestive anatomy of ruminants. We described Nigerian indigenous cattle breeds (White Fulani, Sokoto Gudali, Red Bororo, Ndama, WAD cattle) and exotic breeds (Holstein-Friesian, Jersey, Simmental) and explained crossbreeding objectives and the optimum 50 to 62.5 per cent exotic blood level for Nigerian conditions. We described Nigerian sheep breeds (Yankasa, Uda, Balami, WAD sheep) and goat breeds (Red Sokoto, Sahel goat, WAD goat) and covered the general characteristics of ruminants including normal vital signs.

We described the four stomach compartments: the rumen (fermentation vat, 100-150 L, papillae for VFA absorption); the reticulum (honeycomb wall, initiates regurgitation, traps metal objects); the omasum (leaf-like laminae absorb water and electrolytes); and the abomasum (true stomach, glandular, enzymatic digestion begins). We covered the rumen microbiome (bacteria, protozoa, fungi, methanogens), the importance of rumen pH (6.0-7.0; below 5.5 causes acidosis), and saliva buffering. We explained the physiology of prehension and rumination (7-10 hours per day), VFA production and utilisation (acetate for fat, propionate for glucose, butyrate for fat), and digestive disorders (bloat, acidosis, hardware disease, pregnancy toxaemia). By completing this Series, you should be able to achieve all eight Series Learning Outcomes (SLO 2.1 to SLO 2.8).

## Glossary of Terms

- **Abomasum:** the fourth and true stomach compartment of a ruminant; has a glandular mucosa secreting pepsin and HCl for enzymatic protein digestion.
- **Acetate:** the most abundant VFA produced in the rumen; used for fat and milk fat synthesis; its proportion in total VFAs increases with forage-based diets.
- **Bloat:** accumulation of fermentation gas (free gas or foam) in the rumen causing distension; frothy bloat is caused by lush legumes or grain; free-gas bloat by physical obstruction.

- **Butyrate:** a VFA produced in the rumen; used primarily for fat synthesis and stimulates rumen papillae development in young ruminants.
- **Crossbreeding:** the mating of animals from two different breeds to produce F1 offspring with combined desirable traits from both parents.
- **Diastema:** the gap between the incisor teeth and the molar teeth in the lower jaw of a ruminant; equivalent in function to the interdental space.
- **Eructation:** the belching of fermentation gases (CO2 and methane) from the rumen; occurs approximately once per minute in a healthy ruminant; failure causes bloat.
- **Grade upgrading:** the repeated use of exotic sires on indigenous females over several generations to progressively increase the proportion of exotic genes in the herd.
- **Hardware disease:** traumatic reticuloperitonitis caused by sharp metal objects (wire, nails) swallowed by cattle and penetrating the reticulum wall; prevented by rumen magnets.
- **Heterosis (hybrid vigour):** the superior performance of an F1 crossbred over the average of its two parent breeds; contributes to improved growth, reproduction, and survival in crossbred ruminants.
- **Holstein-Friesian:** the highest milk-yielding cattle breed globally; black and white; requires excellent management, nutrition, and heat management in Nigerian conditions.
- **Ndama:** a trypanotolerant West African taurine cattle breed important in tsetse-infested zones of southern Nigeria and West Africa.
- **Omasum:** the third stomach compartment; filled with leaf-like laminae that absorb water and electrolytes from digesta before it enters the abomasum.
- **Papillae:** small finger-like projections lining the rumen wall that increase surface area for absorption of volatile fatty acids.
- **Propionate:** a VFA produced in the rumen; the primary gluconeogenic precursor converted to glucose in the liver; its proportion increases with high-grain diets.

- **Red Sokoto (Maradi) goat:** the most economically important Nigerian goat breed; characteristically red/reddish-brown; famous for producing high-quality Sokoto leather.
- **Reticulum:** the second stomach compartment; has a characteristic honeycomb inner wall; initiates regurgitation and traps swallowed metal objects.
- **Rumen:** the largest stomach compartment of a ruminant (100-150 L in cattle); acts as the fermentation vat where rumen microbes break down fibrous feed.
- **Rumen acidosis:** a metabolic disorder caused by excessive rapidly fermentable starch driving rumen pH below 5.0; causes laminitis, dullness, diarrhoea, and death in severe cases.
- **Rumen microbiome:** the diverse community of bacteria, protozoa, anaerobic fungi, and methanogenic archaea inhabiting the rumen and responsible for fibre digestion.
- **Rumination:** the re-chewing of regurgitated rumen contents (cud) to reduce particle size; a healthy cow ruminates 7-10 hours per day.
- **Trypanotolerant:** the ability of a breed to survive and maintain productivity in areas infested with tsetse flies that transmit trypanosomiasis; characteristic of WAD breeds and Ndama cattle.
- **Volatile fatty acids (VFAs):** acetate, propionate, and butyrate produced by rumen fermentation; absorbed through the rumen wall and provide 60-80% of the ruminant's metabolisable energy.
- **West African Dwarf (WAD):** small, trypanotolerant breeds of sheep and goats important in the forest and humid zones of southern Nigeria; hardy and prolific.
- **White Fulani (Bunaji):** the most numerous indigenous Nigerian cattle breed; raised by Fulani pastoralists across the north for both beef and milk.



## Concept Check Questions [Series 2]

Objective Questions

1. The _____ cattle breed is the most important trypanotolerant breed in West Africa and is found in tsetse-infested zones. (Linked to SLO 2.1)
2. The F1 Friesian x White Fulani crossbred shows _____ (hybrid vigour), producing 6-10 litres of milk per day compared with 2-5 litres for the pure White Fulani. (Linked to SLO 2.2)
3. The reticulum has a _____ inner wall and initiates regurgitation of the cud for re-chewing. (Linked to SLO 2.5)
4. The three main VFAs produced in the rumen are acetate, _____, and butyrate; propionate is converted to glucose in the liver. (Linked to SLO 2.7)
5. Rumen acidosis is caused by excessive fermentable _____ dropping the rumen pH below 5.0; prevention requires gradual introduction and adequate roughage. (Linked to SLO 2.8)

Short-Answer Questions

6. Name three indigenous Nigerian cattle breeds and state the distinguishing characteristic of each. (Linked to SLO 2.1)
7. Explain why the West African Dwarf sheep is preferred by smallholder farmers in southern Nigeria. (Linked to SLO 2.3)
8. Describe the function of the rumen and state its volume in an adult cow. (Linked to SLO 2.5)
9. Explain the role of saliva in maintaining rumen function. (Linked to SLO 2.6)
10. Distinguish between frothy bloat and rumen acidosis in terms of cause and prevention. (Linked to SLO 2.8)

Long-Answer Questions

11. Describe the major cattle breeds used in Nigeria (both indigenous and exotic) and explain the objectives and outcomes of crossbreeding for breed improvement. (Linked to SLOs 2.1, 2.2)
12. Describe the anatomy and function of each of the four compartments of the ruminant stomach and explain the role of the rumen microbiome in digestion. (Linked to SLOs 2.5, 2.6)
13. Describe the physiology of feed intake, rumination, and VFA utilisation in ruminants, and explain the causes, signs, and prevention of the major digestive disorders. (Linked to SLOs 2.7, 2.8)

## Answers to Concept Check Questions [Series 2]

Objective Questions

1. Ndama.
2. Heterosis.
3. Honeycomb.
4. Propionate.
5. Starch (grain).

Short-Answer Questions

6. White Fulani (Bunaji): white coat with black muzzle and lyre-shaped horns; most numerous Nigerian breed; dual-purpose beef and milk. Sokoto Gudali: compact, heavy-bodied; found in Sokoto and Zamfara; valued primarily for beef. Red Bororo (Rahaji): tall, slender, predominantly red-and-white; kept by Fulani for social prestige; relatively high milk yield among indigenous breeds.
7. WAD sheep are trypanotolerant (can survive without intensive trypanocidal treatment in the tsetse-infested humid zone); highly prolific (frequently producing twins and triplets under village management); small and hardy (thrive on household scraps, browse, and communal grazing without supplementary feeding); require minimal capital and

management; resistant to the primary sheep gastrointestinal worm Haemonchus contortus that devastates more susceptible breeds in the humid south.

8. The rumen is the largest stomach compartment, approximately 100 to 150 litres in an adult cow (about 85% of total stomach capacity). Its primary function is microbial fermentation of ingested fibrous feed: bacteria, protozoa, and fungi break down cellulose and hemicellulose into volatile fatty acids (acetate, propionate, butyrate) that are absorbed through the papillae-lined rumen wall; the rumen also allows sorting of feed particles (large particles stay for further fermentation; small particles pass on to the omasum) and regurgitation of cud for rumination.
9. An adult cow produces 60 to 180 litres of saliva per day, mainly during eating and rumination. Saliva serves three functions in rumen physiology: (1) buffering: saliva contains large amounts of bicarbonate ($NaHCO_3$) and phosphate ($Na_2HPO_4$) which neutralise the acids (VFAs and lactic acid) produced by rumen fermentation, maintaining rumen pH in the optimal range of 6.0-7.0; (2) moisture: saliva moistens the feed, lubricates swallowing, and maintains the fluid environment needed for rumen microbial activity; (3) urea recycling: saliva contains urea which enters the rumen and is hydrolysed to ammonia by microbial urease, providing nitrogen for microbial protein synthesis.
10. Frothy bloat: caused by rapid ingestion of lush legume pastures (clover, alfalfa, young green crop) or high-starch grain feeds; plant saponins and rapidly solubilised proteins stabilise foam that traps fermentation gas, preventing eructation; prevention: introduce animals gradually to lush legumes; use antifoaming agents (poloxalene); avoid wet or frosted pastures; offer hay before grazing. Rumen acidosis: caused by excessive rapidly fermentable starch (grain overload) producing massive lactic acid accumulation and rumen pH dropping below 5.0; rumen microbiota shifts to acid-tolerant lactic acid producers (Streptococcus bovis); prevention: gradual introduction of grain over 2-3 weeks; maintain minimum 50% long-fibre roughage in diet dry matter; add sodium bicarbonate buffer to feedlot rations.

Long-Answer Questions

11. Indigenous breeds: all Bos indicus (zebu); hump, pendulous dewlap, large ears, heat/tick/trypanosome tolerance. White Fulani (Bunaji): most numerous, white, black muzzle, lyre horns, dual-purpose, Fulani herds across north. Sokoto Gudali: compact, heavy, Sokoto/Zamfara/Adamawa, beef-emphasis. Red Bororo: tall, slender, red-white, Fulani social prestige, some milk. Ndama: taurine Bos taurus, trypanotolerant, forest/sub-humid south, critical where tsetse endemic. WAD cattle (Muturu): very small taurine, trypanotolerant, Niger Delta/forest, very low productivity. Exotic breeds: Holstein-Friesian (black-white, highest global milk yield 8,000-12,000 L/lactation, requires excellent management, heat management in Nigeria); Jersey (light brown, highest milk fat 4.5-5.5%, smaller, more heat-tolerant than Friesian); Simmental (large European dual-purpose, fast-growing, crosses for beef quality); Hereford (red-white face, docile, pasture efficient); Charolais (very large-framed white, AI crossbreeding for heavier carcasses). Crossbreeding objectives: combine exotic production potential with indigenous adaptability; F1 heterosis for milk, growth, reproduction; Friesian x White Fulani F1 produces 6-10 L/day vs 2-5 L pure WAF. Optimum exotic blood: 50-62.5% (F1 to BC1); beyond this adaptability problems outweigh production gains. Methods: AI with exotic semen; grade upgrading; rotational crossbreeding. Government support: National Livestock Breeding Policy, AI at subsidised cost.
12. Rumen: largest compartment (100-150 L in cattle, 85% of total capacity); left side of abdomen; papillae-lined wall for VFA absorption; large fermentation vat; continuous muscular contractions (1-3/min) mix contents; separates large particles (retained for fermentation/rumination) from small particles (passed to omasum). Reticulum: smallest compartment; just behind diaphragm; honeycomb inner wall; free communication with rumen (reticulorumen); functions: sorts ingesta for passage; initiates regurgitation for rumination; traps swallowed metal causing hardware disease (traumatic reticuloperitonitis). Omasum: spherical; leaf-like laminae greatly increase absorptive surface; absorbs water and electrolytes (dehydrates digesta); grinds particles further; 8% of total stomach capacity. Abomasum: true stomach; glandular mucosa secreting pepsin and HCl; enzymatic protein digestion of dietary and microbial protein; 7% of capacity; analogous to simple-stomach animal's stomach. Small intestine: bile and pancreatic enzymes secreted into duodenum; major site of enzymatic digestion and nutrient

absorption (amino acids, glucose, fatty acids, minerals, vitamins). Large intestine: absorbs remaining water; forms and excretes faeces. Rumen microbiome: bacteria (10^10-10^11/mL): Fibrobacter succinogenes, Ruminococcus flavefaciens (fibre digesters), Butyrivibrio fibrisolvens, Selenomonas ruminantium; protozoa (10^5-10^6/mL): engulf bacteria and starch, contribute to fermentation; anaerobic fungi: attack most resistant plant cell wall; methanogens: produce CH4 (5-15% energy loss, eructation). Rumen pH 6.0-7.0; below 5.5 microbial die-off and acidosis. Saliva 60-180 L/day: HCO3 and phosphate buffering; nitrogen recycling via urea.

13. Prehension: cattle use tongue to wrap around forage and pull against dental pad to tear; less selective than sheep/goats; brief mastication, copious saliva, swallowed into rumen. Rumination cycle: reticular contraction initiates regurgitation; bolus travels up oesophagus; liquid swallowed immediately; solid bolus chewed 40-60 times; re-swallowed; 7-10 hours/day in healthy cow; 15-20 bouts/day; reduces particle size for greater microbial surface area; generates additional saliva for pH buffering; cessation = early sign of illness. VFA production and fate: rumen fermentation yields acetate:propionate:butyrate approximately 65:20:15 on forage diet; absorbed through rumen wall papillae; provide 60-80% of metabolisable energy. Acetate: used by mammary gland for milk fat synthesis; body fat deposition; high-forage diets raise acetate proportion and milk fat content. Propionate: primary gluconeogenic precursor; converted to glucose in liver; essential for lactose synthesis and energy balance in high-yield dairy cows; proportion rises with high-grain diets. Butyrate: fat synthesis; stimulates rumen papillae development in calves. CO2 and CH4 by-products removed by eructation; failure = bloat. Digestive disorders: frothy bloat (lush legumes/grain, saponin foam traps gas; antifoaming agents, gradual introduction, hay pre-grazing); free-gas bloat (oesophageal obstruction or rumen atony; remove obstruction, stomach tube); rumen acidosis (grain overload, lactic acid, pH <5.0, dullness, diarrhoea, laminitis, death; gradual grain introduction, 50% roughage DM minimum, NaHCO3 buffer); hardware disease (metal objects in reticulum penetrate wall; rumen magnets at herd entry); pregnancy toxaemia/ketosis (energy deficiency last trimester; adequate steaming-up nutrition).

## Answers to Pilot Questions [Series 2]

Part 2.1

1. White Fulani (Bunaji): characteristic white coat with black muzzle and lyre-shaped horns; most numerous Nigerian breed; used for dual-purpose beef and milk production by Fulani pastoralists. Sokoto Gudali: compact, heavy-bodied build compared with other Nigerian zebu; found in Sokoto, Zamfara, and Adamawa states; primary use is beef production. Red Bororo (Rahaji): very tall, slender frame, predominantly red-and-white coat pattern; the longest horns of any Nigerian breed; kept by Fulani primarily for social prestige; somewhat higher milk yield than other Nigerian zebu breeds.
2. The Ndama is important in southern Nigeria because it is trypanotolerant: it can survive, reproduce, and maintain acceptable productivity in tsetse-infested areas (the forest and sub-humid zones of southern and south-western Nigeria and the Middle Belt) that would be fatal for the zebu breeds of the north. The tsetse fly transmits Trypanosoma brucei brucei and T. congolense (nagana in cattle) which cause progressive anaemia, weight loss, and death in susceptible breeds. The Ndama's trypanotolerance means that cattle can be kept in the south without the constant application of expensive trypanocidal drugs (such as diminazene aceturate or isometamidium chloride), making cattle farming economically feasible in these zones.
3. Holstein-Friesian: advantage: highest milk yield globally (8,000-12,000 L/lactation under temperate conditions; 15-30 L/day even under Nigerian conditions with good management); disadvantage: poor heat tolerance (large body size and high metabolic rate generate excess body heat; severe production loss and mortality during hot dry season without shade, fans, and cool water); susceptible to tick-borne diseases (east coast fever, babesiosis, anaplasmosis) to which indigenous zebu have some tolerance. Jersey: advantage: highest milk fat percentage (4.5-5.5%); smaller body size requiring less feed; somewhat more heat-tolerant than Friesian; disadvantage: absolute milk yield lower than Friesian (5,000-8,000 L/lactation); calves are small at birth and calf mortality may be higher in harsh conditions.
4. Objective of crossbreeding in Nigeria: to produce offspring that combine the high production potential (milk yield, growth rate, reproductive efficiency) of exotic breeds

with the heat tolerance, tick resistance, trypanotolerance, and ability to perform on low-quality roughage diets of indigenous zebu breeds; the F1 crossbred also exhibits heterosis (hybrid vigour), performing better than the average of both parents for production traits. Optimum exotic blood level: approximately 50 to 62.5 per cent exotic, corresponding to F1 (50%) or first backcross to exotic (62.5%); at this level the animal shows substantial production improvement while retaining adequate adaptability to Nigerian conditions; above 62.5% exotic, problems with heat stress, tick susceptibility, and poor performance on low-quality roughage diets increasingly outweigh the production gains.

5. Heterosis (hybrid vigour) is the phenomenon in which the F1 offspring of a cross between two different breeds or lines performs better than the average (or in some cases the better) of the two parent breeds for one or more traits, due to increased heterozygosity at loci where the parental breeds carry different alleles. Nigerian cattle crossbreeding example: a Friesian x White Fulani F1 crossbred cow produces approximately 6 to 10 litres of milk per day under adequate management conditions in Nigeria; the pure White Fulani dam produces only 2 to 5 litres per day, and the pure Holstein-Friesian is extremely difficult to maintain under Nigerian conditions; the F1 therefore not only averages the two parents but exceeds the pure White Fulani significantly, demonstrating heterosis for milk yield.

Part 2.2

1. Yankasa: medium-sized, brown or white with brown patches, earless or small-eared, males horned; most numerous Nigerian sheep breed; Sudan savanna and Jos Plateau; primarily meat, some milk. Uda (Fulani long-legged): large, long-legged, bicoloured (black/white or brown/white), rams have large spiralled horns; Sahel zone; meat and some milk production; valued for large body size. Balami (White Sahel): largest Nigerian sheep breed, predominantly white; Borno, Yobe, and Adamawa; valued for large body size and white fleece used in local weaving.
2. WAD sheep are preferred in southern Nigeria for five reasons: trypanotolerance (survive in tsetse-infested humid zone without trypanocidal drugs); prolificacy (frequently

produce twins and triplets, generating more offspring per ewe per year than larger breeds); hardiness (thrive on household and market waste, browse, and communal grazing without expensive supplementary feeding, minimising the cost of production); resistance to Haemonchus contortus (the dominant gastrointestinal nematode of the humid tropics that kills susceptible introduced breeds); and small body size (each animal represents a small, manageable financial unit that can be sold individually to meet cash needs without selling the entire flock).

3. The Red Sokoto (Maradi) goat is a medium-sized breed with a characteristic short, smooth, reddish-brown to red coat; it is found primarily in Sokoto, Zamfara, and Katsina states in north-western Nigeria. It is the most economically important Nigerian goat breed for the following reasons: its skin produces the finest quality goat leather in West Africa, known internationally as Sokoto leather or Maradi leather; the tight, smooth, short coat results in a thin but strong skin with very fine grain that is used to produce top-quality gloves, shoes, and accessories; Nigeria exports significant quantities of Red Sokoto skins to the European tanning industry, earning foreign exchange; the breed also has acceptable meat and moderate milk production, making it a versatile multipurpose goat suited to the mixed farming systems of the north.
4. Normal body temperature: 38.5 to 39.5 degrees Celsius (a temperature above 40 degrees indicates fever or severe heat stress). Normal heart rate: 60 to 80 beats per minute (measured by stethoscope over the left chest wall or by palpation of the femoral artery in the inner thigh). Normal respiratory rate: 10 to 30 breaths per minute (counted by watching chest or flank movement; higher in hot weather and after exercise).
5. Any four: multi-compartment stomach (rumen, reticulum, omasum, abomasum) enabling microbial fermentation of cellulose; practice of rumination (re-chewing of cud after initial ingestion); absence of upper incisor teeth replaced by a dental pad; even-toed hooves (cloven hooves, two functional toes per foot, placing them in Artiodactyla); lower incisor arcade with dental gap (diastema) between incisors and cheek teeth; ability to digest cellulose and hemicellulose through rumen microbial fermentation; endothermic (warm-blooded) with normal body temperature 38.5-39.5 degrees Celsius in cattle.

Part 2.3

1. The rumen in an adult cow has a volume of approximately 100 to 150 litres, which represents about 85 per cent of total stomach capacity. Its primary function is as a large fermentation vat: it harbours billions of bacteria, protozoa, and fungi that digest cellulose and hemicellulose in plant cell walls into volatile fatty acids (primarily acetate, propionate, and butyrate) which are absorbed through the papillae-lined rumen wall into the bloodstream and serve as the primary energy source for the animal. Secondary functions include: holding and sorting ingesta (large undigested particles are retained for continued fermentation and eventual rumination while small particles and liquid pass on to the omasum); generating heat through fermentation (contributes to thermoregulation in cold conditions); and housing the microbial synthesis of B vitamins and microbial protein.
2. The reticulum has a characteristic honeycomb-pattern inner wall made of mucosal folds forming hexagonal cells; this is the most distinctive and easily recognised feature of the reticulum and a defining characteristic of all ruminant stomachs. Two main functions: (1) initiates regurgitation by generating retrograde (anti-peristaltic) contraction that propels a bolus of semi-digested rumen contents back up the oesophagus into the mouth for re-chewing during rumination; (2) sorts ingesta by allowing small particles and liquid to pass through to the omasum while large, coarse particles are returned to the rumen mat for further fermentation. The condition it predisposes cattle to: traumatic reticuloperitonitis (hardware disease), caused by sharp metal objects (wire, nails, staples) accidentally swallowed with feed that settle to the bottom of the reticulum and penetrate its wall, causing localised peritonitis, pain (humped back posture, reluctance to move, grunting), fever, and reduced production.
3. The omasum is filled with numerous large leaf-like folds (laminae) that give it a book-like appearance; its nickname "manyplies" or "psalterium" refers to this leaf structure. These laminae greatly increase the surface area available for absorption. The omasum absorbs water and electrolytes (sodium, potassium, chloride, bicarbonate) from the digesta passing through from the reticulum; this dehydration of the digesta concentrates it before it enters the abomasum, improving the efficiency of enzymatic digestion. The

omasum also continues the grinding of feed particles between its laminae, further reducing particle size.

4. Four types of rumen microorganisms: (1) Bacteria (the most numerous, 10^10-10^11 cells per mL of rumen fluid; key species include Fibrobacter succinogenes and Ruminococcus flavefaciens which digest cellulose, Butyrivibrio fibrisolvens which digests hemicellulose and produces butyrate, and Selenomonas ruminantium which ferments soluble sugars and starch); role: primary producers of VFAs from fibre and starch digestion; major source of microbial protein. (2) Ciliate protozoa (10^5-10^6/mL; engulf and digest bacteria and starch granules; contribute to fibre digestion); role: ferment structural carbohydrates, modulate rumen fermentation, but may reduce net microbial protein synthesis by engulfing bacteria. (3) Anaerobic fungi (fewer in number but important; role: penetrate and break down the most resistant lignocellulosic plant cell wall structures, making them accessible to bacterial attack). (4) Methanogenic archaea (role: produce methane CH4 from CO2 and H2 produced by other fermenters; methane represents 5-15% of gross energy intake lost as gas; removed by eructation).
5. Rumen pH is a critical determinant of rumen microbial community composition and function. The optimal range for a healthy rumen microbiome is pH 6.0 to 7.0: at this pH, the fibre-digesting bacteria (Fibrobacter succinogenes, Ruminococcus flavefaciens) thrive and efficiently degrade plant cell wall material. When pH falls below 5.5 (due to excessive rapid fermentation of starch producing lactic acid), several important events occur: the fibre-digesting bacteria, which cannot tolerate low pH, die off rapidly, eliminating the rumen's capacity to digest fibre; acid-tolerant lactic acid-producing bacteria (Streptococcus bovis, Lactobacillus spp.) dominate, further driving pH down; the rumen becomes effectively non-functional; lactic acid is absorbed into the bloodstream causing metabolic acidosis; the animal develops diarrhoea, dehydration, laminitis (a painful inflammation of the hoof laminae caused by endotoxin release), and in severe cases dies.

Part 2.4

1. Cattle prehend (grasp) forage by extending their tongue, wrapping it around a bunch of grass or leaves, and pulling it against the lower incisors and dental pad to tear it; because they have no upper incisors (only a dental pad), cattle cannot bite cleanly like horses or small ruminants; they tend to be less selective grazers, taking larger mouthfuls and sometimes pulling up roots. The brief initial mastication mixes feed with copious saliva before swallowing. Role of rumination: after initial ingestion, the rumen sorts digesta and large particles are returned to the mouth via regurgitation for rumination; the bolus is chewed 40-60 times per bout, during which the feed particles are broken down mechanically to a smaller size (increasing the surface area available to rumen microbes for fermentation), and additional saliva (rich in bicarbonate) is generated and mixed with the bolus before it is re-swallowed; the combined mechanical breakdown and increased saliva production from rumination are essential for efficient rumen fermentation and pH maintenance.
2. Three main VFAs and their approximate ratio on a forage-based diet: acetate (approximately 65% of total VFA molar percentage); propionate (approximately 20%); butyrate (approximately 15%). Metabolic fate: Acetate is taken up by body tissues (mammary gland, adipose tissue, muscle); in the mammary gland it is the primary precursor for milk fat synthesis (short-chain and medium-chain fatty acids in milk are made from acetate); in adipose tissue it contributes to body fat deposition; high-forage diets that produce high acetate concentrations result in high milk fat content. Propionate is absorbed from the rumen into portal blood and transported to the liver, where it is the primary substrate for gluconeogenesis (the synthesis of glucose from non-carbohydrate precursors); glucose is essential for lactose synthesis in the mammary gland, brain function, and energy balance, particularly in high-yielding dairy cows in early lactation when dietary glucose supply is insufficient; high-grain diets increase the propionate proportion and often increase milk protein yield. Butyrate is taken up by the rumen epithelium and converted to beta-hydroxybutyrate before entering the bloodstream; it stimulates rumen papillae development in young calves and contributes to body fat synthesis.
3. Frothy bloat: caused by the rapid ingestion of young lush leguminous pastures (clover, alfalfa, lucerne) or high-starch grain diets; plant saponins and rapidly solubilised leaf

proteins stabilise a stable foam in the rumen that traps fermentation gas bubbles, preventing the gas from coalescing and being eructated normally; the rumen distends with foam, the left flank bulges visibly above the paralumbar fossa, and if severe the distension compresses the diaphragm causing respiratory distress and death within 1 to 4 hours. Prevention: avoid giving cattle sudden access to lush legume pastures; always offer long dry hay before turning onto legume pasture; graze legume pastures in the afternoon when dew has dried; add antifoaming agents (poloxalene as a pasture spray or in a drench); maintain legumes as a mixture with grasses rather than pure stands. Free-gas bloat: gas accumulates in the rumen as free gas (not foam) due to failure of eructation caused by physical obstruction of the oesophagus (foreign body, choke), or by rumen atony (loss of normal rumen contractions due to hypocalcaemia or systemic illness); prevention: remove the obstruction; treat the underlying cause of rumen atony.

4. Cause: rumen acidosis occurs when a ruminant consumes excessive amounts of rapidly fermentable starch (usually grain: maize, sorghum, wheat, or millet) without adequate adaptation time; rumen bacteria rapidly ferment the starch to produce large quantities of lactic acid (via Streptococcus bovis and Lactobacillus spp.); rumen pH falls below 5.0 and then below 4.0 in acute cases; fibre-digesting microbes die off; lactic acid is absorbed causing metabolic (D-lactic) acidosis; osmotic pressure in the rumen draws water from the bloodstream causing circulatory dehydration; endotoxins released from dying gram-negative bacteria cause laminitis. Signs: the animal is dull, depressed, and off-feed; the abdomen is distended; watery diarrhoea (often with undigested grain); rumination ceases; elevated heart and respiratory rates; in severe cases recumbency, inability to rise, coma, and death within 24-72 hours; survivors may develop laminitis (chronic foot lameness) weeks later. Prevention: introduce grain gradually over 2-3 weeks in a feedlot system, increasing the proportion by no more than 10-15% of dry matter per week; always maintain a minimum of 50% long-fibre roughage (hay, straw, silage) in the diet dry matter; add sodium bicarbonate (1-2% of diet DM) as a rumen buffer in feedlot rations; provide ad libitum access to sodium bicarbonate loose mineral in self-feeders.
5. Hardware disease (traumatic reticuloperitonitis) is a condition caused by sharp metal objects (wire clippings, nails, staples, fence wire fragments, bottle caps) accidentally swallowed by cattle while eating from contaminated pastures, hay, or silage; these objects

fall to the floor of the reticulum (the lowest point of the digestive tract when the animal is standing) and with the normal reticular contractions of digestion, the sharp object penetrates the reticulum wall, causing acute localised peritonitis (inflammation of the peritoneum). Clinical signs: sudden onset of decreased milk production; reluctance to move; humped back posture (indicating abdominal pain); grunting on deep breathing, defecation, or going down and up; reduced rumen motility; mild fever. Prevention: (1) rumen magnets: a cylindrical cylindrical metal magnet (approximately 8 cm long) is placed in the reticulum via a balling gun at the time animals enter the herd or farm; the magnet attracts and holds all ferromagnetic metal objects, preventing them from moving and penetrating the wall; this is the most effective preventive measure and should be standard practice on all cattle farms; (2) farm hygiene: remove all wire, nails, fencing materials, and scrap metal from feeding areas and pastures before cattle are introduced; use plastic or nylon baling twine rather than wire for hay bales; check silage and feed for metal contamination.

## References and Attributions [Series 2]

Textual References (Books and External Sources)


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Figures, Plates, Tables, and Boxes

- Table 2.1: Major cattle breeds in Nigeria Attribution: AI generated. Suggested OER search string: "Nigeria cattle breeds indigenous exotic White Fulani Ndama Holstein Friesian OER table".
- Table 2.2: Nigerian sheep and goat breeds Attribution: AI generated. Suggested OER search string: "Nigerian sheep goat breeds Yankasa Uda WAD Red Sokoto characteristics table OER".
- Figure 2.1: Ruminant four-compartment stomach diagram Attribution: AI generated. Suggested OER search string: "ruminant stomach four compartments rumen reticulum omasum abomasum diagram OER".
- Figure 2.2: Rumen fermentation pathways diagram Attribution: AI generated. Suggested OER search string: "rumen fermentation volatile fatty acids acetate propionate butyrate metabolism diagram OER".

**Course code: AGE 402**

**Course title: Husbandry of Ruminant Animals**

# Series 3: Feeding, Nutrition, and Management Practices

- **Part 3.1: Nutrient Requirements of Ruminants**
  - Sub Part 3.1.1: Classes of nutrients and their functions
  - Sub Part 3.1.2: Nutrient requirements of cattle
  - Sub Part 3.1.3: Nutrient requirements of sheep and goats
- **Part 3.2: Feeding Materials and Ration Formulation**
  - Sub Part 3.2.1: Roughages and forages
  - Sub Part 3.2.2: Concentrates and feed supplements
  - Sub Part 3.2.3: Principles of ration formulation
- **Part 3.3: Management of Breeding Stock**
  - Sub Part 3.3.1: Management of bulls, rams, and bucks
  - Sub Part 3.3.2: Management of cows, ewes, and does
  - Sub Part 3.3.3: Calf, lamb, and kid rearing
- **Part 3.4: Growing, Finishing, and Dairy Management**
  - Sub Part 3.4.1: Growing and finishing operations for cattle
  - Sub Part 3.4.2: Milk production and milking management
  - Sub Part 3.4.3: Milk handling, processing, and quality

## Introduction

Good nutrition is the single most important management input for ruminant productivity. An animal that is well-fed will grow, reproduce, and produce milk or fibre efficiently; nutritional deficiency reduces every aspect of performance. This Series covers nutrient requirements, feeding materials, ration formulation, and the management of breeding stock, young stock, and milk production. These topics are the practical core of ruminant husbandry as it is practised on Nigerian farms.

We move from the nutrient requirements of cattle, sheep, and goats through the major categories of feeding materials (roughages and concentrates), to the principles of ration formulation. We then cover the management of breeding animals and rearing of young stock, and conclude with growing, finishing, and dairy management including milking technique and milk hygiene. All content builds directly on the breed and digestive anatomy knowledge of Series 2.

## Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 3.1** describe the nutrient classes required by ruminants and explain the function of each (Linked to Part 3.1),
- **SLO 3.2** state the nutrient requirements of cattle, sheep, and goats for maintenance, growth, pregnancy, and lactation (Linked to Part 3.1),
- **SLO 3.3** classify and describe the feeding materials available for ruminants in Nigeria (Linked to Part 3.2),
- **SLO 3.4** apply the principles of ration formulation for ruminants (Linked to Part 3.2),
- **SLO 3.5** describe the management of bulls, rams, bucks, cows, ewes, and does on a Nigerian farm (Linked to Part 3.3),
- **SLO 3.6** describe the rearing of calves, lambs, and kids (Linked to Part 3.3),
- **SLO 3.7** describe growing, finishing, and feedlot operations for beef cattle (Linked to Part 3.4), and

- **SLO 3.8** describe milking management, milk handling, and milk processing for a Nigerian dairy operation (Linked to Part 3.4).

## 3.1 Nutrient Requirements of Ruminants

### 3.1.1 Classes of nutrients and their functions

Ruminants require six classes of nutrients: water (the most critical; required for all metabolic processes; a cow producing 20 litres of milk needs 80 to 100 litres of water per day); carbohydrates (structural carbohydrates in forage provide energy via VFAs; non-structural carbohydrates in grains provide readily available energy); proteins (required for growth, reproduction, milk production, enzyme synthesis, and tissue repair); fats (concentrated energy source; provide fat-soluble vitamins A, D, E, and K and essential fatty acids); minerals (macro-minerals: calcium, phosphorus, magnesium, sodium, potassium; micro-minerals: copper, zinc, iron, cobalt, iodine, selenium); and vitamins (A, D, E, K, B-complex synthesised in the rumen).

Rumen microbes synthesise B-complex vitamins and vitamin K, meaning adult ruminants on adequate diets rarely require supplementation with these. However, vitamin A (from beta-carotene in green forages) becomes deficient during the dry season when animals subsist on dry brown crop residues; vitamin A deficiency causes night blindness, poor reproduction, and increased susceptibility to infection. Vitamin D (from sunlight or sun-cured forages) and vitamin E (from fresh forages and seeds) may also become limiting in confined animals with no sunlight exposure.

Fill in the blank: Rumen microbes synthesise B-complex vitamins, so adult ruminants rarely need supplementation; however, vitamin _____ from green forages becomes deficient during the dry season when animals subsist on dry crop residues.

### 3.1.2 Nutrient requirements of cattle

Nutrient requirements of cattle are expressed as maintenance requirements (the amount needed just to keep the animal alive and healthy with no production) plus production requirements (the

additional nutrients needed for growth, pregnancy, or milk production). Maintenance energy requirement increases with body weight: a 400 kg cow requires approximately 55 MJ of metabolisable energy (ME) per day for maintenance. Each litre of milk with 3.5% fat requires an additional 5 MJ ME. Dietary crude protein for a lactating cow should be 14 to 18 per cent of diet dry matter; for a dry cow 10 to 12 per cent; for a growing calf 16 to 18 per cent.

Calcium and phosphorus requirements are highest during late pregnancy and early lactation: a cow producing 20 litres/day needs approximately 80 to 90 g calcium and 55 to 60 g phosphorus daily. The Ca:P ratio should be maintained at 1.5:1 to 2:1; inversion (phosphorus exceeding calcium) predisposes to urinary calculi. Grass and crop residues are usually adequate in phosphorus but deficient in calcium; lime, bone meal, and dicalcium phosphate are commonly used mineral supplements in Nigerian cattle rations.

Fill in the blank: The dietary crude protein for a lactating cow should be _____ to 18 per cent of diet dry matter; for a dry (non-lactating) cow the requirement drops to 10 to 12 per cent.

### 3.1.3 Nutrient requirements of sheep and goats

Sheep and goats have similar nutrient requirements to cattle per unit of body weight but their smaller size means total daily requirements are much lower. A 40 kg ewe in late pregnancy requires approximately 9 to 10 MJ ME per day and 130 to 150 g crude protein. Multiple-bearing ewes (twins and triplets) have significantly higher energy and protein requirements; failure to meet them causes pregnancy toxaemia (twin lamb disease). A lactating doe (goat) requires 50 to 100 per cent more energy than a dry doe, depending on milk yield.

Copper toxicity is a specific nutritional hazard for sheep: sheep are much more sensitive to copper accumulation in the liver than cattle or goats; supplementing sheep with copper levels appropriate for cattle causes copper toxicosis and sudden death. Cobalt and selenium deficiencies are also important in sheep in some Nigerian soils; cobalt is needed for rumen microbial synthesis of vitamin B12 (cobalamin), and deficiency causes "pine" (wasting disease) in lambs and kids. Regular mineral supplementation through lick blocks formulated specifically for sheep is the safest approach.

Fill in the blank: Sheep are unusually sensitive to copper; supplementing sheep at cattle copper levels causes _____ toxicosis and sudden death; mineral lick blocks formulated specifically for sheep must be used.

### Pilot questions 3.1

1. State the six nutrient classes required by ruminants and give one function of each.
2. Explain why vitamin A deficiency is common in Nigerian cattle during the dry season.
3. State the energy and protein requirements for a lactating cow producing 20 litres of milk per day.
4. Explain what pregnancy toxaemia is and which class of ruminant is most at risk.
5. Explain why copper supplementation of sheep requires special caution.

## 3.2 Feeding Materials and Ration Formulation

### 3.2.1 Roughages and forages

Roughages are bulky feeds with high fibre content (greater than 18 per cent crude fibre) and relatively low energy density; they form the dietary foundation for ruminants. Natural pasture grasses (Guinea grass Panicum maximum, Napier grass Pennisetum purpureum, Gamba grass Andropogon gayanus, Stylosanthes and Centrosema legumes) are the main roughage sources in Nigeria. Crop residues (maize stover, sorghum straw, cowpea haulms, groundnut haulms, rice straw, cassava peels) are critically important during the dry season when green pasture is unavailable.

Hay is dried grass or legume forage; if well-made at the correct moisture content (below 15%) it is a highly nutritious stored roughage. Silage is fermented green forage preserved in anaerobic conditions; maize silage is the highest-quality silage available in Nigeria. Leguminous forages (cowpea haulms, groundnut haulms, Stylosanthes, Gliricidia) are particularly valuable because their protein content (12 to 25%) is much higher than grass (3 to 10%); mixing legume and grass roughage improves the overall diet protein level significantly at low cost.

Fill in the blank: Crop residues such as maize stover, cowpea haulms, and groundnut haulms are critically important roughages during the _____ season in Nigeria when green pasture is unavailable.

| Feed Material | Dry Matter % | Crude Protein % | Metabolisable Energy (MJ/kg DM) | Primary Use |
|---|---|---|---|---|
| Guinea Grass | 25–30 | 6–10 | 8–9 | Roughage for grazing and cut-and-carry feeding |
| Cowpea Haulms | 85–90 | 12–15 | 9–10 | Protein-rich crop residue, supplementary feed |
| Groundnut Cake | 90 | 40–45 | 11–12 | Protein concentrate for fattening and dairy |
| Maize Grain | 88–90 | 9–10 | 12–13 | Energy concentrate for growth and lactation |
| Wheat Bran | 88–90 | 14–16 | 10–11 | Energy and protein supplement, palatable |
| Cottonseed Cake | 90 | 25–30 | 10–11 | Protein concentrate, often used in fattening diets |

Table 3.1: Common roughage and concentrate feeds used for ruminants in Nigeria with their approximate nutritive values

### 3.2.2 Concentrates and feed supplements

Concentrates are low-fibre, energy- or protein-rich feeds used to supplement roughage diets. Energy concentrates include: maize grain (the best energy source; 8 to 9 MJ ME/kg DM; 9% crude protein); sorghum grain (similar to maize); wheat bran (good energy, 16% crude protein; laxative effect useful in finishing rations); and molasses (a liquid by-product of sugar refining; 11 to 12 MJ ME/kg DM; excellent for palatability; used as a binder in feed blocks). Protein concentrates include: groundnut cake (45% crude protein; the most widely available protein supplement in northern Nigeria); cottonseed cake (20 to 36% CP); brewers' dried grains (25 to

30% CP; abundant near cities with breweries); soyabean meal (44 to 48% CP; high quality but expensive).

Mineral supplements commonly used in Nigeria include: bone meal (calcium and phosphorus); limestone or chalk (calcium); common salt (sodium chloride; essential for water balance; cattle require 30 to 50 g/day); dicalcium phosphate (both calcium and phosphorus). Urea is a non-protein nitrogen (NPN) source: rumen bacteria can use ammonia from urea hydrolysis to synthesise microbial protein; urea can replace up to 30 per cent of dietary protein in adult ruminants on low-protein diets, but excess urea causes ammonia toxicity; urea must never be fed to young pre-ruminant calves or lambs whose rumens are not yet functional.

Fill in the blank: Urea is a non-protein nitrogen source that rumen bacteria can use to synthesise microbial protein; it must never be fed to _____ pre-ruminant calves or lambs whose rumens are not yet functional.

### 3.2.3 Principles of ration formulation

A ration is the total amount of feed provided to an animal in 24 hours to meet all its nutrient requirements for maintenance and production. Ration formulation starts with: (1) identifying the animal's category (species, body weight, production stage); (2) looking up its nutrient requirements (energy, protein, calcium, phosphorus); (3) listing available feed ingredients with their nutrient compositions; (4) combining ingredients to meet requirements at minimum cost. The Pearson square method is the simplest tool for balancing a two-ingredient mixture for a single nutrient (usually crude protein).

Key principles: the roughage:concentrate ratio should be appropriate to the production level (high-producing dairy cows may receive up to 50% concentrate; growing cattle on good pasture need little or no concentrate); total dry matter intake is approximately 2 to 3 per cent of body weight per day for cattle (a 400 kg cow should consume 8 to 12 kg DM/day); never sacrifice roughage below 35 to 40 per cent of diet DM as this risks rumen acidosis; and feed supplements only what is deficient (over-supplementation wastes money and may cause toxicities such as copper toxicosis in sheep or vitamin A toxicity).

Fill in the blank: Total dry matter intake for cattle is approximately 2 to 3 per cent of body _____ per day; a 400 kg cow should consume 8 to 12 kg of dry matter daily.

### Pilot questions 3.2

1. Distinguish between roughages and concentrates and give two Nigerian examples of each.
2. Explain the nutritional value of leguminous forages compared with grasses.
3. State two energy concentrates and two protein concentrates used in Nigerian ruminant rations.
4. Explain what urea can and cannot be used for in ruminant feeding.
5. Describe the Pearson square method and explain when it is used.

## 3.3 Management of Breeding Stock

### 3.3.1 Management of bulls, rams, and bucks

Bulls, rams, and bucks must be kept in good body condition (score 3 to 3.5 on a 1-to-5 scale) throughout the breeding season; over-fat males are sluggish, under-conditioned males have poor libido and semen quality. Males should be evaluated for breeding soundness before each season: physical examination (feet, legs, eyes, genitalia) and semen evaluation (motility, morphology, and concentration). A bull serving too many cows becomes exhausted; the recommended ratio is 25 to 30 cows per bull for natural service. Bulls should be kept separate from cows except during designated breeding periods.

Young males should not be over-worked before 2 years of age: a yearling bull can serve 5 to 10 cows; at 2 years 15 to 25 cows; full capacity at 3 years. Rams and bucks require a "flushing" period before breeding: feeding extra energy (above maintenance) for 2 to 3 weeks before joining with females increases libido, sperm output, and conception rates by 10 to 20 per cent. Males should be vaccinated, dewormed, and treated for external parasites before the breeding season, as disease and heavy parasite burdens reduce semen quality and fertility.

Fill in the blank: Feeding extra energy above maintenance for 2 to 3 weeks before breeding (_____ period) increases ram and buck libido and sperm output, improving conception rates by 10 to 20 per cent.

### 3.3.2 Management of cows, ewes, and does

Female management is centred on maintaining adequate body condition throughout the reproductive cycle. Body condition scoring (BCS) on a 1 to 5 scale assesses subcutaneous fat cover; cows should calve at BCS 3 to 3.5 and not lose more than 0.5 BCS units in the first 60 days of lactation (negative energy balance in early lactation is unavoidable but must be limited). Ewes and does should be at BCS 3 to 3.5 at joining (start of breeding season). Flushing (extra feeding for 2 to 3 weeks before joining) increases ovulation rate and litter size in ewes and does.

The dry period in dairy cows (the 6 to 8 weeks before calving when milking stops) is critical for udder regeneration and preparation for the next lactation. Dry cows should receive a "dry cow diet" (maintenance nutrition only) for the first 4 to 5 weeks, then a "steaming-up" diet (increasing energy and protein) in the last 3 weeks before calving to build body reserves and condition the rumen for the high-concentrate lactation diet. Abrupt cessation of milking (dry-off) is the recommended method in Nigeria as it is simpler and less labour-intensive.

Fill in the blank: The _____ period (6-8 weeks before calving when milking stops) allows udder regeneration; dry cows are then gradually introduced to the steaming-up diet in the last 3 weeks before calving.

| Score | Description |
|---|---|
| Score 1 | Extremely thin; all bones prominent; no fat detectable |
| Score 2 | Thin; ribs and spine visible |
| Score 3 | Moderate; ribs barely visible; spine detectable but not prominent; target for calving and breeding |

| | |
|---|---|
| **Score 4** | Fat; ribs not visible; spine and hooks detectable with pressure |
| **Score 5** | Obese; all bony structures buried in fat |

Box 3.1: Body condition scoring guide for cattle on a 1-to-5 scale

### 3.3.3 Calf, lamb, and kid rearing

The first priority for every new-born ruminant is colostrum intake within the first 6 hours of life (see Series 1). After the colostrum period, calves may be reared by: natural (dam) suckling (calf left with the cow; simplest but reduces milk available for sale); restricted suckling (calf allowed to suckle once or twice daily at milking; balances milk production and calf nutrition); or artificial rearing (calf separated at birth or 2 to 3 days old; fed whole milk, colostrum bank, or milk replacer via bucket or bottle). Weaning of beef calves is at 6 to 8 months; dairy calves are weaned from milk at 8 to 12 weeks when consuming adequate dry feed.

Calves should have access to clean, fresh water from 1 week of age and to good-quality hay and starter concentrate from 10 to 14 days to encourage rumen development. The rumen is non-functional at birth and develops gradually; by 6 to 8 weeks the calf's rumen can support adequate forage digestion. Lambs and kids follow similar principles: they are weaned at 8 to 12 weeks in intensive systems, or 12 to 16 weeks in traditional systems. Major causes of young stock mortality in Nigeria are failure of passive immunity transfer (inadequate colostrum), diarrhoea (scours), pneumonia, and internal parasites.

Fill in the blank: Dairy calves are weaned from milk at _____ to 12 weeks when they are consuming adequate starter concentrate and hay; the rumen is non-functional at birth and develops over the first 6 to 8 weeks of life.

Pilot questions 3.3

1. Describe breeding soundness evaluation for a bull.
2. Explain what flushing is and state when it is applied to ewes and does.

3. Explain the significance of the dry period in dairy cow management.
4. Describe three systems of calf rearing and state the advantage of each.
5. State four major causes of calf, lamb, and kid mortality in Nigeria.

## 3.4 Growing, Finishing, and Dairy Management

### 3.4.1 Growing and finishing operations for cattle

Growing refers to the period from weaning to the start of fattening, during which the animal develops its skeletal frame; it is supported primarily by roughage-based diets with limited concentrate supplementation. Finishing (fattening or feedlot) is the intensive feeding of cattle on high-energy diets (60 to 70% concentrate, 30 to 40% roughage) to promote rapid fat deposition before slaughter. In Nigeria, feedlot operations typically run for 90 to 120 days; young steers or bulls of 200 to 250 kg starting weight are targeted to reach 380 to 450 kg at slaughter.

Common feedlot rations in Nigeria include: maize or sorghum grain (energy base), groundnut cake or cottonseed cake (protein), wheat bran (fibre and protein), molasses (palatability), mineral-vitamin premix, and common salt. Cattle should be adapted to the feedlot ration gradually over 2 to 3 weeks to prevent rumen acidosis. Weigh animals every 2 to 3 weeks to calculate average daily gain (ADG) and feed conversion ratio (FCR = feed consumed / weight gain); target ADG of 0.8 to 1.2 kg/day; FCR of 5 to 8 is typical in Nigerian feedlot conditions.

Fill in the blank: The target average daily gain (ADG) in a Nigerian cattle feedlot is 0.8 to 1.2 kg per day; the feed conversion ratio (FCR = feed consumed / weight _____ ) is typically 5 to 8 under Nigerian conditions.

| Ingredient | Inclusion Rate (% of DM) | Crude Protein % | Metabolisable Energy (MJ/kg DM) | Primary Use |
|---|---|---|---|---|
| Maize Grain | 40 | 9–10 | 12–13 | Energy concentrate |

| | | | | |
|---|---|---|---|---|
| Groundnut Cake | 20 | 40–45 | 11–12 | Protein concentrate |
| Wheat Bran | 20 | 14–16 | 10–11 | Energy + protein supplement |
| Molasses | 10 | 3–5 | 9–10 | Energy source, palatability enhancer |
| Mineral-Vitamin Premix | 5 | – | – | Micronutrient balance |
| Salt | 5 | – | – | Electrolyte balance, palatability |

Table 3.2: Example feedlot ration for growing-finishing cattle in Nigeria showing ingredients and proportions

### 3.4.2 Milk production and milking management

Milk production in Nigerian dairy operations ranges from 2 to 5 litres per day in indigenous cows to 15 to 25 litres in well-managed Friesian crossbreds. Milking is performed twice daily (morning and evening) at 12-hour intervals to maximise milk yield; once-daily milking reduces yield by 15 to 25 per cent. Before milking: the udder is washed with clean warm water and dried with a single-use cloth; the first few streams from each teat are discarded (fore-stripping) to detect mastitis and remove bacteria-laden milk from the teat canal. Hand milking (full-hand or knuckle method) is used on most Nigerian farms; machine milking is used only on larger commercial operations.

After milking: the teats should be dipped in an iodine-based teat dip (post-milking teat dipping) to prevent mastitis-causing bacteria from entering the open teat orifice after milking. The milking parlour and all equipment must be cleaned and sanitised after every milking session. Mastitis (inflammation of the udder) is the most costly disease of dairy cattle worldwide; its signs are swelling, heat, pain, and abnormal milk (clots, watery, or blood-tinged). The California Mastitis Test (CMT) detects sub-clinical mastitis before visible signs appear.

Fill in the blank: After milking, teats are dipped in an iodine-based _____ dip to prevent mastitis bacteria from entering the open teat orifice; this simple practice dramatically reduces mastitis incidence.

### 3.4.3 Milk handling, processing, and quality

Fresh raw milk is a perishable product that deteriorates rapidly at ambient Nigerian temperatures (28 to 35 degrees Celsius). The standard preservation method is pasteurisation: heating milk to 72 degrees Celsius for 15 seconds (HTST method) or 63 degrees Celsius for 30 minutes (LTLT method) to destroy pathogenic bacteria (Brucella abortus, Mycobacterium bovis, Listeria, Salmonella) without significantly affecting nutritional quality. In the absence of a pasteuriser, boiling destroys pathogens but slightly reduces nutritional value. All milk for public sale in Nigeria should be pasteurised under the NAFDAC food safety regulations.

Traditional Nigerian dairy products include: wara (soft white cheese made by coagulating milk with Calotropis latex or lemon juice; consumed fresh); nono (soured whole milk; naturally fermented; sold in calabashes or sachets); fura de nono (fermented milk mixed with millet balls; popular in northern Nigeria). Milk quality is measured by: specific gravity (normal 1.028 to 1.033); fat content (3.5 to 4.5% in indigenous breeds); titratable acidity (fresh milk 0.14 to 0.16% lactic acid); and somatic cell count (SCC below 200,000 cells/mL indicates healthy udder; above 500,000 indicates mastitis).

Fill in the blank: The HTST pasteurisation method heats milk to 72 degrees Celsius for _____ seconds to destroy pathogenic bacteria, including Brucella abortus and Mycobacterium bovis, which cause zoonotic diseases.

Pilot questions 3.4

1. Distinguish between growing and finishing operations for beef cattle.
2. Describe a typical Nigerian cattle feedlot ration and state the target ADG.
3. Describe the correct procedure for hand milking a cow.
4. Explain what mastitis is and describe two measures to prevent it.
5. Describe the HTST pasteurisation method and explain why pasteurisation is required.

## Series Summary

This Series covered feeding, nutrition, and management of ruminants. We described the six nutrient classes (water, carbohydrates, proteins, fats, minerals, vitamins), nutrient requirements for cattle (maintenance plus production; 14-18% CP for lactating cows), sheep, and goats (specific copper toxicity risk in sheep). We classified feeding materials (roughages: pasture, crop residues, hay, silage; concentrates: maize, groundnut cake, urea as NPN for adults only) and described ration formulation principles (2-3% DM intake of body weight; minimum 35-40% roughage).

We covered breeding stock management (BCS 3-3.5 at calving and joining; flushing for females; breeding soundness evaluation for males; dry period management for dairy cows) and rearing of young stock (colostrum within 6 hours; three calf rearing systems; rumen develops by 8 weeks). We concluded with growing and finishing (feedlot: 90-120 days, ADG 0.8-1.2 kg/day, FCR 5-8), milking management (twice daily, fore-stripping, post-milking teat dipping, mastitis detection by CMT), and milk processing (HTST pasteurisation at 72°C/15 sec; traditional products wara, nono, fura de nono). By completing this Series, you should achieve all eight SLOs (3.1 to 3.8).

## Glossary of Terms

- **Average daily gain (ADG):** total weight gain divided by the number of days on feed; the primary growth performance measure in feedlot operations; target 0.8-1.2 kg/day in Nigerian beef feedlots.
- **Body condition score (BCS):** a numerical assessment (1-5 scale) of the subcutaneous fat reserves of a ruminant based on visual and tactile evaluation; target 3.0-3.5 at calving and mating.

- **California Mastitis Test (CMT):** a rapid cow-side test using a reagent that reacts with somatic cells in milk to detect sub-clinical mastitis before visible signs appear.
- **Concentrate:** a low-fibre, energy- or protein-rich feed material used to supplement roughage; examples include maize grain, groundnut cake, soyabean meal, and molasses.
- **Crude protein (CP):** total nitrogen in a feed multiplied by 6.25; includes both true protein and non-protein nitrogen; expressed as a percentage of dry matter.
- **Dry period:** the 6-8 weeks before calving during which a dairy cow is not milked; essential for udder tissue regeneration and preparation for the next lactation.
- **Feed conversion ratio (FCR):** kilograms of feed dry matter consumed per kilogram of live weight gain; a measure of feeding efficiency; typical value 5-8 in Nigerian beef feedlots.
- **Finishing (fattening):** the intensive feeding of cattle on high-energy diets to promote rapid fat deposition and increase carcass weight and quality before slaughter.
- **Flushing:** the practice of providing extra energy above maintenance to ewes, does, or other females for 2-3 weeks before and after joining, to increase ovulation rate and litter size.
- **Fore-stripping:** the discarding of the first few streams of milk from each teat before milking to remove bacteria-laden milk and detect mastitis signs.
- **Groundnut cake:** the protein-rich by-product remaining after oil extraction from groundnuts; approximately 45% crude protein; the most widely used protein supplement in northern Nigeria.
- **HTST pasteurisation:** high-temperature short-time pasteurisation; heats milk to 72 degrees Celsius for 15 seconds to destroy pathogens while preserving most nutritional quality.
- **Mastitis:** inflammation of the mammary gland caused by bacterial infection (Staphylococcus aureus, Streptococcus agalactiae, E. coli); the most economically costly disease of dairy cattle.

- **Metabolisable energy (ME):** the energy in feed available to the animal after subtracting losses in faeces, urine, and methane; expressed in megajoules (MJ) per kg dry matter.
- **Molasses:** a viscous liquid by-product of sugar refining; high in rapidly fermentable sugars; used as a palatability enhancer, energy source, and binder in feed blocks.
- **Pearson square:** a simple graphical method for calculating the proportions of two feed ingredients needed to achieve a target nutrient level (usually crude protein) in a mixture.
- **Post-milking teat dipping:** immersing each teat in an iodine-based or chlorhexidine-based disinfectant solution immediately after milking to prevent mastitis bacteria from entering the open teat orifice.
- **Roughage:** bulky feed with more than 18% crude fibre and relatively low energy density; forms the dietary foundation for ruminants; examples include grass, hay, silage, and crop residues.
- **Steaming-up:** increasing the energy and protein in the diet of a pregnant cow, ewe, or doe during the last 3-6 weeks of pregnancy to build body reserves for lactation.
- **Urea:** a non-protein nitrogen (NPN) source that rumen microbes hydrolyse to ammonia for microbial protein synthesis; used only for adult ruminants; toxic if over-fed or fed to pre-ruminants.
- **Wara:** a traditional Nigerian soft white cheese made by coagulating fresh cow or goat milk with Calotropis leaf latex or citrus juice; consumed fresh without aging.

## Concept Check Questions [Series 3]

Objective Questions

1. Rumen microbes synthesise B-complex vitamins; however, vitamin _____ from green forages becomes deficient in Nigerian cattle during the dry season. (Linked to SLO 3.1)

2. Total dry matter intake for cattle is approximately 2 to 3 per cent of body _____ per day; a 400 kg cow should consume 8 to 12 kg DM daily. (Linked to SLO 3.4)
3. Feeding extra energy to ewes and does for 2-3 weeks before joining is called _____ and increases ovulation rate and litter size. (Linked to SLO 3.5)
4. Dairy calves are weaned from milk at 8 to _____ weeks when they are consuming adequate starter concentrate and hay. (Linked to SLO 3.6)
5. The HTST pasteurisation method heats milk to 72 degrees Celsius for _____ seconds to destroy pathogenic bacteria. (Linked to SLO 3.8)

Short-Answer Questions

- State the six nutrient classes required by ruminants and give one function of each. (Linked to SLO 3.1)
- Distinguish between roughages and concentrates and give two examples of each used in Nigeria. (Linked to SLO 3.3)
- Explain the importance of BCS in managing breeding females. (Linked to SLO 3.5)
- Describe the procedure for pre-milking udder preparation. (Linked to SLO 3.8)
- State four causes of young stock mortality in Nigeria. (Linked to SLO 3.6)

Long-Answer Questions

1. Describe the nutrient requirements of cattle for maintenance, growth, pregnancy, and lactation; explain the feeding materials available in Nigeria; and describe the principles of ration formulation. (Linked to SLOs 3.1, 3.2, 3.3, 3.4)
2. Describe the management of breeding stock (bulls, cows, and the dry period) and the rearing of calves in a Nigerian beef or dairy farm. (Linked to SLOs 3.5, 3.6)
3. Describe growing and finishing operations for beef cattle in Nigeria and describe milking management, milk handling, and traditional dairy products. (Linked to SLOs 3.7, 3.8)

## Answers to Concept Check Questions [Series 3]

Objective Questions

6. A.
7. Weight.
8. Flushing.
9. 12.
10. 15.

Short-Answer Questions

11. Water (all metabolic processes, milk production); carbohydrates (primary energy source via VFAs); proteins (growth, milk, enzymes, tissue repair); fats (concentrated energy, fat-soluble vitamins, essential fatty acids); minerals (bone, enzyme function, fluid balance: calcium, phosphorus, sodium, copper, cobalt); vitamins (A for vision/reproduction; D for calcium absorption; E as antioxidant; B-complex from rumen microbes).
12. Roughages: bulky feeds with >18% crude fibre, low energy density; form the dietary foundation for ruminants; Nigerian examples: Guinea grass, cowpea haulms. Concentrates: low-fibre, energy- or protein-rich supplements; used to top up roughage diets; Nigerian examples: maize grain (energy), groundnut cake (protein).
13. Body condition score (BCS) reflects the fat reserves of the animal and predicts its reproductive efficiency. Cows in BCS below 2.5 at calving have low conception rates, prolonged post-partum anoestrus, and poor milk production. Ewes below BCS 2.5 at joining have lower ovulation rates and smaller litter sizes. Maintaining target BCS (3.0-3.5) through appropriate feeding at each stage of the reproductive cycle is the primary lever for improving fertility and production efficiency.
14. Pre-milking udder preparation: (1) observe the cow from a distance for any signs of lameness or abnormality before approaching; (2) gently restrain the cow and approach

from the side; (3) wash the udder and teats with clean warm water using a disposable or single-use cloth; (4) dry the udder and teats thoroughly with a clean dry cloth; (5) fore-strip each teat (discard the first 2-3 streams) to remove bacteria from the teat canal, stimulate milk let-down, and check for signs of mastitis (clots, abnormal colour, or watery consistency); (6) begin milking promptly, completing within 5-7 minutes of initial stimulation.

15. Failure to absorb adequate colostral immunoglobulins (passive immunity failure); neonatal diarrhoea (scours) from E. coli, Salmonella, Cryptosporidium, or rotavirus; pneumonia from Pasteurella, Mannheimia, or Mycoplasma; internal parasitism (Haemonchus contortus in lambs/kids).

Long-Answer Questions

1. Nutrient classes: water (80-100 L/day for a 400 kg lactating cow); carbohydrates (structural in roughage via VFAs; non-structural in grains); protein (14-18% DM for lactating cow; 10-12% for dry cow; 16-18% for growing calf); fats (fat-soluble vitamins; concentrated energy); minerals (Ca 80-90 g/day lactating; P 55-60 g/day; Ca:P = 1.5-2:1; sheep copper toxicity risk); vitamins (A from beta-carotene, deficient dry season; D from sunlight; E from fresh forage; B-complex from rumen). Feeding materials: roughages (Guinea grass, Napier, Gamba, crop residues, hay, maize silage; legumes: cowpea haulms 12-25% CP); concentrates (energy: maize 9% CP 8-9 MJ ME, sorghum, wheat bran, molasses; protein: groundnut cake 45% CP, cottonseed cake 20-36%, brewers' grains 25-30%, soyabean meal 44-48%; minerals: bone meal, limestone, salt, DCP; NPN: urea for adults only, toxic to pre-ruminants). Ration formulation: identify animal category; look up requirements; list available ingredients and compositions; balance to meet requirements at minimum cost using Pearson square for two-ingredient CP balancing; DM intake 2-3% of BW; maintain minimum 35-40% roughage DM; concentrate up to 50% for high-producing dairy cows.
2. Bull management: maintain BCS 3-3.5; conduct breeding soundness evaluation (physical exam + semen motility/morphology/concentration); limit young bulls (25-30 cows per

adult bull; 5-10 per yearling); vaccinate, deworm, and treat for ectoparasites before breeding season; separate from cows outside breeding periods. Cow management: maintain BCS 3-3.5 at calving and joining; apply flushing (extra energy for 2-3 weeks pre-joining) to boost ovulation rate; monitor and limit BCS loss in early lactation (<0.5 units in first 60 days); dry-off 6-8 weeks before next calving; dry-cow diet for first 4-5 weeks of dry period then steaming-up in last 3 weeks. Calf rearing: colostrum within first 6 hours (ensures passive immunity from maternal IgG); three systems: natural suckling (simplest, calf with dam), restricted suckling (once/twice daily at milking), artificial rearing (bucket/bottle from birth/day 2-3, whole milk or replacer); water from 1 week; starter concentrate and hay from 10-14 days to develop rumen; wean dairy calves at 8-12 weeks; beef calves at 6-8 months. Major mortality causes: passive immunity failure, scours, pneumonia, internal parasites.

3. Growing: post-weaning to start of finishing; skeletal development; roughage-based diet with limited concentrate; body weight 200-250 kg at feedlot entry. Finishing (feedlot): 90-120 days; high-energy ration (60-70% concentrate: maize/sorghum grain, groundnut cake, cottonseed cake, wheat bran, molasses, mineral premix, salt); adapt gradually over 2-3 weeks; weigh every 2-3 weeks; target ADG 0.8-1.2 kg/day; FCR 5-8; slaughter at 380-450 kg. Milking management: twice daily at 12-hour intervals; wash udder with warm water; dry; fore-strip (discard first streams, detect mastitis); hand-milk using full-hand/knuckle technique; complete within 5-7 minutes; post-milking teat dip in iodine solution; clean and sanitise equipment after every milking. Mastitis prevention: pre- and post-milking teat dipping; clean, dry milking environment; CMT screening monthly; dry-cow intramammary antibiotic therapy. Milk handling and processing: chill immediately after milking to below 4 degrees Celsius; HTST pasteurisation at 72°C/15 sec or LTLT at 63°C/30 min to destroy Brucella, M. bovis, Listeria; all public sale milk must comply with NAFDAC standards. Traditional products: wara (soft cheese, Calotropis coagulation); nono (soured fermented milk); fura de nono (fermented milk with millet balls). Milk quality measures: specific gravity 1.028-1.033; fat 3.5-4.5%; titratable acidity 0.14-0.16% lactic acid; SCC <200,000/mL.

## Answers to Pilot Questions [Series 3]

Part 3.1

6. Six nutrient classes and one function each: (1) Water: solvent for all metabolic reactions; a 20-L/day dairy cow needs 80-100 L/day. (2) Carbohydrates: primary energy source; structural carbohydrates in roughage fermented to VFAs; grain starch provides rapidly available energy. (3) Proteins: required for muscle growth, milk protein synthesis, enzymes, and tissue repair; 14-18% DM required in lactating cow diet. (4) Fats: concentrated energy source (2.25 times more energy per gram than carbohydrates); carry fat-soluble vitamins A, D, E, K; supply essential fatty acids. (5) Minerals: calcium and phosphorus for bone and milk synthesis; sodium for fluid balance; cobalt for B12 synthesis by rumen microbes; copper and zinc for enzyme function. (6) Vitamins: A for vision and immune function (deficient in dry season); D for calcium absorption; E as antioxidant protecting cell membranes; B-complex synthesised by rumen microbes in adults.
7. During the wet season, green pasture grasses are rich in beta-carotene (provitamin A), which animals convert to vitamin A in the intestinal wall. During the dry season in Nigeria (November to April in the south; longer in the north), green vegetation disappears and animals subsist on dry brown crop residues (maize stover, sorghum straw, rice straw) which contain negligible beta-carotene because it degrades rapidly on drying. The animal's liver stores of vitamin A become depleted after 2 to 4 months on dry brown feeds, and deficiency signs (night blindness, poor reproduction, skin thickening, increased infection susceptibility) appear.
8. Energy: a 400 kg cow producing 20 litres of milk with 3.5% fat requires approximately 55 MJ ME/day for maintenance plus 20 x 5 = 100 MJ ME for milk production = approximately 155 MJ ME per day total. Protein: a lactating cow requires 14 to 18 per cent crude protein of diet dry matter; for a cow consuming 12 kg DM/day at 16% CP this means 1.92 kg CP per day. Calcium: approximately 80 to 90 g per day. Phosphorus: approximately 55 to 60 g per day.
9. Pregnancy toxaemia (twin lamb disease in sheep; acetonaemia/ketosis in cattle) occurs in the last 4 to 6 weeks of pregnancy when the energy demands of rapid foetal growth

exceed the energy the animal can obtain from its diet; the body mobilises fat reserves, producing excessive ketone bodies (acetoacetate, beta-hydroxybutyrate, acetone) that cause neurological signs, dullness, refusal to eat, sweet-smelling breath, and death if untreated. Most at risk: ewes carrying twins or triplets (very common in West African Dwarf sheep) because their energy requirement is approximately 50% above that of a single-bearing ewe at the same body weight, and their rumen capacity is physically limited by the large foetal mass.

10. Sheep absorb dietary copper very efficiently from the gut and accumulate it in the liver; unlike cattle, they have a low threshold for hepatic copper toxicosis. When liver copper exceeds a critical level, a haemolytic crisis occurs: copper is suddenly released from the liver into the bloodstream, causing massive intravascular haemolysis (red blood cell destruction), jaundice, haemoglobinuria (red urine), and death within 24 to 48 hours, often with no warning signs. Cattle can safely tolerate copper supplementation levels (1,000-2,000 mg/kg DM) that are acutely toxic to sheep; therefore, mineral lick blocks, premixes, and boluses labelled for cattle must never be given to sheep.

Part 3.2

11. Roughages: bulky feeds with more than 18% crude fibre and relatively low energy density that form the dietary foundation for ruminants; require rumen microbial fermentation to release energy. Nigerian examples: Guinea grass (Panicum maximum); cowpea haulms. Concentrates: feeds with less than 18% crude fibre and high energy or protein density; used to supplement roughage diets. Nigerian examples: maize grain (energy concentrate); groundnut cake (protein concentrate).
12. Leguminous forages (cowpea haulms, groundnut haulms, Stylosanthes hamata, Gliricidia sepium, Leucaena leucocephala) typically contain 12 to 25% crude protein on a dry matter basis, compared with only 3 to 10% for mature grass species and 3 to 6% for cereal crop residues. They also have higher calcium content and generally lower fibre content than grasses at equivalent maturities. Mixing legume forage with grass at a ratio of about 30:70 by weight brings the diet protein content to the minimum requirements for

maintenance and moderate production, essentially eliminating the need for expensive protein concentrate supplementation in moderate-production systems.

13. Energy concentrates: (1) maize grain (approximately 8-9 MJ ME/kg DM; 9% crude protein; best energy source for ruminant concentrates); (2) molasses (11-12 MJ ME/kg DM; excellent palatability enhancer and binder; by-product of sugar refining; abundant near sugar mills). Protein concentrates: (1) groundnut cake (approximately 45% crude protein; most widely available and affordable protein supplement in northern Nigeria; by-product of groundnut oil extraction); (2) cottonseed cake (20-36% CP depending on processing; by-product of cottonseed oil extraction; widely available in the cotton-growing states).
14. Urea can be used as a non-protein nitrogen (NPN) supplement in the diet of adult ruminants with functional rumens: rumen bacteria possess the enzyme urease, which hydrolyses urea to ammonia and carbon dioxide; the ammonia is used by rumen bacteria to synthesise microbial protein, which then flows to the abomasum for digestion. Urea can safely replace up to 30% of dietary protein in adult cattle, sheep, and goats on low-protein roughage diets, significantly reducing feed cost. Urea cannot be used for young pre-ruminant calves, lambs, or kids (under 3 months of age) whose rumens are non-functional and who cannot handle ammonia; nor can it be fed at excessive levels (more than 1% of diet DM) to any animal as excess ammonia is absorbed causing tremors, salivation, and death.
15. The Pearson square is a simple graphical method for calculating the proportions of exactly two feed ingredients (one higher and one lower in the target nutrient than the desired level) needed to produce a mixture with a specified target nutrient level, most commonly crude protein. Procedure: write the target CP% in the centre of a square; write the CP% of ingredient A at the top left corner and the CP% of ingredient B at the bottom left; subtract diagonally (ignoring minus signs) to get the parts of each ingredient needed. It is used when a farmer has two available feeds and needs to combine them to meet a target protein level for a ration, without access to a computer or more complex formulation software.

Part 3.3

1. Breeding soundness evaluation (BSE) for a bull consists of three components: (1) Physical examination: systematic inspection of eyes (vision), hooves and feet (soundness for mounting), legs (ability to mount and thrust), prepuce and sheath (no injury or infection), scrotum and testes (both testes present, symmetrical, firm but not hard, no adhesions), and epididymis (no enlargement suggesting epididymitis); body condition score 3.0-3.5. (2) Semen evaluation: a semen sample is collected by electro-ejaculator or artificial vagina; motility (at least 30% progressively motile under the microscope); morphology (at least 70% morphologically normal sperm: no double heads, bent midpieces, bent tails, or cytoplasmic droplets); concentration (at least 500 million sperm per mL). (3) Mating ability test: observe the bull's libido and mating behaviour in the presence of an oestrous female; a bull that consistently fails to mount or mate after multiple opportunities is classified as a breeding failure regardless of good semen quality.
2. Flushing is the practice of providing extra nutritional energy above the animal's maintenance requirement for 2 to 3 weeks before and approximately 2 to 3 weeks after the start of the breeding season (joining). It is applied to ewes before the ram is introduced and to does before the buck is put in. The mechanism: the increased energy intake raises circulating glucose and insulin levels, which in turn stimulate the hypothalamic-pituitary axis to increase the frequency of LH (luteinising hormone) pulses; this leads to the maturation and ovulation of more follicles than would occur in a lower-condition animal. The practical result is a 10 to 20 per cent increase in conception rate at first mating and a significant increase in twinning and triplet rate in breeds capable of multiple ovulation (WAD sheep, WAD goats, Yankasa sheep).
3. The dry period has three critical functions: (1) Udder regeneration: the mammary secretory epithelium undergoes involution and regeneration during the dry period; cows dried off for fewer than 4 weeks enter the next lactation with incomplete udder regeneration and lower peak milk yields than cows with a full 6-8 week dry period. (2) Body condition recovery: the dry period allows the cow to recover body condition that was lost in early lactation; cows entering calving at BCS below 2.5 have poor post-calving conception rates and prolonged anoestrus. (3) Metabolic preparation: the rumen

and metabolic systems are gradually adapted during steaming-up to cope with the dramatic dietary change from the dry cow ration to the high-concentrate early lactation diet without developing acidosis or displaced abomasum.

4. Three calf rearing systems: (1) Natural (dam) suckling: the calf is left with the cow and suckles whenever it desires; advantage: lowest management labour and lowest calf mortality (adequate colostrum and milk intake guaranteed); disadvantage: all available milk is consumed by the calf, leaving nothing for sale; used in beef herds. (2) Restricted suckling: the calf is separated from the dam and allowed to suckle once or twice daily at milking time; the calf's suckling stimulates milk letdown, reducing the need for oxytocin injections; advantage: balances calf nutrition with some milk available for sale; used in smallholder dairy herds in Nigeria. (3) Artificial rearing: the calf is permanently separated from the dam at birth or within 2-3 days after colostrum feeding; fed whole milk, banked colostrum, or milk replacer by bucket or bottle; advantage: all milk is available for sale; maximum milk revenue; most common on commercial dairy farms.
5. Major causes of calf, lamb, and kid mortality in Nigeria: (1) Failure of passive transfer (FPT): inadequate intake or poor absorption of colostral immunoglobulins, leaving the new-born without circulating antibodies and vulnerable to any pathogen; most common cause of early mortality, particularly in calves separated from their dams before adequate colostrum intake. (2) Neonatal diarrhoea (scours): caused by E. coli (within first 2 days), rotavirus and coronavirus (days 5-14), and Cryptosporidium parvum (days 5-21); causes dehydration, acidosis, and electrolyte imbalance; the leading cause of calf deaths. (3) Pneumonia (enzootic calf pneumonia, caprine respiratory disease): caused by Pasteurella multocida, Mannheimia haemolytica, Mycoplasma spp.; exacerbated by inadequate ventilation, overcrowding, temperature fluctuations, and stress. (4) Internal parasitism: Haemonchus contortus (barber's pole worm) causes severe anaemia in lambs and kids under traditional management; Strongyloides spp. and Neoascaris vitulorum (roundworms) affect young calves.



Part 3.4

1. Growing is the phase from weaning to the start of intensive fattening; the animal is depositing bone and muscle on a largely roughage-based diet with limited concentrate; the goal is skeletal development without excessive fat deposition; this phase may last 6 to 12 months in a typical Nigerian beef system, taking the animal from weaning weight (approximately 100-150 kg) to feedlot entry weight (200-250 kg). Finishing (fattening or feedlot) is the intensive feeding of cattle on a high-energy diet (60-70% concentrate, 30-40% roughage) in a confined pen with the specific goal of rapidly depositing fat to increase carcass weight, marbling (intramuscular fat), and meat quality before slaughter; typically 90 to 120 days duration in Nigeria.
2. A typical Nigerian cattle feedlot ration by DM basis: maize grain 40-50% (primary energy source); groundnut cake or cottonseed cake 15-20% (protein); wheat bran 10-15% (fibre, protein, rumen stability); molasses 5-8% (palatability, energy, binder); mineral-vitamin premix 1-2% (macro and micro mineral balance); common salt 0.5-1% (sodium, chloride). Resulting analysis approximately: crude protein 14-16% DM; ME 10-11 MJ/kg DM. Target ADG: 0.8 to 1.2 kg of live weight per day; animals not achieving 0.8 kg/day should be examined for disease, feed refusal, or overcrowding; animals achieving consistently above 1.0 kg/day are performing at the top of Nigerian feedlot capacity.
3. Procedure for hand milking: (1) prepare the cow (see answer to CCQ 3.4); (2) squat or sit on a low stool at the right side of the cow, facing the rear; (3) grasp the fore teat with the full hand, closing the thumb and forefinger first (this traps milk in the teat cistern), then closing the remaining fingers sequentially to express the milk downward into a clean, covered bucket; (4) alternate between right and left fore teats, then move to the rear teats; (5) use a rhythmic alternating pattern maintaining continuous stimulation to sustain milk ejection; (6) milk out completely (strip out the last milk with two fingers to prevent mastitis and maximise yield); (7) complete all four quarters within 5 to 7 minutes; (8) apply post-milking teat dip; (9) record the milk yield if monitoring individual production.
4. Mastitis is inflammation of the mammary gland caused by bacterial infection, resulting in reduced milk yield, abnormal milk, and in severe cases fever and loss of the affected quarter. Two prevention measures: (1) Post-milking teat dipping: immediately after milking each cow, dip all four teats in a 0.5-1% iodine solution (or similar approved disinfectant); this kills bacteria on the teat skin and prevents them from entering the open

teat sphincter, which remains slightly dilated for 15-30 minutes after milking; this one practice reduces new infection rate by 50-80%. (2) Milking hygiene: always use clean water and individual clean cloths for pre-milking udder preparation; never use the same cloth on two cows; ensure milkers have clean hands or wear gloves; maintain clean, dry lying surfaces in the housing area to minimise faecal contamination of teats.

5. HTST (High-Temperature Short-Time) pasteurisation heats a continuous stream of milk to exactly 72 degrees Celsius for 15 seconds using a plate heat exchanger, then immediately cools it to below 4 degrees Celsius; this combination of temperature and time is sufficient to achieve a 5-log (100,000-fold) reduction in the most heat-resistant pathogenic non-spore-forming bacteria. Pasteurisation is required because raw milk can transmit several serious human diseases: Brucella abortus causes brucellosis (undulant fever) in humans; Mycobacterium bovis causes bovine tuberculosis in humans; Listeria monocytogenes causes listeriosis, particularly dangerous for pregnant women; Salmonella and E. coli O157:H7 cause acute gastroenteritis. In Nigeria where brucellosis and bovine tuberculosis are prevalent in cattle herds, pasteurisation of milk is a critical public health measure required by NAFDAC for all commercially sold milk products.

## References and Attributions [Series 3]

Textual References (Books and External Sources)


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Figures, Plates, Tables, and Boxes

1. Table 3.1: Common ruminant feed materials in Nigeria with nutritive values Attribution: AI generated. Suggested OER search string: "ruminant feed materials Nigeria roughage concentrate nutritive value table OER".
2. Box 3.1: Cattle body condition scoring guide 1-to-5 Attribution: AI generated. Suggested OER search string: "cattle body condition scoring BCS 1 to 5 guide ruminant OER box".
3. Table 3.2: Nigerian cattle feedlot ration example Attribution: AI generated. Suggested OER search string: "Nigeria cattle feedlot ration ingredients groundnut cake maize sorghum OER table".

**Course code: AGE 402**

**Course title: Husbandry of Ruminant Animals**

# Series 4: Housing, Equipment, and Production Systems

- **Part 4.1: Housing for Cattle**
  - Sub Part 4.1.1: Principles of ruminant housing
  - Sub Part 4.1.2: Types of cattle housing
  - Sub Part 4.1.3: Space requirements and housing components
- **Part 4.2: Housing for Sheep and Goats**
  - Sub Part 4.2.1: Sheep housing in Nigeria
  - Sub Part 4.2.2: Goat housing in Nigeria
  - Sub Part 4.2.3: Housing design for small ruminant health
- **Part 4.3: Equipment for Ruminant Production**
  - Sub Part 4.3.1: Feeding and watering equipment
  - Sub Part 4.3.2: Restraint and handling equipment
  - Sub Part 4.3.3: Identification, recording, and health equipment
- **Part 4.4: Production Systems and Pasture Management**
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  - Sub Part 4.4.2: Pasture establishment and management
  - Sub Part 4.4.3: Rangeland management and the farmer-herder challenge

## Introduction

Appropriate housing protects ruminants from rain, sun, predators, and disease, while well-designed equipment improves efficiency and animal welfare. Equally important is the production system: whether animals are managed extensively on open range, semi-intensively on improved pastures, or intensively in confined facilities determines all other management decisions. This Series covers housing for cattle, sheep, and goats; key equipment items; and the major production systems and pasture management practices used in Nigeria.

Students completing this Series will be able to design simple but functional housing for cattle and small ruminants, select suitable equipment, and evaluate the production system options available to Nigerian ruminant farmers. The content connects directly to the feeding and health management topics of Series 3 and 5.

## Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 4.1** state the principles of ruminant housing and describe how each applies in Nigerian conditions (Linked to Part 4.1),
- **SLO 4.2** describe the main types of cattle housing used in Nigeria and specify space requirements (Linked to Part 4.1),
- **SLO 4.3** describe housing systems for sheep and goats and explain how design affects health (Linked to Part 4.2),
- **SLO 4.4** describe feeding, watering, restraint, and identification equipment used in ruminant production (Linked to Part 4.3),
- **SLO 4.5** distinguish between extensive, semi-intensive, and intensive ruminant production systems (Linked to Part 4.4),

- **SLO 4.6** describe the steps in establishing and managing improved pastures in Nigeria (Linked to Part 4.4), and
- **SLO 4.7** explain rangeland management principles and describe the farmer-herder conflict challenge in Nigeria (Linked to Part 4.4).

## 4.1 Housing for Cattle

### 4.1.1 Principles of ruminant housing

Good ruminant housing must satisfy six key principles: protection (from rain, direct sun, wind, predators, and theft); comfort (adequate space, clean dry bedding, good air circulation); hygiene (floors and drains easy to clean and disinfect); ventilation (open-sided or louvred openings for free air movement in Nigeria's tropical climate); economy (locally available materials: timber, thatch, mud brick, corrugated iron); and functionality (designed for the specific animal class and task).

In Nigeria's tropical climate, shade is the primary housing need; a simple shade structure with compacted earth or concrete floor and good drainage serves most cattle classes adequately. Confined, poorly ventilated structures cause heat stress, ammonia build-up, and respiratory disease; all housing should allow natural through-ventilation by orienting the long axis perpendicular to the prevailing breeze and keeping at least two sides open or screened.

Fill in the blank: Good ruminant housing must provide protection, comfort, _____, ventilation, economy, and functionality; shade and drainage are the primary requirements in Nigeria's tropical climate.

### 4.1.2 Types of cattle housing

Free-stall (loose housing) allows cattle to move freely within a yard or barn; animals lie in open areas or individual stalls and are fed at common feed bunks. It is suitable for large beef or dry dairy herds where individual monitoring at feeding is not required. Tied (stanchion) housing

restrains each cow at an individual stall with a neck chain or headlock, allowing individual feeding and milk yield monitoring; it suits small dairy operations of 3 to 20 cows.

Calving boxes are individual pens of approximately 3 m x 3 m where cows are placed 1 to 2 days before parturition; they allow supervision and protect the cow and calf from herd mates. Bull pens are strongly constructed individual enclosures of at least 4 m x 4 m with reinforced walls. Calf creeps are low-fenced areas inside a paddock accessible only to calves, allowing them to receive supplementary feed without competition from their dams.

Fill in the blank: _____ housing restrains each cow at an individual stall with a neck chain or headlock; it suits small dairy operations where monitoring of individual milk yield is required.


FIGURE 4.1: PHOTOGRAPH OF A TYPICAL NIGERIAN OPEN-SIDED CATTLE SHELTER

Figure 4.1: Photograph of a typical Nigerian open-sided cattle shelter

### 4.1.3 Space requirements and housing components

Recommended floor space per animal: dairy cow tied stall 2.0 m x 1.2 m; dairy cow loose housing 7 to 9 m2; beef steer grow-out yard 4 to 6 m2; calf group pen 1.5 to 2.0 m2; bull pen 16

m2 minimum. Trough space: 0.6 m per dairy cow; 0.5 m per beef cattle; 0.3 m per calf. Insufficient trough space causes competition and prevents subordinate animals from eating adequate feed.

Key structural components: floor (concrete or compacted earth; sloped 1 to 2% toward the drain); roof (corrugated iron; eaves at least 0.6 m beyond the wall; minimum 3.5 m height at eave); feed trough (concrete; 0.6 m wide, 0.3 m deep); water trough (automatic float-valve preferred; 50 to 80 litres per cow per day); drainage channel (concrete; 0.3 m wide; sloped away from building).

Fill in the blank: The minimum floor space for a dairy cow in loose housing is _____ to 9 m2; the floor should slope at 1 to 2 per cent toward the drain to prevent waterlogging.

### Pilot questions 4.1

- State six principles of ruminant housing.
- Distinguish between free-stall and tied housing systems for dairy cattle.
- State the minimum floor space for: a dairy cow in tied housing; a beef steer in a grow-out yard; a bull pen.
- Describe the key structural components of a simple open-sided cattle house.
- Explain why ventilation is critical in tropical cattle housing.

## 4.2 Housing for Sheep and Goats

### 4.2.1 Sheep housing in Nigeria

In northern Nigeria, traditional sheep are largely unhoused, scavenging during the day and enclosed in simple compounds at night. Commercial sheep production benefits from a raised slatted or mesh floor pen: the elevated platform keeps animals off damp ground, allows manure to fall through, and reduces gastrointestinal parasite reinfestation from contaminated soil. In humid southern Nigeria this design is particularly important for controlling Haemonchus contortus.

Floor space requirements: ewe 0.7 to 1.0 m2; ram 1.5 to 2.0 m2; lamb 0.3 to 0.5 m2. A lambing pen (2 m2 per ewe-lamb pair) provides a quiet, protected space for the first 3 to 5 days post-partum. Troughs should allow 0.3 to 0.4 m per sheep; shade of at least 1.5 m2 per animal is essential during the hot dry season. Draughts at ground level must be avoided, especially for newborn lambs susceptible to pneumonia.

Fill in the blank: Raising sheep on a _____ floor keeps animals off damp ground, allows manure to fall through, and reduces reinfestation with gastrointestinal parasites.

### 4.2.2 Goat housing in Nigeria

Goats are more agile than sheep and require more secure housing. Pen walls must be at least 1.5 m high for small breeds and 2.0 m for large breeds; horizontal rails that goats can use as footholds must be avoided. The most effective low-cost design is a raised platform pen: bamboo or wooden slats on a frame 0.5 to 0.8 m above the ground, with mesh sides for air circulation and predator protection at night.

Floor space: doe 0.7 to 1.0 m2; buck 1.5 to 2.0 m2; kid 0.3 to 0.5 m2. A kidding pen (1.5 m2 per doe-kid pair) reduces trampling mortality of newborns. Tethering (tying individual goats to a stake) is common in smallholder households in southern Nigeria but increases parasite burden on repeatedly used ground; the tethering point should be rotated to fresh ground daily.

Fill in the blank: Goat pen walls must be at least _____ m high for small breeds with no horizontal rails, as goats are agile climbers that will use any foothold to escape.


FIGURE 4.2: PHOTOGRAPH OF A RAISED SLATTED-FLOOR GOAT PEN

Figure 4.2: Photograph of a raised slatted-floor goat pen

### 4.2.3 Housing design for small ruminant health

The three most important housing design factors for preventing small ruminant disease are: adequate ventilation (open-sided or mesh-walled structures prevent ammonia build-up and respiratory infections); dry floor (raised slatted floors or frequently changed dry bedding breaks the lifecycle of Haemonchus and coccidian parasites); and age-group separation (keeping adults away from lambs and kids prevents transfer of high worm burdens to more susceptible young stock).

Additional health-critical design factors: shade during the hot season; sheltered areas free from cold harmattan draughts for newborns; clean water accessible at all times; regular manure removal (daily in intensive pens); and siting the pen on elevated, well-drained ground to prevent flooding during heavy rains, which wets bedding and creates conditions for foot rot and parasite development.

Fill in the blank: Separating lambs and kids from adult animals reduces their parasite _____ dramatically, as adult animals carry high worm burdens that contaminate the environment and infect the susceptible young.

### Pilot questions 4.2

- Describe two advantages of a raised slatted floor pen for small ruminants.
- State the floor space requirements for an adult ewe, a ram, and a lamb in housed production.
- Explain why goat housing must be designed differently from sheep housing.
- Describe the tethering system and state its main disadvantage.
- State three housing design features that reduce small ruminant disease.

## 4.3 Equipment for Ruminant Production

### 4.3.1 Feeding and watering equipment

Feed bunks (feed troughs) for cattle are constructed of concrete or galvanised iron; standard specifications are 0.5 to 0.6 m wide, 0.3 m deep, and 0.5 m linear space per adult animal. Hay racks hold roughage above floor level; they are particularly important for sheep and goats because feed on the floor quickly becomes contaminated with manure and is then refused. Feed blocks (molasses-urea) supplement grazing animals with protein, energy, and minerals in the field.

Water troughs for cattle must supply 50 to 80 litres per animal per day; automatic float-valve troughs are preferred in intensive operations. Troughs for sheep and goats should be shallow (maximum 0.2 m depth) for lambs and kids. All troughs must be cleaned at least weekly. Water deprivation for even 24 hours significantly reduces dry matter intake and milk production; clean water at all times is one of the lowest-cost and highest-return management investments.

Fill in the blank: Cattle require 50 to _____ litres of water per day; water deprivation for 24 hours causes significant loss of dry matter intake and milk production in dairy cows.

### 4.3.2 Restraint and handling equipment

The nose ring (brass ring through the nasal septum) provides a point of control for bulls; a rope clipped to it gives the handler strong leverage. The halter leads and restrains individual cattle safely; it is the most humane routine restraint for dairy cows. The cattle crush (squeeze chute) is an adjustable metal frame that immobilises cattle for veterinary procedures (vaccination, deworming, pregnancy diagnosis, hoof trimming) without roping or casting; it is the standard facility for any commercial operation.

The casting rope (Reuff's method) allows field restraint of a large bovine without a crush: a rope is looped around the neck, girth, and flank; simultaneous pulling of the loops causes the animal to kneel and lie down. For sheep and goats, the foot bath (a shallow concrete trough containing copper sulphate or formalin solution) treats and prevents foot rot when walked through regularly.

Fill in the blank: The cattle _____ (squeeze chute) immobilises cattle safely for veterinary procedures; it reduces stress and injury risk for both the animal and the handler.


**Figure 4.3:** Photograph of a cattle crush (squeeze chute) with a cow restrained inside.

Figure 4.3: Photograph of a cattle crush (squeeze chute) with a cow restrained inside

### 4.3.3 Identification, recording, and health equipment

Individual animal identification is essential for farm records, pedigree tracking, and disease control. Methods used in Nigeria: ear tags (plastic or metal numbered tags inserted through the ear; cheapest and most widely used); ear notching (permanent notch pattern representing a code; no material to lose); tattooing (permanent number inside ear pinna using a tattoo plier; difficult to read on dark-skinned animals); freeze branding (liquid-nitrogen-cooled irons destroy pigmentation leaving a permanent white brand; more humane than hot branding).

Essential health equipment for every ruminant farm: clinical thermometer (rectal temperature; fever detection); stethoscope (heart, lung, and rumen sounds); drenching gun (oral anthelmintic dosing); injection syringes and needles (18-20 gauge for subcutaneous or intramuscular injections); CMT kit (mastitis detection); weighing equipment (platform scale or weigh tape for cattle; hanging scale for lambs and kids); and a basic health kit (antiseptic, iodine, wound spray, bandages).

Fill in the blank: _____ tags (numbered plastic or metal inserts through the ear) are the cheapest and most widely used method of individual animal identification on Nigerian ruminant farms.

#### Pilot questions 4.3

1. Describe the specifications of a good concrete cattle feed trough.
2. Explain why hay racks are particularly important for sheep and goats.
3. Describe three methods of restraining cattle and state when each is used.
4. Name four animal identification methods and state one advantage of each.
5. List five essential items in a ruminant farm health equipment kit.

## 4.4 Production Systems and Pasture Management

### 4.4.1 Extensive, semi-intensive, and intensive production systems

Extensive systems: animals graze natural pastures or open range with minimal supplementary feed, housing, or veterinary inputs; very low cost per animal but low productivity; typical of Fulani pastoral herds and village small ruminant management; best suited to land-abundant, capital-scarce conditions. Semi-intensive systems: animals housed at night or during the dry season and receive supplementary feed; vaccinated and dewormed; moderate cost and production; typical of peri-urban smallholder cattle and goat operations.

Intensive systems: animals fully confined; receive 100 per cent of diet as provided feed; regular health inputs; high capital requirement (housing, feed, labour, veterinary care); highest production per animal and per unit of land; typical of commercial dairy farms, feedlots, and urban pen-fattening operations. For most Nigerian ruminant farmers, a shift from extensive to semi-intensive is the most feasible improvement pathway: adding a night pen, dry-season supplementary feeding, and annual vaccination dramatically improves productivity at modest cost.

Fill in the blank: Intensive ruminant production systems are fully _____ with animals receiving all feed as provided; they require high capital investment but achieve the highest production per animal and per unit of land.

### 4.4.2 Pasture establishment and management

Steps in establishing an improved pasture: (1) clear existing vegetation and burn or remove; (2) apply lime if soil pH is below 5.5; (3) plough and harrow the seedbed; (4) sow improved grasses (Guinea grass, Napier, Gamba, Brachiaria humidicola) at the start of the rainy season; (5) oversow legumes (Stylosanthes, Centrosema) to increase sward protein; (6) apply basal phosphorus fertiliser at establishment; (7) defer grazing for 3 to 4 months to allow establishment.

Key management practices: rotational grazing (divide into paddocks; rest each paddock for 4 to 6 weeks between grazings to allow regrowth and reduce surface parasite burden); avoid overgrazing (maintain minimum sward height of 10 to 15 cm; overgrazing destroys root systems and allows weed invasion); apply nitrogen fertiliser at 60 to 80 kg N/ha/year in split applications; make hay or silage during wet-season surplus for dry-season feeding.

Fill in the blank: Rotational grazing allows a 4 to 6 week _____ period for each paddock; this enables grass regrowth and reduces the infective larval burden on the pasture surface.

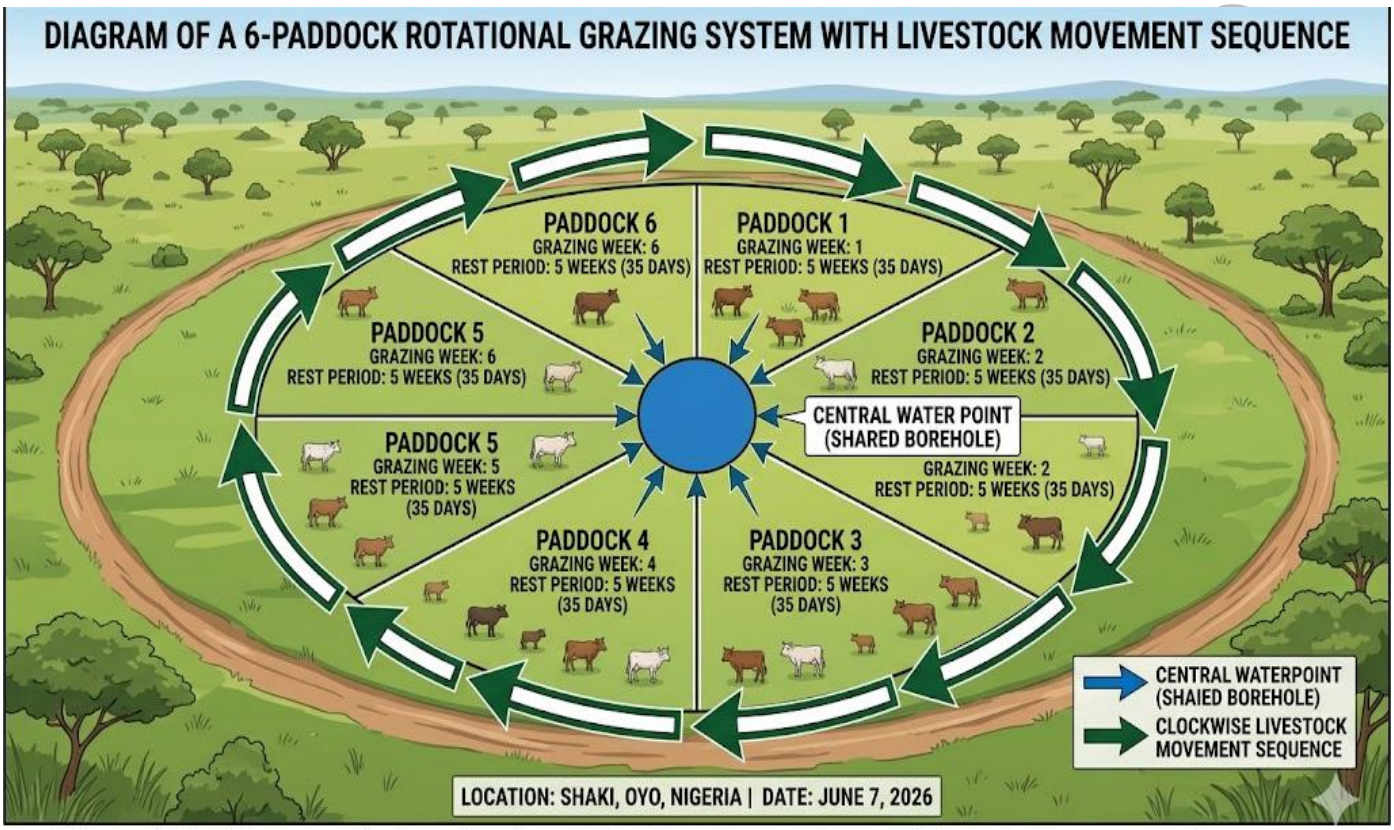


**Figure 4.4:** Diagram of a 6-paddock rotational grazing system with livestock movement sequence.

Figure 4.4: Diagram of a 6-paddock rotational grazing system with livestock movement sequence

### 4.4.3 Rangeland management and the farmer-herder challenge

Sustainable rangeland management requires: stocking rate control (carrying capacity of Nigeria's Sahel rangeland is approximately 1 livestock unit per 4 to 8 hectares during the rains; overstocking causes vegetation degradation and desertification); distributed water points (prevent concentration of animals and overgrazing around single sources); controlled early dry-season burning (stimulates fresh grass regrowth); and transhumance (seasonal migration of herds between wet-season and dry-season grazing areas).

The farmer-herder conflict is one of Nigeria's most serious agricultural challenges: expanding farmland in the Middle Belt blocks traditional Fulani cattle routes and dry-season grazing

reserves, leading to violent clashes in Benue, Nasarawa, Plateau, and Kaduna states. Solutions include: legally demarcated and enforced grazing reserves and cattle routes; ranching development programmes; early warning and conflict monitoring systems; community dialogue and compensation schemes; and legal land-use frameworks that protect both farming and herding rights.

Fill in the blank: The carrying capacity of Nigeria's Sahel rangeland is approximately 1 livestock unit per _____ to 8 hectares during the rainy season; overstocking beyond this causes vegetation degradation and desertification.

| Strategy | Explanation |
|---|---|
| Legally demarcated grazing reserves | Establishing designated areas for livestock grazing to reduce encroachment on farmlands. |
| Cattle routes | Mapping and maintaining stock routes to guide seasonal livestock movement safely. |
| Ranching development | Promoting modern ranch systems to reduce nomadic practices and improve productivity. |
| Improved pasture | Cultivating high-quality forage on designated lands to sustain livestock year-round. |
| Early warning systems | Monitoring and alerting communities about potential clashes to enable preventive action. |
| Community dialogue and compensation | Facilitating negotiations and providing compensation for losses to build trust. |
| Legal land-use frameworks | Enforcing laws that clearly define land ownership and usage rights. |
| Government-sponsored ranch settlements | Establishing state-supported ranches to provide secure and sustainable livestock production. |

Box 4.1: Key strategies for resolving the farmer-herder conflict in Nigeria

Pilot questions 4.4

1. Distinguish between extensive, semi-intensive, and intensive ruminant production systems.
2. Describe the steps in establishing an improved pasture in Nigeria.
3. Explain what rotational grazing is and state two benefits over continuous grazing.
4. Explain what carrying capacity is and state the consequence of overstocking.
5. State two causes and two solutions of the farmer-herder conflict in Nigeria.

## Series Summary

This Series covered housing, equipment, and production systems. Housing principles (protection, comfort, hygiene, ventilation, economy, functionality) were applied to cattle types: free-stall and tied housing; calving box; bull pen; calf creep; with space requirements (loose dairy cow 7-9 m2; bull pen minimum 16 m2). Sheep and goat housing (raised slatted floor, lambing/kidding pens, age-group separation, ventilation) was described with health implications. Equipment covered: feed troughs, hay racks, water troughs; cattle crush, nose ring, halter, casting rope, foot bath; ear tags, notching, tattooing, freeze branding; health kit essentials.

Production systems (extensive, semi-intensive, intensive) were compared and the practical improvement pathway for Nigerian farmers described. Pasture establishment steps and rotational grazing management (4-6 week rest, 10-15 cm minimum sward height, N fertilisation) were covered alongside hay and silage conservation. Rangeland management (1 LU per 4-8 ha carrying capacity; stocking control; transhumance) and the farmer-herder conflict (causes and solutions) completed the Series. By completing this Series, you should achieve all seven SLOs (4.1 to 4.7).

## Glossary of Terms

1. **Calving box:** an individual pen of approximately 3 m x 3 m where a cow is placed 1-2 days before calving; allows supervision and protects the cow and calf from the herd.
2. **Calf creep:** a low-fenced area inside a paddock accessible only to calves, allowing them supplementary feed without competition from adult cattle.
3. **Carrying capacity:** the maximum number of livestock units a unit of land can support sustainably without permanent vegetation degradation.
4. **Cattle crush (squeeze chute):** an adjustable metal frame that immobilises cattle for veterinary procedures without roping; the standard restraint facility for commercial operations.
5. **Ear tag:** a numbered plastic or metal identification device inserted through the ear pinna; the most widely used animal identification method in Nigeria.
6. **Extensive system:** a low-input livestock production system relying on natural pasture with minimal supplementary feeding, housing, or veterinary inputs.
7. **Farmer-herder conflict:** violent clashes between crop farmers and Fulani pastoralists over access to land in Nigeria's Middle Belt, caused by expanding farmland blocking traditional grazing routes.
8. **Feed bunk (feed trough):** a concrete or galvanised iron feeding container; standard cattle specifications are 0.5-0.6 m wide, 0.3 m deep, 0.5 m trough space per animal.
9. **Foot bath:** a shallow concrete trough filled with copper sulphate or formalin solution through which sheep and goats walk to treat and prevent foot rot.
10. **Freeze branding:** an animal identification method using liquid-nitrogen-cooled metal irons that destroy skin pigmentation to produce a permanent white mark.
11. **Free-stall housing:** a loose cattle housing system where animals move freely and are fed at common feed bunks; suitable for large beef or dry dairy herds.
12. **Hay rack (manger):** a raised feeding frame holding roughage above the floor to prevent contamination by faeces and trampling.

13. **Intensive system:** a livestock production system with full confinement; animals receive 100% of feed as provided; high capital requirements; highest production per unit land.

14. **Nose ring:** a brass ring inserted through the nasal septum of a bull; provides a safe point of control; a lead rope clipped to it gives the handler strong leverage.

15. **Overgrazing:** grazing beyond the carrying capacity of the land, causing sward deterioration, soil erosion, weed invasion, and eventual desertification.

16. **Raised slatted floor:** an elevated pen floor of wooden or bamboo slats that keeps animals off damp ground, allows manure to fall through, and reduces parasite reinfestation.

17. **Rotational grazing:** a grazing management system that divides pasture into paddocks and rests each paddock for 4-6 weeks between grazings to allow regrowth.

18. **Semi-intensive system:** a livestock production system combining grazing with housing at night and supplementary feeding; moderate cost and production; typical of peri-urban smallholder operations.

19. **Tethering:** restraining an individual animal by a rope tied to a stake; common for goats in smallholder households; requires daily rotation to fresh ground to control parasite burden.

20. **Tied (stanchion) housing:** a cattle housing system restraining each cow at an individual stall with a neck chain or headlock; suitable for small dairy operations requiring individual monitoring.

21. **Transhumance:** the seasonal migration of pastoral livestock herds between wet-season and dry-season grazing areas; the traditional management strategy of Fulani pastoralists.



## Concept Check Questions [Series 4]

Objective Questions

1. Good ruminant housing must provide protection, comfort, _____, ventilation, economy, and functionality. (Linked to SLO 4.1)
2. The minimum floor space for a dairy cow in loose housing is _____ to 9 m2; a bull pen requires a minimum of 16 m2. (Linked to SLO 4.2)
3. Raising sheep and goats on a _____ floor keeps animals off damp ground and reduces gastrointestinal parasite reinfestation. (Linked to SLO 4.3)
4. The cattle _____ (squeeze chute) immobilises cattle safely for veterinary procedures without roping or casting. (Linked to SLO 4.4)
5. Rotational grazing allows a 4 to 6 week _____ period for each paddock; this enables grass regrowth and reduces the surface parasite burden. (Linked to SLO 4.6)

Short-Answer Questions

- Distinguish between free-stall and tied housing for dairy cattle. (Linked to SLO 4.2)
- Describe three housing design features that reduce disease in small ruminants. (Linked to SLO 4.3)
- Name four animal identification methods and state one advantage of each. (Linked to SLO 4.4)
- Distinguish between extensive and intensive ruminant production systems. (Linked to SLO 4.5)
- State two causes and two solutions of the farmer-herder conflict in Nigeria. (Linked to SLO 4.7)

Long-Answer Questions

1. Describe the principles of ruminant housing, the main types of cattle housing in Nigeria, and the space requirements and key structural components for a simple Nigerian dairy farm. (Linked to SLOs 4.1, 4.2)

2. Describe housing for sheep and goats, how design affects health, and the feeding, watering, restraint, and identification equipment used on a ruminant farm. (Linked to SLOs 4.3, 4.4)
3. Describe the three ruminant production systems in Nigeria, the steps in establishing and managing improved pastures, and evaluate the farmer-herder conflict and its solutions. (Linked to SLOs 4.5, 4.6, 4.7)

## Answers to Concept Check Questions [Series 4]

Objective Questions

6. Hygiene.
7. 7.
8. Slatted.
9. Crush.
10. Rest.

Short-Answer Questions

11. Free-stall: cattle move freely; lie in open areas or stalls; fed at common bunks; suitable for large beef or dry dairy herds; lower labour. Tied (stanchion): each cow restrained at individual stall with neck chain; individual feeding and milk yield monitoring; suits small dairy operations of 3-20 cows.
12. Any three: adequate ventilation (open/mesh sides prevent ammonia build-up and respiratory disease); raised slatted floor (keeps animals off damp ground; breaks gastrointestinal parasite lifecycle); separation of age groups (prevents transfer of adult worm burdens to susceptible lambs and kids); dry bedding and good drainage (reduces parasite larval development).

13. Ear tags (cheapest, most widely used, readable from a distance); ear notching (permanent, no material to lose, readable without catching the animal); tattooing (permanent, inside ear pinna, good for dark-skinned small ruminants in good light); freeze branding (permanent white mark, visible from a distance on all coat colours, more humane than hot branding).
14. Extensive: natural pasture grazing; minimal supplementary feed, housing, or health inputs; very low cost but low productivity per animal; best where land is abundant and capital scarce. Intensive: full confinement; 100% feed provided; regular health inputs; high capital; highest production per animal and per unit of land; commercial dairy and feedlot operations.
15. Causes: (1) expanding farmland blocking traditional Fulani cattle routes and dry-season grazing reserves; (2) loss of demarcated grazing reserves to farming. Solutions: (1) legally demarcated and enforced grazing reserves and cattle routes; (2) ranching development programmes providing herders secure land for settled cattle production.

Long-Answer Questions

1. Principles: protection (rain, sun, predators); comfort (space, bedding, air); hygiene (clean floors, drains); ventilation (open-sided, tropical); economy (local materials); functionality (class-specific design). Cattle housing types: free-stall (large beef/dry dairy herds, common feed bunks); tied/stanchion (small dairy, individual monitoring); calving box (3x3 m, supervision); bull pen (4x4 m, reinforced); calf creep (low fence, supplementary feed without adult competition). Space: dairy cow tied 2.0x1.2 m; dairy cow loose 7-9 m2; beef steer 4-6 m2; calf 1.5-2.0 m2; bull pen 16 m2 minimum. Structural components: floor (concrete or compacted earth; 1-2% slope to drain); roof (corrugated iron; 0.6 m eave overhang; min 3.5 m height); feed trough (concrete; 0.6 m wide, 0.3 m deep; 0.6 m/cow); water trough (50-80 L/cow/day, float-valve); drainage channel (0.3 m wide concrete).
2. Sheep housing: raised slatted/mesh floor preferred; ewe 0.7-1.0 m2; ram 1.5-2.0 m2; lamb 0.3-0.5 m2; lambing pen 2 m2/ewe-lamb pair; no ground draughts for lambs. Goat

housing: walls 1.5-2.0 m high; no horizontal rails; raised platform pen (bamboo/wood slats 0.5-0.8 m above ground, mesh sides); doe 0.7-1.0 m2; buck 1.5-2.0 m2; kid 0.3-0.5 m2; kidding pen 1.5 m2; tethering common but rotate daily. Health design: ventilation; dry floor/bedding; age group separation. Equipment: feed troughs (0.5-0.6 m wide, 0.3 m deep, 0.5 m/cattle, 0.3-0.4 m/sheep or goat); hay racks (above floor, prevent faecal contamination); water troughs (50-80 L/cattle/day; max 0.2 m depth for lambs/kids; clean weekly). Restraint: nose ring (bull control); halter (daily dairy cow handling); cattle crush (veterinary procedures); casting rope (field restraint); foot bath (copper sulphate/formalin for foot rot). Identification: ear tags (cheapest, most widely used); ear notching (permanent, no material to lose); tattooing (permanent, ear pinna); freeze branding (permanent white mark). Health kit: thermometer; stethoscope; drenching gun; syringes and needles; CMT kit; weighing equipment; antiseptic, iodine, bandages.

3. Extensive: natural pasture, minimal inputs, low cost, low productivity; Fulani pastoral herds. Semi-intensive: night pen, supplementary feed, vaccinated and dewormed; peri-urban smallholder operations. Intensive: fully confined, 100% provided feed, high inputs, highest production; commercial dairy and feedlot. Practical improvement pathway: extensive to semi-intensive most feasible; night pen + dry-season feed + annual vaccination dramatically improves productivity at modest cost. Pasture establishment: clear and burn; lime if pH <5.5; plough and harrow; sow improved grasses (Guinea grass, Brachiaria, Napier) at start of rains; oversow legumes (Stylosanthes, Centrosema) for protein; apply basal P; defer grazing 3-4 months. Pasture management: rotational grazing (4-6 week rest; prevents overgrazing; reduces parasite larval burden); maintain 10-15 cm minimum sward height; apply 60-80 kg N/ha/year; control weeds; make hay or silage in wet season for dry season use. Rangeland: carrying capacity 1 LU per 4-8 ha in Sahel rains; lower in dry season; overstocking causes desertification; management tools: stocking rate control; distributed water points; controlled burning; transhumance routes. Farmer-herder conflict: causes: farmland expansion blocking traditional routes; loss of grazing reserves. Solutions: legally demarcated and enforced reserves and routes; ranching development; improved pasture on designated land; early warning systems; community dialogue; legal land-use frameworks.

## Answers to Pilot Questions [Series 4]

Part 4.1

6. Protection (rain, sun, predators, theft); comfort (space, bedding, air circulation); hygiene (floors and drains easy to clean); ventilation (open-sided or louvred for free air movement in tropics); economy (locally available materials); functionality (design specific to animal class and task).
7. Free-stall: cattle move freely; lie in open areas or individual stalls; fed at common bunks; suitable for large beef or dry dairy herds; lower labour cost per animal. Tied stanchion: each cow restrained at her own stall with a neck chain or headlock; individual feed allocation and milk yield monitoring possible; suitable for small dairy operations (3-20 cows); higher labour per animal.
8. Dairy cow in tied stall: 2.0 m x 1.2 m. Beef steer in grow-out yard: 4 to 6 m2 per steer. Bull pen: minimum 16 m2 (at least 4 m x 4 m) with reinforced walls.
9. Roof: corrugated iron on timber or steel rafters; minimum 3.5 m height at eave; eaves extending 0.6 m beyond walls. Walls/posts: timber or concrete posts; open-sided or louvred for ventilation. Floor: concrete sloped 1-2% to drain. Feed trough: concrete, 0.6 m wide, 0.3 m deep, 0.6 m/cow. Water trough: float-valve automatic, 50-80 L/cow/day. Drainage channel: 0.3 m wide concrete, sloped away from building.
10. High ambient temperatures plus body heat from cattle and fermentation heat from manure create a microclimate exceeding the thermal comfort of cattle (above 30 degrees Celsius for zebu breeds); heat stress reduces feed intake, milk yield, and reproduction. Ammonia from urine and manure accumulates in still air, irritating the respiratory mucosa and predisposing to pneumonia. High humidity with warm temperature accelerates multiplication of bacterial and fungal pathogens in bedding and on equipment.

Part 4.2

11. Any two: (1) Keeps animals dry and clean: the raised platform prevents animals from lying on damp or wet ground, reducing skin infections, foot rot, and respiratory disease associated with dampness. (2) Parasite control: gastrointestinal nematode infective larvae accumulate on contaminated floor surfaces; by keeping animals above the ground, the raised floor dramatically reduces larval ingestion and the need for anthelmintic treatment.
12. Adult ewe: 0.7 to 1.0 m2 per animal. Ram: 1.5 to 2.0 m2 per animal (more space for dominance behaviour and safety of handlers). Lamb: 0.3 to 0.5 m2 per lamb in a group pen.
13. Escape prevention: goats are agile climbers; walls must be at least 1.5-2.0 m high with no horizontal rails as footholds; sheep need only 1.0-1.2 m walls. Feed access: goats prefer to eat from an elevated position; floor-fed hay is quickly contaminated by their own faeces and refused; elevated hay racks are more critical for goats than for sheep. Manipulation: goats investigate and manipulate latches; all fastenings must be goat-proof above the animal's reach.
14. Individual animals are tied by one leg or neck with a rope to a stake in the ground or to a tree; they graze a small circle of vegetation around the tethering point; the animal must be moved to a fresh spot twice daily and provided with water and supplementary feed. Main disadvantage: repeated use of the same ground accumulates gastrointestinal nematode infective larvae; animals tethered in the same area rapidly become heavily parasitised; this is particularly severe in the warm, humid south where larval survival on pasture is prolonged.
15. Any three: adequate ventilation (open or mesh walls dilute ammonia rapidly, reducing respiratory disease risk); raised slatted floor or dry bedding (breaks lifecycle of Haemonchus and coccidian parasites by keeping animals off moist contaminated ground); separation of age groups (prevents high adult worm burdens contaminating the environment around susceptible lambs and kids); siting on elevated well-drained ground (prevents flooding and maintains dry conditions that discourage parasite larval development).

1. Width 0.5 to 0.6 m; depth 0.25 to 0.3 m; height at trough lip 0.3 to 0.4 m above floor; linear length 0.5 to 0.6 m per adult animal; poured concrete with smooth interior that drains and cleans easily; no protruding edges that could injure muzzle or tongue.
2. Sheep and goats are fastidious feeders that refuse hay or roughage contaminated with urine or faeces from the floor; wastage from floor-fed hay can reach 30-50%; a hay rack holds feed above floor level, preventing contamination and reducing wastage. Additionally, gastrointestinal nematode infective larvae migrate onto roughage pieces lying on contaminated pen floors; animals eating floor hay ingest larvae with each mouthful; hay racks prevent this route of reinfestation.
3. Halter and lead rope: for docile dairy cows trained since calfhood; safest and most stress-free for routine handling, milking preparation, and minor examinations. Cattle crush: standard restraint for veterinary procedures (vaccination, deworming, hoof trimming, pregnancy diagnosis) on commercial operations; safest for both animal and handler. Casting with Reuff's rope: used in field conditions without a crush; rope loops around neck, girth, and flank; pulling simultaneously causes the animal to kneel and lie down.
4. Ear tags: cheapest, most widely used, easily read from a distance without restraining the animal. Ear notching: permanent, requires no material that can be lost, readable in any animal regardless of coat colour. Tattooing: permanent, inside ear pinna, good for small ruminants with light inner ear skin. Freeze branding: permanent white mark, highly visible on all coat colours, more humane than hot branding as the cold anaesthetises the skin.
5. Any five: clinical thermometer (fever detection by rectal temperature); stethoscope (heart, lung, and rumen sounds assessment); drenching gun (accurate oral anthelmintic dosing); injection syringes and needles 18-20 gauge (vaccines, antibiotics, vitamins); CMT paddle and reagent (monthly sub-clinical mastitis screening); platform scale or weigh tape (body weight for accurate drug dosing and growth monitoring); wound spray, iodine, antiseptic, bandages (first aid).

Part 4.4

1. Extensive: natural pasture or range; minimal supplementary feed, no housing, minimal health inputs; very low cost per animal; very low productivity; best for land-abundant, capital-scarce conditions; typical of Fulani pastoral cattle, village sheep and goats. Semi-intensive: housing at night or during dry season; some supplementary feed; vaccinated and dewormed; moderate cost and productivity; typical of peri-urban smallholder cattle and goat farms. Intensive: fully confined; 100% feed provided; regular health inputs; high capital (housing, feed, labour, veterinary); highest production per animal and per land area; commercial dairy and feedlot.
2. Steps: (1) clear and burn or remove existing vegetation; (2) if soil pH below 5.5, apply 1-2 t/ha agricultural lime; (3) plough to 15-20 cm depth and harrow to fine seedbed; (4) sow improved grass species (Guinea grass at 2-3 kg/ha, Brachiaria humidicola for wet areas, Napier as stem cuttings) at the start of the rainy season; (5) oversow legumes (Stylosanthes hamata, Centrosema) for protein; (6) apply basal phosphorus (50 kg P2O5/ha) at establishment; (7) defer grazing for 3-4 months to allow establishment before the first grazing.
3. Rotational grazing divides the total pasture into paddocks (typically 4-8) and grazes each in sequence, moving animals when the sward is grazed down to 10-15 cm, then resting the paddock for 4-6 weeks before return. Benefit 1 over continuous grazing: sward quality and persistence; plants allowed to complete a regrowth cycle replenish root carbohydrate reserves; roots remain vigorous and dense, maintaining weed-free, productive swards over many years; continuous grazing progressively weakens plants and opens the sward to weed invasion. Benefit 2: parasite control; most infective nematode larvae die within 4-6 weeks on pasture; returning animals to a rested paddock encounter far lower larval contamination than on a continuously grazed paddock with daily fresh faecal deposits.
4. Carrying capacity is the maximum stocking rate (livestock units per hectare) that a land unit can support sustainably without permanent vegetation degradation; for Nigeria's Sahel zone it is approximately 1 livestock unit per 4 to 8 hectares during the rainy season and lower during the dry season. Consequence of overstocking: vegetation is grazed faster than it can regrow; plant cover declines; bare soil patches expand and are eroded by wind and water; shrubs and unpalatable annuals replace productive perennial grasses; in

the Sahel the land becomes permanently degraded or desertified and can no longer support any livestock production.

5. Causes: (1) population growth drives expansion of farmland into traditional Fulani cattle routes and dry-season fadama and floodplain grazing areas, blocking the movement of migratory herds; cattle straying into crops cause crop damage that triggers retaliation. (2) State governments have released formerly gazetted grazing reserves for farming; the loss of these designated areas forces herders to compete with farmers on unprotected land. Solutions: (1) legal demarcation and enforcement of grazing reserves and cattle routes with physical markers and security backing, protecting herders' right to traditional corridors; (2) ranching development programmes that provide herder families with secure, titled land for settled intensive or semi-intensive cattle production, eliminating the need for long-distance transhumance through cultivated areas.

## References and Attributions [Series 4]

Textual References (Books and External Sources)


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2. Devendra, C., & Burns, M. (1983). Goat production in the tropics (2nd ed.). Commonwealth Agricultural Bureaux.
3. FAO (Food and Agriculture Organization of the United Nations). (2018). Livestock and pasture management. FAO.
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Figures, Plates, Tables, and Boxes

1. Figure 4.1: Nigerian open-sided cattle shelter Attribution: AI generated. Suggested OER search string: "Nigeria open-sided cattle shelter corrugated iron roof trough drainage OER photograph".
2. Figure 4.2: Raised slatted-floor goat pen Attribution: AI generated. Suggested OER search string: "raised slatted floor goat house pen Nigeria small ruminant housing OER photograph".
3. Figure 4.3: Cattle squeeze chute in use Attribution: AI generated. Suggested OER search string: "cattle squeeze chute crush restraint Nigeria farm vaccination OER photograph".
4. Figure 4.4: Rotational grazing system diagram Attribution: AI generated. Suggested OER search string: "rotational grazing paddocks livestock management diagram pasture OER".
5. Box 4.1: Strategies for resolving the farmer-herder conflict Attribution: AI generated. Suggested OER search string: "farmer herder conflict Nigeria solutions grazing reserves ranching strategies OER box".

**Course code: AGE 402**

**Course title: Husbandry of Ruminant Animals**

# Series 5: Health, Diseases, and Parasite Control in Ruminants

- **Part 5.1: Principles of Animal Health and Disease Prevention**
  - Sub Part 5.1.1: Signs of health and disease in ruminants
  - Sub Part 5.1.2: Biosecurity and disease prevention
  - Sub Part 5.1.3: Vaccination programmes for Nigerian ruminants
- **Part 5.2: Major Bacterial and Viral Diseases**
  - Sub Part 5.2.1: Major bacterial diseases
  - Sub Part 5.2.2: Major viral diseases
  - Sub Part 5.2.3: Zoonotic diseases of ruminants
- **Part 5.3: Parasitic Diseases**
  - Sub Part 5.3.1: Internal parasites (helminths and protozoa)
  - Sub Part 5.3.2: External parasites (ectoparasites)
  - Sub Part 5.3.3: Anthelmintic use and resistance management
- **Part 5.4: Veterinary Practices and Farm Records**
  - Sub Part 5.4.1: Drug administration routes and dosing
  - Sub Part 5.4.2: Common veterinary procedures on the farm
  - Sub Part 5.4.3: Farm health records and surveillance

## Introduction

Disease is the most common cause of economic loss in Nigerian ruminant production; it reduces growth, milk yield, and reproductive efficiency, and causes direct mortality. The great majority of disease losses are preventable through biosecurity, timely vaccination, parasite control, and prompt treatment. This final Series equips students with the knowledge to recognise disease, implement prevention programmes, control internal and external parasites, administer basic treatments, and maintain the health records that make professional management possible.

We begin with the principles of health and disease prevention, cover the major bacterial, viral, and zoonotic diseases affecting Nigerian ruminants, describe internal and external parasites and their control, and conclude with practical veterinary skills (drug administration, common procedures) and farm health record keeping. All content builds on the nutrition, housing, and management knowledge of Series 3 and 4, and completes the course.

## Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 5.1** distinguish between signs of health and signs of disease in ruminants (Linked to Part 5.1),
- **SLO 5.2** describe the principles of biosecurity and the components of a disease prevention programme for Nigerian ruminants (Linked to Part 5.1),
- **SLO 5.3** describe the major bacterial and viral diseases of Nigerian ruminants, including their signs, causative agents, and control (Linked to Part 5.2),
- **SLO 5.4** identify the major zoonotic diseases of ruminants and explain the public health significance of each (Linked to Part 5.2),
- **SLO 5.5** describe the major internal and external parasites of ruminants in Nigeria and explain their impact on productivity (Linked to Part 5.3),

- **SLO 5.6** describe anthelmintic drug classes and explain the principles of resistance management (Linked to Part 5.3),
- **SLO 5.7** describe the correct routes of drug administration and perform basic veterinary procedures on ruminants (Linked to Part 5.4), and
- **SLO 5.8** design a farm health record system and explain how records support disease surveillance (Linked to Part 5.4).

## 5.1 Principles of Animal Health and Disease Prevention

### 5.1.1 Signs of health and disease in ruminants

A healthy ruminant has: a bright, alert expression; normal body temperature (38.5 to 39.5 degrees Celsius in cattle; 38.5 to 40.0 in sheep and goats); normal heart rate (60 to 80 beats per minute in cattle; 70 to 90 in sheep and goats); normal respiratory rate (10 to 30 breaths per minute); active rumination (1 to 3 rumen contractions per minute); normal posture and gait; normal faecal consistency; a moist, clean muzzle; clear bright eyes; and normal feed and water intake.

Signs of disease include: dullness, depression, or isolation from the herd; reduced or absent feed intake; cessation of rumination; abnormal body temperature (fever above 39.5 degrees in cattle); abnormal posture (humped back, head down, reluctance to move); abnormal faeces (watery diarrhoea, blood-stained, or black and tar-like); nasal or ocular discharge; swelling of joints or lymph nodes; abnormal breathing (coughing, laboured respiration); sudden drop in milk production; and increased mortality in the herd. Early detection of disease is critical; a farmer who observes animals twice daily will detect problems earlier than one who checks once a week.

Fill in the blank: Early signs of disease in ruminants include dullness, reduced feed intake, cessation of _____, abnormal body temperature, and isolation from the herd; daily observation is essential for early detection.

### 5.1.2 Biosecurity and disease prevention

Biosecurity is the set of management practices designed to prevent the introduction of pathogens into the farm and their spread within and from the farm. Key biosecurity measures: quarantine all new animals for 3 to 4 weeks in a separate facility before mixing with the resident herd; purchase animals only from known, disease-free sources; disinfect vehicles, boots, and equipment used by visitors or used on other farms; control access to the farm by people, vehicles, and wildlife; do not share equipment or feed with neighbouring farms.

Additional prevention measures: maintain adequate nutrition (well-nourished animals have better immune responses); avoid overcrowding (overcrowding increases stress, which suppresses immunity, and increases pathogen transmission); maintain clean, dry housing (wet floors and poor ventilation predispose to respiratory and skin disease); segregate sick animals immediately into a hospital pen away from the herd; implement a scheduled vaccination and deworming programme; and record all disease events, treatments, and outcomes for pattern recognition.

Fill in the blank: Biosecurity measures include _____ all new animals for 3 to 4 weeks before mixing with the resident herd, purchasing from disease-free sources, and disinfecting all vehicles and equipment.

### 5.1.3 Vaccination programmes for Nigerian ruminants

Vaccination is the most cost-effective disease prevention tool available to ruminant farmers. Core vaccines recommended for Nigerian cattle: Foot-and-Mouth Disease (FMD) vaccine (every 6 months; particularly important for exotic and crossbred cattle); Contagious Bovine Pleuropneumonia (CBPP) vaccine (annually; compulsory in many states); Blackquarter (Black leg, Clostridium chauvoei) vaccine (annually before rainy season); Bovine Brucellosis (strain RB51 or S19; given to heifers at 4 to 8 months; state-authorised programmes); and Lumpy Skin Disease (LSD) vaccine annually in affected areas.

Core vaccines for small ruminants: Peste des Petits Ruminants (PPR) vaccine (combined with sheep pox where available; every 3 years in vaccinated animals, annually in naive populations); Contagious Ecthyma (Orf) live vaccine applied to scarified skin; Pasteurellosis vaccine (Mannheimia haemolytica; annually before high-stress periods such as the dry season); Contagious Caprine Pleuropneumonia (CCPP) vaccine in affected areas. Cold chain maintenance

(vaccines kept at 2 to 8 degrees Celsius throughout handling) is essential; vaccines spoiled by heat are inactive and give no protection.

Fill in the blank: Cold chain maintenance (keeping vaccines at _____ to 8 degrees Celsius throughout handling and storage) is essential; heat-spoiled vaccines are inactive and provide no protection.

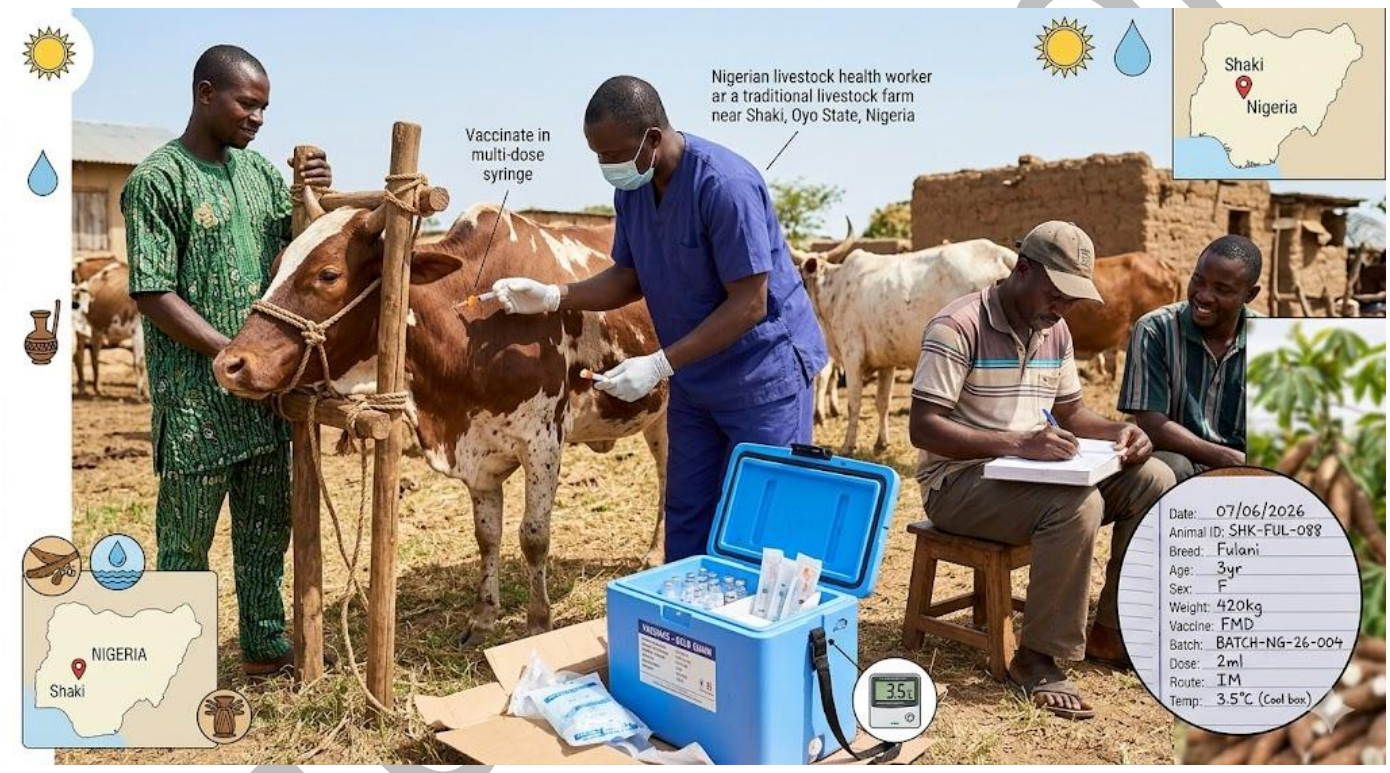


Figure 5.1: Photograph of a vaccination exercise for cattle on a Nigerian farm

## Pilot questions 5.1

- List six signs of a healthy ruminant and six signs of disease.
- Define biosecurity and state four biosecurity measures for a Nigerian cattle farm.
- State four core vaccines recommended for Nigerian cattle and give the recommended frequency of each.
- Explain why cold chain maintenance is critical for vaccine effectiveness.
- Explain why overcrowding is a disease risk factor on a ruminant farm.

## 5.2 Major Bacterial and Viral Diseases

### 5.2.1 Major bacterial diseases

Contagious Bovine Pleuropneumonia (CBPP): caused by Mycoplasma mycoides subspecies mycoides; spread by respiratory droplets between cattle in close contact; signs: fever, coughing, laboured breathing, nasal discharge; in advanced cases fluid in the chest cavity causes characteristic "marbling" of the lung; mortality up to 50% in naive herds; control: vaccination, movement restrictions, slaughter of positive reactors in government eradication programmes. CBPP is a notifiable disease in Nigeria.

Blackquarter (Blackleg): caused by Clostridium chauvoei; a soil-borne spore-forming bacterium that infects cattle through wounds or by ingestion; signs: sudden death or severe lameness with swelling and crepitation (gas crackling) in the large muscle masses of the thigh, shoulder, or back; affected muscle is dark red-black; mortality nearly 100% once clinical signs appear; prevention: annual vaccination before the rainy season when soil disturbance is highest. Anthrax (Bacillus anthracis) causes sudden death in cattle with bloody discharge from natural orifices; carcasses must never be opened; notifiable disease.

Fill in the blank: Blackquarter (Blackleg) is caused by Clostridium _____; it is a soil-borne spore-forming bacterium; the disease causes gas-filled swelling in large muscle masses and near-100% mortality once clinical signs appear.

### 5.2.2 Major viral diseases

Foot-and-Mouth Disease (FMD): caused by a Picornavirus (seven serotypes: O, A, C, SAT1, SAT2, SAT3, Asia1); highly contagious; spread by direct contact, contaminated equipment, aerosol, and animal products; signs: fever, drooling, blisters (vesicles) on the tongue, dental pad, feet, and teats; lameness; reduced milk yield; mortality low in adults but high in calves; economic impact severe (production losses, trade restrictions); control: vaccination every 6 months, movement restrictions during outbreaks.

Peste des Petits Ruminants (PPR): a Morbillivirus causing a disease of sheep and goats similar to rinderpest in cattle; signs: high fever, profuse nasal and ocular discharge, necrotic stomatitis (mouth lesions), diarrhoea, pneumonia; mortality up to 80% in naive flocks; spreads rapidly between closely housed animals; PPR has devastated Nigerian small ruminant herds since its first identification in the 1970s; control: vaccination every 3 years (immunity lasts longer than most livestock vaccines); targeted eradication is a global FAO/OIE goal by 2030. Lumpy Skin Disease (LSD) causes skin nodules over the entire body of cattle.

Fill in the blank: Peste des Petits Ruminants (PPR) is caused by a _____ virus; it causes high fever, mouth lesions, diarrhoea, and pneumonia in sheep and goats with mortality up to 80% in unvaccinated flocks.

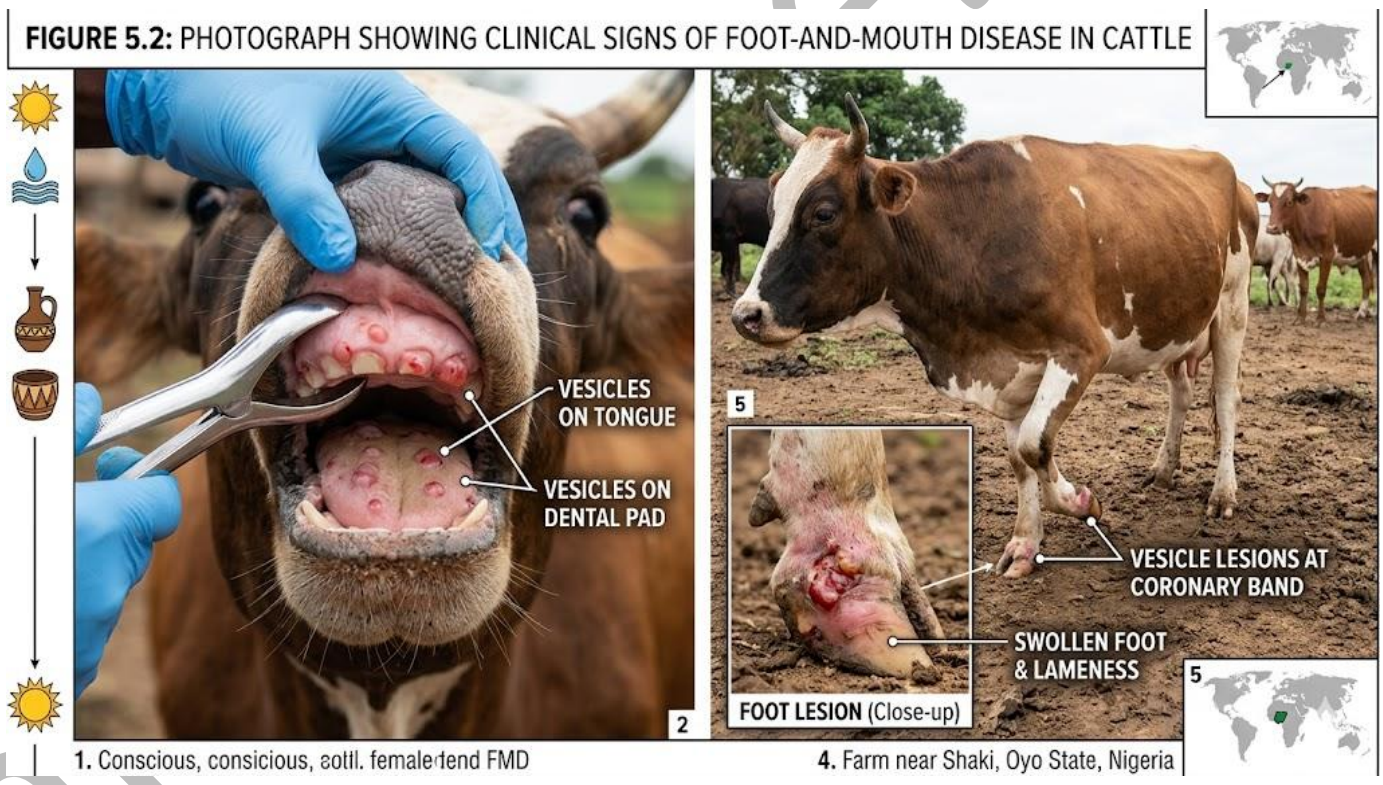


Figure 5.2: Photograph showing clinical signs of Foot-and-Mouth Disease in cattle

## 5.2.3 Zoonotic diseases of ruminants

Zoonoses are diseases transmissible from animals to humans. Brucellosis (Brucella abortus in cattle; B. melitensis in goats and sheep): causes abortion storms in cattle and chronic debilitating

fever (undulant fever) in humans who drink raw milk or contact infected birth fluids; the most important ruminant zoonosis in Nigeria; control: vaccination of female calves at 4 to 8 months; test-and-slaughter of positive reactors in control programmes; pasteurisation of all milk; protective clothing and gloves when handling abortions. Human brucellosis causes months of intermittent fever, sweating, joint pain, and depression.

Bovine Tuberculosis (Mycobacterium bovis): spread to humans by drinking raw infected milk or by respiratory exposure to infected cattle; causes pulmonary and extra-pulmonary tuberculosis in humans; control in Nigeria relies on slaughter inspection at abattoirs (condemnation of infected carcasses and organs) and pasteurisation of milk; the tuberculin skin test (TST) is used for herd screening. Rabies is transmitted by the bite of infected dogs or wild animals; affects all ruminants; vaccination of dogs around livestock farms is the primary prevention. Rift Valley Fever causes abortions in ruminants and acute hepatitis in humans.

Fill in the blank: Brucellosis is caused by Brucella _____ in cattle; it causes abortion storms in cattle and undulant fever in humans who drink raw milk or contact infected birth fluids.

### Pilot questions 5.2

- Describe CBPP: causative agent, signs, and control.
- Describe the signs of FMD and explain why it has major economic impact beyond direct mortality.
- Explain what PPR is and state why vaccination is particularly important.
- Define zoonosis and describe the public health significance of brucellosis in Nigeria.
- Explain how bovine tuberculosis reaches humans and how it is controlled in Nigeria.

## 5.3 Parasitic Diseases

### 5.3.1 Internal parasites (helminths and protozoa)

Gastrointestinal nematodes (roundworms): Haemonchus contortus (the barber's pole worm) is the most economically important internal parasite of small ruminants in the Nigerian humid

zone; it is a blood-sucking worm of the abomasum causing anaemia, oedema (bottle jaw), and death; sheep and goats are highly susceptible; cattle are less affected. Trichostrongylus spp. and Ostertagia spp. cause protein loss and diarrhoea in cattle and small ruminants. Bunostomum (hookworm) and Strongylus spp. also occur. Neoascaris vitulorum is an important roundworm of calves under 3 months.

Liver fluke (Fasciola gigantica): the most important trematode in Nigeria; requires the mud snail Lymnaea natalensis as intermediate host; common in irrigated fadama land, river floodplains, and the Niger Delta; causes acute liver damage (haemorrhagic hepatitis), poor growth, reduced milk, and death; cattle, sheep, and goats are all affected. Trypanosomiasis (Trypanosoma vivax, T. congolense, T. brucei brucei): transmitted by tsetse flies (Glossina spp.); causes progressive anaemia, weight loss, reproductive failure, and death; a major constraint on cattle production in the sub-humid zone; trypanotolerant breeds (Ndama, WAD) survive in tsetse zones. Coccidiosis (Eimeria spp.): protozoan disease causing bloody diarrhoea in young stock.

Fill in the blank: Haemonchus contortus (the barber's pole worm) parasitises the _____ of sheep and goats; it is a blood-sucking worm causing severe anaemia, bottle jaw, and death in the humid zone.

### 5.3.2 External parasites (ectoparasites)

Ticks are the most economically important ectoparasites of cattle in Nigeria: they cause direct blood loss, wound myiasis (secondary fly strike), tick paralysis, and transmit numerous tick-borne diseases including East Coast Fever (Theileria parva), Babesiosis (Babesia bovis, B. bigemina), Anaplasmosis (Anaplasma marginale), and Heartwater (Ehrlichia ruminantium). The major tick species in Nigeria include Amblyomma variegatum (bont tick; vector of heartwater and dermatophilosis), Boophilus (Rhipicephalus) microplus (cattle tick; vector of babesiosis and anaplasmosis), and Hyalomma spp.

Control of ticks: dipping (total immersion of cattle in acaricide solution in a plunge dip) or spraying (applying acaricide solution to the body surface using a knapsack sprayer or spray race) with organophosphate, pyrethroid, or amidine acaricides; strategic dipping (at least weekly in the rainy season when tick burden is highest). Mange mites (Sarcoptes, Psoroptes) cause severe skin

disease and wool/hair loss. Nasal botfly (Oestrus ovis) deposits larvae in the nostrils of sheep; larvae migrate to the sinuses causing sneezing and nasal discharge; control with macrocyclic lactone anthelmintics (ivermectin). Warble flies affect cattle in the north.

Fill in the blank: Amblyomma variegatum (the bont tick) transmits _____ (Ehrlichia ruminantium) and dermatophilosis in Nigerian cattle; strategic dipping in acaricide solution at least weekly during the rainy season is the primary control.

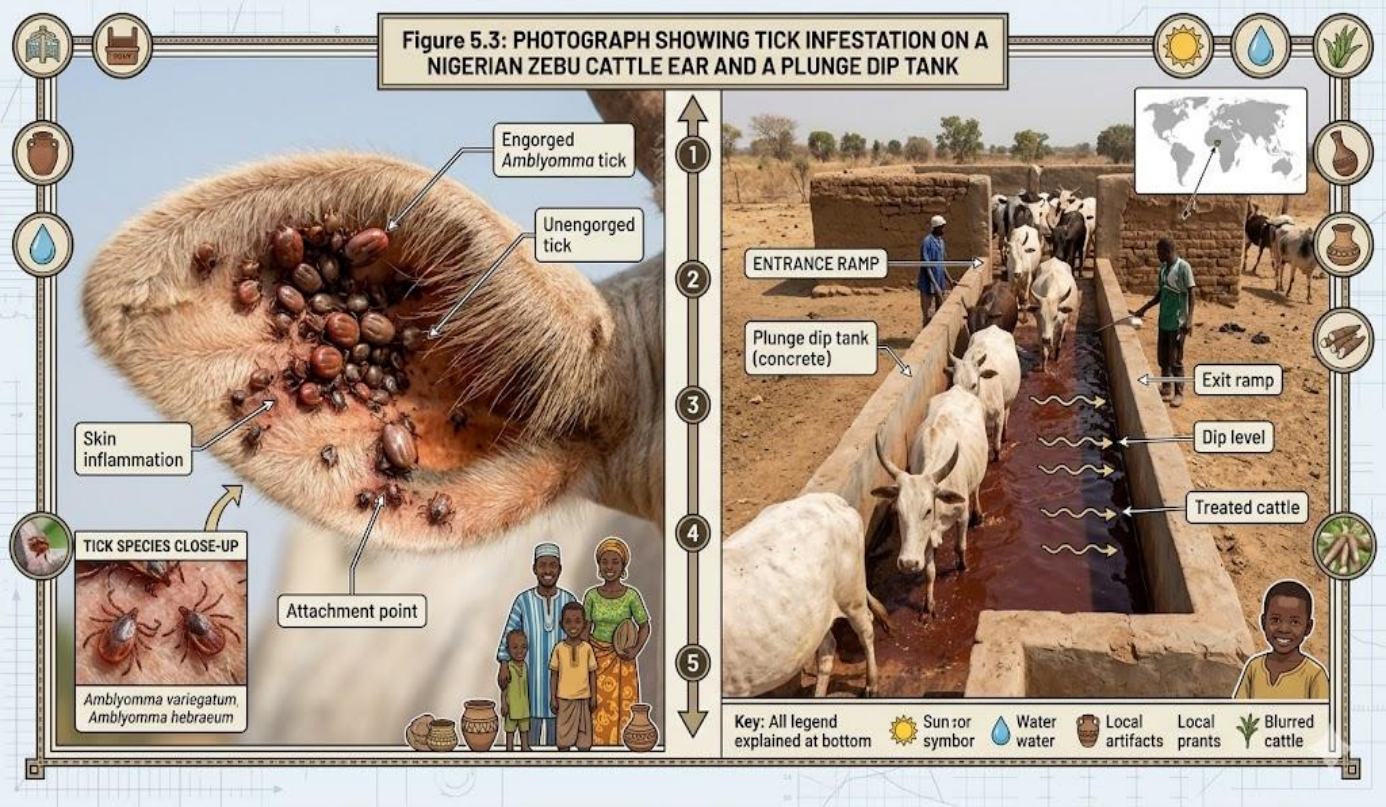


Figure 5.3: Photograph showing tick infestation on a Nigerian zebu cattle ear and a plunge dip tank

## 5.3.3 Anthelmintic use and resistance management

Anthelmintics are drugs that kill or expel parasitic worms. The four main drug classes used for ruminants in Nigeria: benzimidazoles (albendazole, fenbendazole; broad-spectrum, effective against roundworms and liver fluke; cheap; oral drench); macrocyclic lactones (ivermectin, doramectin; very broad-spectrum including roundworms, botfly larvae, mites; subcutaneous

injection or pour-on; do not treat liver fluke alone); levamisole (tetramisole; effective against roundworms; stimulates the immune system; subcutaneous or oral); and salicylanilides/closantel (effective against Haemonchus and liver fluke at the same time; particularly useful in mixed infections).

Anthelmintic resistance is the ability of parasites to survive drug doses that would normally kill them; it is the most serious problem in small ruminant parasite control worldwide and is already widespread in Nigeria. Resistance management strategies: targeted selective treatment (FAMACHA system: treat only animals showing signs of anaemia or haemonchosis rather than treating all animals; reduces drug selection pressure); rotate anthelmintic drug classes; never under-dose (use accurate body weight to calculate the correct dose); quarantine and treat new animals before introduction; and never use the same drug class for more than 2 consecutive years.

Fill in the blank: The FAMACHA system is a _____ selective treatment approach where only animals showing anaemia signs are treated, reducing drug selection pressure and slowing the development of anthelmintic resistance.

## Pilot questions 5.3

1. Describe the lifecycle and pathogenic effects of Haemonchus contortus in sheep.
2. Explain how Fasciola gigantica (liver fluke) is transmitted and how its lifecycle can be interrupted.
3. Name three tick species found in Nigeria and state one disease each transmits.
4. Name the four anthelmintic drug classes used in Nigerian ruminants and give one example of each.
5. Explain what anthelmintic resistance is and describe three strategies to prevent or slow its development.

## 5.4 Veterinary Practices and Farm Records

### 5.4.1 Drug administration routes and dosing

The correct route of administration determines whether a drug reaches its target at adequate concentration. Subcutaneous (SC) injection: given under the skin, usually at the side of the neck or behind the shoulder; used for vaccines and some antibiotics; the needle is inserted at a shallow angle (30 to 45 degrees) through a tent of skin; a 16 to 18 gauge needle is used for cattle, 19 to 21 gauge for small ruminants. Intramuscular (IM) injection: given into muscle, usually the neck muscle or hindquarter; used for antibiotics, vitamins, and hormones; a 16 to 18 gauge needle inserted perpendicular to the skin to the full depth.

Intravenous (IV) injection: into a vein (jugular vein in cattle; jugular or ear vein in small ruminants); used for fluid therapy, calcium borogluconate (for milk fever), and some antibiotics; requires skill to avoid perivascular injection. Oral administration: drenching (using a drenching gun to deliver anthelmintics or minerals at the back of the tongue); important to position the drenching gun over the tongue and not into the trachea. Topical (pour-on): some anthelmintics and acaricides are applied to the dorsal midline and absorbed through the skin; easy to apply but absorption may be lower in wet conditions.

Fill in the blank: The _____ route of injection delivers drugs under the skin at a 30 to 45 degree angle; it is used for vaccines and some antibiotics in cattle, using a 16 to 18 gauge needle.

### 5.4.2 Common veterinary procedures on the farm

Dehorning: removing the horn bud in calves under 3 weeks of age using a hot iron disbudder or caustic paste (potassium hydroxide); older animals require surgical dehorning under local anaesthesia and sedation; dehorning prevents injuries between animals and handlers in intensive systems; the younger the animal, the less stress and bleeding. Castration: removing the testes (surgical method using a Burdizzo bloodless castrator or surgical incision) to produce steers or wethers; improves docility and allows mixed-sex group housing; reduces fighting and unintended mating.

Hoof trimming: overgrown hooves cause lameness and foot rot; hooves of housed cattle and stall-fed goats should be trimmed every 3 to 6 months using a hoof knife, chisel, or angle grinder; a correctly trimmed hoof has a flat bearing surface with all four claws at equal height. Dosing (drenching): oral administration of anthelmintics, minerals, or electrolytes using a drenching gun; the correct dose is calculated on body weight and the nozzle inserted over the back of the tongue. Wound treatment: clean wound with antiseptic, apply wound spray or Terramycin spray, and cover if possible to prevent fly strike.

Fill in the blank: Dehorning of calves should be done before _____ weeks of age using a hot iron disbudder or caustic paste; early dehorning causes less stress, bleeding, and risk of infection than late dehorning.

| Months/Season | Procedures |
|---|---|
| January–February (Dry Season) | Check and treat for mange; replenish health kit; trim hooves |
| March–April (Late Dry Season) | Vaccinate for blackquarter and CBPP before rains; stock acaricide before rainy season; deworm all stock |
| May–August (Rainy Season) | Weekly dipping/spraying; monitor for FMD and CBPP; deworm lambs and kids monthly |
| September–October (Post-Rain) | Liver fluke treatment; pregnancy diagnosis; FAMACHA assessment |
| November–December (Early Dry Season) | PPR vaccination; brucellosis vaccination of heifers; annual performance review |

Box 5.1: Essential farm health and veterinary procedures calendar for Nigerian ruminant farms

### 5.4.3 Farm health records and surveillance

Good health records are the foundation of professional farm management. Every ruminant farm should maintain: an individual animal register (tag number, species, breed, sex, date of birth, dam and sire, date of purchase or birth on farm); a treatment record (date, animal ID, diagnosis, drug name, dose, route, person treating, and outcome); a vaccination record (date, vaccine name,

batch number, expiry date, animals vaccinated, and next due date); a mortality record (date, animal ID, age, estimated cause of death, and any postmortem findings); and a production record (milk yield per cow per day; litter sizes; growth weights at key ages).

Health records serve four purposes: disease surveillance (patterns of illness, deaths, and treatment failures identify emerging disease problems early); regulatory compliance (movement permits, export health certificates, and disease-free status declarations require documentation of vaccination and treatment history); financial management (drug and veterinary costs per animal per year can be calculated and compared with productivity; cost-benefit of interventions evaluated); and farm improvement (comparing disease incidence between seasons, housing types, or feeding regimes guides management improvements that reduce future disease losses).

Fill in the blank: Health records serve the purposes of disease _____, regulatory compliance, financial management, and farm improvement; without records a farmer cannot identify emerging problems or demonstrate animal health status to buyers or authorities.

### Pilot questions 5.4

1. Describe the correct technique for subcutaneous and intramuscular injection in cattle.
2. Explain the difference between the drenching and pour-on routes of anthelmintic administration.
3. Describe the dehorning procedure for calves under 3 weeks of age.
4. State five types of health records that every ruminant farm should maintain.
5. Explain four uses of farm health records.

## Series Summary

This final Series covered health, diseases, and parasite control. We described signs of health versus disease in ruminants; biosecurity measures (quarantine, disinfection, nutrition, no overcrowding, segregation of sick animals); and vaccination programmes for cattle (FMD every

6 months, CBPP annually, Blackquarter annually) and small ruminants (PPR every 3 years, Pasteurellosis annually). Major bacterial diseases (CBPP, Blackquarter, Anthrax) and viral diseases (FMD, PPR, LSD) were described with their causative agents, signs, and control, alongside zoonoses (brucellosis, bovine TB, rabies, Rift Valley Fever).

Internal parasites (Haemonchus contortus causing anaemia and bottle jaw; Fasciola gigantica liver fluke; trypanosomiasis by tsetse; coccidiosis) and external parasites (Amblyomma, Boophilus, Hyalomma ticks transmitting East Coast Fever, Babesiosis, Heartwater; mange mites; nasal botfly) were described with control strategies. Anthelmintic classes (benzimidazoles, macrocyclic lactones, levamisole, closantel) and resistance management (FAMACHA targeted treatment, drug rotation, accurate dosing) were covered. Veterinary practices (SC, IM, IV, oral, pour-on drug routes; dehorning, castration, hoof trimming, wound care) and farm health record keeping completed the Series and the course. By completing this Series, you should achieve all eight SLOs (5.1 to 5.8).

## Glossary of Terms

1. **Anthelmintic:** a drug that kills or expels parasitic worms; classified into benzimidazoles, macrocyclic lactones, levamisole, and salicylanilides/closantel.
2. **Anthelmintic resistance:** the ability of parasitic worm populations to survive drug doses that would normally kill susceptible worms; now widespread in Haemonchus in Nigeria.
3. **Babesiosis:** a tick-transmitted protozoan disease of cattle caused by Babesia bovis and B. bigemina; causes haemolytic anaemia, fever, and red urine ("redwater"); transmitted by Boophilus (Rhipicephalus) microplus.
4. **Benzimidazoles:** a class of broad-spectrum anthelmintics including albendazole and fenbendazole; effective against roundworms and liver fluke; given orally; cheap.
5. **Biosecurity:** the set of management practices designed to prevent introduction of pathogens to a farm and their spread within or from the farm.

6. **Blackquarter (Blackleg):** a bacterial disease of cattle caused by Clostridium chauvoei; causes gas-filled dark muscle swelling and near-100% mortality; prevented by annual vaccination.

7. **Bottle jaw:** oedematous fluid accumulation under the jaw caused by severe protein loss and anaemia; a classic sign of heavy Haemonchus contortus infestation in sheep and goats.

8. **Bovine Tuberculosis:** a bacterial disease caused by Mycobacterium bovis; a zoonosis transmitted to humans by raw milk or respiratory contact; controlled by abattoir inspection and pasteurisation.

9. **Brucellosis:** a bacterial zoonosis caused by Brucella abortus (cattle) or B. melitensis (goats and sheep); causes abortion storms in animals and undulant fever in humans.

10. **CBPP (Contagious Bovine Pleuropneumonia):** a highly contagious bacterial respiratory disease of cattle caused by Mycoplasma mycoides subspecies mycoides; notifiable; controlled by vaccination and movement restrictions.

11. **Cold chain:** the unbroken refrigerated (2 to 8 degrees Celsius) supply chain for vaccines from manufacturer to point of use; essential to maintain vaccine potency and effectiveness.

12. **Closantel:** a salicylanilide anthelmintic effective against Haemonchus contortus and liver fluke (Fasciola spp.); given orally or by injection.

13. **Dipping:** immersion of cattle in a plunge tank containing acaricide solution to kill ticks and other ectoparasites; the most effective tick control method.

14. **East Coast Fever (ECF):** a tick-borne disease of cattle caused by Theileria parva; transmitted by Rhipicephalus appendiculatus; causes severe lymph node enlargement, dyspnoea, and high mortality in susceptible cattle.

15. **FAMACHA system:** a targeted selective treatment approach for Haemonchus control in sheep and goats; anaemia is assessed by comparing the eye conjunctiva colour to a FAMACHA card; only animals showing anaemia are treated.

16. **FMD (Foot-and-Mouth Disease):** a highly contagious viral disease of cloven-hoofed animals caused by a Picornavirus; causes vesicles on the mouth and feet; vaccination every 6 months.

17. **Heartwater:** a tick-borne rickettsial disease caused by Ehrlichia ruminantium; transmitted by Amblyomma variegatum; causes neurological signs and high mortality in cattle, sheep, and goats.

18. **Haemonchus contortus:** the barber's pole worm; a blood-sucking abomasal nematode of sheep and goats; the most important internal parasite of small ruminants in Nigeria's humid zone.

19. **Ivermectin:** a macrocyclic lactone anthelmintic; broad-spectrum against roundworms, botfly larvae, and mites; given subcutaneously or as a pour-on.

20. **Levamisole:** an anthelmintic effective against roundworms in ruminants; also acts as an immunostimulant; given subcutaneously or orally.

21. **Lumpy Skin Disease (LSD):** a viral disease of cattle caused by a Capripoxvirus; causes widespread skin nodules, fever, and lymph node enlargement; controlled by annual vaccination.

22. **Macrocyclic lactones:** a broad-spectrum anthelmintic class including ivermectin and doramectin; effective against roundworms, botfly larvae, and mites; given as SC injection or pour-on.

23. **Notifiable disease:** a disease that, by law, must be reported to government veterinary authorities upon diagnosis; includes FMD, CBPP, and Anthrax in Nigeria.

24. **PPR (Peste des Petits Ruminants):** a highly contagious viral disease of sheep and goats caused by a Morbillivirus; causes fever, mouth lesions, diarrhoea, and pneumonia; up to 80% mortality in unvaccinated flocks.

25. **Quarantine:** isolation of newly acquired animals for 3-4 weeks before mixing with the resident herd; the most important biosecurity measure for preventing introduction of new pathogens.

26. **Trypanosomiasis:** a disease of cattle and small ruminants caused by protozoan Trypanosoma spp.; transmitted by tsetse flies; causes progressive anaemia, weight loss, and death.

27. **Zoonosis:** a disease transmissible between animals and humans; examples include brucellosis, bovine tuberculosis, rabies, and Rift Valley Fever.

## Concept Check Questions [Series 5]

Objective Questions

1. Early signs of disease in ruminants include dullness, reduced feed intake, cessation of _____, and isolation from the herd. (Linked to SLO 5.1)
2. Biosecurity measures include _____ all new animals for 3-4 weeks before mixing with the resident herd. (Linked to SLO 5.2)
3. Haemonchus contortus parasitises the _____ of sheep and goats and is the most important internal parasite in Nigeria's humid zone. (Linked to SLO 5.5)
4. The FAMACHA system is a targeted _____ treatment approach; only animals showing anaemia signs are treated, reducing drug selection pressure. (Linked to SLO 5.6)
5. Health records serve disease _____, regulatory compliance, financial management, and farm improvement. (Linked to SLO 5.8)

Short-Answer Questions

- State four biosecurity measures for a Nigerian ruminant farm. (Linked to SLO 5.2)
- Describe the signs of FMD and explain why it has major economic impact. (Linked to SLO 5.3)
- Define zoonosis and explain the public health significance of brucellosis. (Linked to SLO 5.4)

- Name the four anthelmintic drug classes used in Nigeria and give one example of each. (Linked to SLO 5.6)
- State five types of health records that a ruminant farm should maintain. (Linked to SLO 5.8)

Long-Answer Questions

1. Describe the principles of biosecurity, vaccination programmes for Nigerian cattle and small ruminants, and the major bacterial and viral diseases of ruminants in Nigeria. (Linked to SLOs 5.2, 5.3)
2. Describe the major internal and external parasites of Nigerian ruminants, their impact on productivity, and the strategies for controlling them including anthelmintic resistance management. (Linked to SLOs 5.5, 5.6)
3. Describe the correct routes of drug administration for ruminants, the common veterinary procedures performed on the farm, and the design and purposes of a farm health record system. (Linked to SLOs 5.7, 5.8)

## Answers to Concept Check Questions [Series 5]

Objective Questions

6. Rumination.
7. Quarantine.
8. Abomasum.
9. Selective.
10. Surveillance.

Short-Answer Questions

11. Any four: quarantine new animals 3-4 weeks before mixing with resident herd; purchase only from known disease-free sources; disinfect vehicles, boots, and equipment; control access of people, vehicles, and wildlife; do not share equipment or feed with neighbouring farms; segregate sick animals immediately into a hospital pen.
12. FMD signs: high fever; profuse drooling; blisters (vesicles) on the tongue, dental pad, feet, and teats; lameness from foot lesions; reduced milk yield; low adult mortality but high calf mortality. Major economic impact beyond direct mortality: severe production losses during the outbreak period; trade and movement restrictions prevent sale of cattle; export bans imposed on countries with active FMD; costs of emergency vaccination campaigns.
13. A zoonosis is a disease transmissible between animals and humans. Brucellosis (Brucella abortus in cattle; B. melitensis in goats) causes abortion storms in ruminants and undulant fever in humans; humans are infected by drinking raw unpasteurised milk or by direct contact with infected birth fluids, placenta, or aborted foetuses during calving; in Nigeria where raw milk consumption is widespread (fura de nono, wara) and protective equipment is rarely worn during calving, brucellosis poses a significant public health risk particularly to pastoralists, abattoir workers, and veterinary personnel.
14. Benzimidazoles (albendazole); macrocyclic lactones (ivermectin); levamisole (tetramisole); salicylanilides/closantel (closantel).
15. Individual animal register (tag, birth date, breed, sex, dam/sire); treatment record (date, animal, diagnosis, drug, dose, route, outcome); vaccination record (date, vaccine, batch, expiry, animals, next due); mortality record (date, animal, age, cause, postmortem findings); production record (milk yield, litter size, growth weights).

Long-Answer Questions

1. Biosecurity: quarantine new animals 3-4 weeks; buy from disease-free sources; disinfect vehicles, boots, equipment; control access; segregate sick animals; maintain nutrition and avoid overcrowding; implement vaccination and deworming schedule; record all events. Cattle vaccines: FMD (every 6 months; 7 serotypes; movement restrictions during

outbreaks); CBPP (annually; compulsory in many states; caused by Mycoplasma mycoides mycoides); Blackquarter (annually before rainy season; Clostridium chauvoei; gas gangrene of muscles; near-100% mortality); Brucellosis (heifers 4-8 months; RB51 or S19); LSD annually in affected areas. Small ruminant vaccines: PPR (every 3 years; Morbillivirus; fever, mouth lesions, diarrhoea, pneumonia; up to 80% mortality); Orf/contagious ecthyma (live vaccine scarified skin); Pasteurellosis (annually). Cold chain 2-8 degrees Celsius throughout. Bacterial diseases: CBPP (Mycoplasma mycoides mycoides; respiratory droplets; fever, coughing, laboured breathing, chest fluid; vaccination and slaughter control); Blackquarter (C. chauvoei; soil spores, wounds; gas-filled dark muscle; near-100% mortality; annual vaccination); Anthrax (B. anthracis; sudden death, bloody discharge; never open carcass; notifiable). Viral diseases: FMD (Picornavirus 7 serotypes; vesicles on mouth, feet, teats; high economic impact; 6-monthly vaccination); PPR (Morbillivirus; sheep and goats; fever, diarrhoea, stomatitis, pneumonia; 80% mortality unvaccinated; 3-yearly vaccination); LSD (Capripoxvirus; skin nodules; annual vaccination). Zoonoses: brucellosis (B. abortus/B. melitensis; abortion in animals, undulant fever in humans; raw milk; pasteurise milk, vaccinate heifers, protective clothing); bovine TB (M. bovis; raw milk, respiratory; abattoir inspection, pasteurisation); rabies (dog bites; vaccinate dogs); Rift Valley Fever (abortions in ruminants, hepatitis in humans).

2. Internal parasites: Haemonchus contortus (barber's pole worm; blood-sucking abomasal nematode; sheep and goats in humid zone; anaemia, bottle jaw, death; high reproductive rate; 10,000 eggs/worm/day); Trichostrongylus, Ostertagia (protein loss, diarrhoea; cattle and small ruminants); Neoascaris vitulorum (calves <3 months); Fasciola gigantica (liver fluke; Lymnaea snail intermediate host; fadama, floodplains, Niger Delta; acute liver damage, haemorrhagic hepatitis, poor growth; cattle sheep goats); Trypanosomiasis (T. vivax, T. congolense; tsetse Glossina; anaemia, weight loss, death; major constraint in sub-humid zone; trypanotolerant breeds Ndama and WAD as biological control; trypanocides: diminazene aceturate, isometamidium chloride); coccidiosis (Eimeria; bloody diarrhoea young stock). External parasites: Amblyomma variegatum (heartwater = Ehrlichia ruminantium; dermatophilosis); Boophilus microplus (babesiosis = Babesia bovis/bigemina; anaplasmosis = Anaplasma marginale); Hyalomma spp. (theileriosis;

Rift Valley Fever); control by dipping or spraying with organophosphate, pyrethroid, or amidine acaricides; strategic dipping weekly in rainy season; mange mites (Sarcoptes, Psoroptes; severe skin disease, wool/hair loss; macrocyclic lactones); Oestrus ovis nasal botfly in sheep (larvae in sinuses; ivermectin). Anthelmintic classes: benzimidazoles (albendazole, fenbendazole; oral; broad-spectrum roundworm + fluke); macrocyclic lactones (ivermectin, doramectin; SC or pour-on; very broad including botfly and mites; not liver fluke alone); levamisole (oral or SC; roundworms; immunostimulant); closantel (Haemonchus and Fasciola). Resistance management: FAMACHA targeted selective treatment (eye conjunctiva anaemia scoring; treat only affected animals; reduces selection pressure); rotate drug classes; never under-dose (calculate dose on body weight); quarantine and treat new animals before introduction; do not use same class more than 2 consecutive years.

3. Drug administration routes: Subcutaneous (SC): under skin at tent of skin; 30-45 degree angle; 16-18 gauge needle cattle, 19-21 gauge small ruminants; side of neck or behind shoulder; for vaccines and some antibiotics. Intramuscular (IM): into muscle (neck or hindquarter); 16-18 gauge needle perpendicular to skin to full depth; for antibiotics, vitamins, hormones. Intravenous (IV): into jugular vein (cattle) or ear vein (small ruminants); for fluid therapy, calcium borogluconate (milk fever), some antibiotics; requires skill. Oral/drenching: drenching gun over tongue; position carefully to avoid trachea; for anthelmintics, minerals, electrolytes. Pour-on: along dorsal midline; absorbed through skin; easy to apply; macrocyclic lactones and some acaricides. Dosing principle: always calculate dose on accurate body weight to avoid under-dosing (resistance risk) or over-dosing (toxicity). Common procedures: dehorning (before 3 weeks: hot iron disbudder or caustic paste; older: surgical under local anaesthesia; reduces animal-animal and animal-handler injury); castration (Burdizzo bloodless castrator or surgical; produces steers/wethers; improves docility; reduces fighting); hoof trimming (every 3-6 months for housed cattle and goats; hoof knife or angle grinder; flat bearing surface; prevents lameness); wound treatment (clean with antiseptic; wound spray; Terramycin; cover to prevent fly strike). Farm health records: individual animal register; treatment record (disease, drug, dose, route, outcome); vaccination record (vaccine, batch, expiry, next due); mortality record (cause, postmortem); production record (milk, litter size, growth).

Uses: disease surveillance (identify emerging patterns); regulatory compliance (movement permits, health certificates); financial management (drug costs per animal, cost-benefit of interventions); farm improvement (compare disease rates between seasons, housing, feeding to guide management changes).

## Answers to Pilot Questions [Series 5]

Part 5.1

6. Signs of health (any six): bright alert expression; normal body temperature 38.5-39.5 degrees Celsius cattle; normal heart rate 60-80 bpm cattle; normal respiratory rate 10-30 breaths/minute; active rumination (1-3 contractions/minute audible with stethoscope); normal posture and gait with free movement; normal faecal consistency (firm moist in cattle, pellets in sheep and goats); moist clean muzzle; clear bright eyes; normal and consistent feed and water intake. Signs of disease (any six): dullness, depression, or isolation from the herd; reduced or absent feed intake; cessation of rumination; abnormal body temperature (fever above 39.5 in cattle; hypothermia below 38.0); abnormal posture (humped back, head down, reluctance to bear weight); abnormal faeces (watery diarrhoea, blood-stained, or black tarry); nasal or ocular discharge; swelling of joints, lymph nodes, or body cavities; laboured breathing, coughing; sudden drop in milk yield; increased mortality in the herd.
7. Biosecurity is the set of management practices designed to prevent the introduction of infectious pathogens into a farm and their spread within and from the farm. Four biosecurity measures: (1) Quarantine all newly acquired animals in a separate isolation facility for 3 to 4 weeks before introducing them to the resident herd; observe for any clinical signs; deworm and treat for ectoparasites; vaccinate according to farm schedule before mixing. (2) Purchase animals only from known disease-free sources with documentation of vaccination and health status; avoid buying from markets where animals from multiple unknown sources are mixed. (3) Disinfect all vehicles entering the farm at a vehicle dip/spray barrier at the farm gate; require all visitors to change into farm

boots and protective clothing before entering animal housing areas; disinfect any borrowed or returned equipment (needles, drenching guns, nets) before and after use. (4) Control access to the farm by restricting entry of unauthorised people, stray dogs, wild animals, and wildlife that might carry and transmit pathogens; fence the farm perimeter; lock gates when staff are absent.

8. FMD: every 6 months; CBPP: annually; Blackquarter: annually before rainy season; Brucellosis (heifers only): once at 4-8 months of age.
9. Cold chain maintenance means keeping vaccines refrigerated at 2 to 8 degrees Celsius from the manufacturer through transport, storage at the veterinary clinic or farm, and right up to the moment of administration. This is critical because vaccines are biological products consisting of live attenuated or killed organisms or protein antigens that are chemically denatured (inactivated) by exposure to temperatures above 8 degrees Celsius; a vaccine stored in a warm vehicle, left in direct sunlight, or kept in a malfunctioning refrigerator may look and feel identical to a potent vaccine but contain no active immunogen; animals vaccinated with a heat-damaged vaccine receive no protection and will be as vulnerable to disease as unvaccinated animals, yet the farmer believes they are protected and does not take additional precautions.
10. Overcrowding is a disease risk factor for three reasons: (1) Stress: overcrowded animals compete for feed and space, establish dominance through fighting, and have limited ability to escape aggressive pen-mates; chronic social stress elevates cortisol levels which suppresses the immune system (reduces lymphocyte numbers and antibody production), making animals more susceptible to any pathogen; (2) Pathogen amplification: in overcrowded conditions, respiratory pathogens (CBPP, PPR, Pasteurellosis) spread more rapidly because exhaled droplets travel shorter distances between animals; faecal-oral pathogens (Salmonella, Campylobacter, coccidial oocysts) accumulate at higher concentrations in the shared environment; skin contact pathogens (mange, lice) transfer more readily; (3) Microenvironment deterioration: overcrowded housing generates more body heat, moisture, ammonia, and carbon dioxide per unit of floor space, creating a warm, humid, ammonia-rich air environment that damages the respiratory mucosa and increases susceptibility to pneumonia.

Part 5.2

11. CBPP: Causative agent: Mycoplasma mycoides subspecies mycoides (a small bacterium without a cell wall); it cannot survive outside the host for more than a few hours. Signs: incubation 3 to 6 weeks; fever (39.5 to 41 degrees Celsius); progressive dry cough; laboured breathing with grunting and elbows abducted; nasal discharge; reduced milk; decreased feed intake; in advanced cases the animal stands with neck extended; postmortem reveals yellow fluid (up to 30 litres) in the pleural cavity and typical "marbling" (yellow and red interlobular oedema) of the consolidated lung; mortality up to 50% in naive herds. Control: vaccination with CBPP attenuated live vaccine (annually; compulsory in many northern states of Nigeria); movement restrictions during outbreaks to prevent spread from endemically infected zones to disease-free areas; test-and-slaughter of reactor animals in eradication programmes in disease-free countries; CBPP is a notifiable disease under Nigerian federal and state livestock legislation.
12. FMD signs: high fever (40-41 degrees Celsius) appearing 1-2 days after infection; profuse salivation and drooling from vesicles (fluid-filled blisters) forming on the tongue, dental pad, and lips causing the characteristic smacking, slobbering sound; vesicles also appear at the coronary band and between the claws of the feet, rupture to form painful ulcers causing severe lameness; teats in milking cows develop vesicles leading to abrupt drop in milk yield; low mortality in adult cattle and sheep (usually below 5%) but high in calves and lambs (up to 50%). Major economic impact beyond direct mortality: (1) severe reduction in milk yield and growth rate during and after the outbreak, sometimes persisting for months; (2) movement bans imposed to contain the outbreak prevent farmers from selling animals or moving them to markets, feedlots, or abattoirs, causing major cash flow disruption; (3) international trade restrictions: countries with active FMD outbreaks lose access to FMD-free export markets for live animals and animal products; Nigeria's ability to export cattle to North Africa and the Middle East is severely limited by FMD status; (4) costs of emergency vaccination campaigns, veterinary investigation, and treatment.

13. PPR (Peste des Petits Ruminants): Caused by a Morbillivirus (related to measles and rinderpest viruses) that infects only sheep and goats (and some wild small ruminants); cattle are infected but do not develop disease. The disease spreads rapidly through close contact between animals; incubation 2 to 6 days; signs: sudden high fever (40-42 degrees Celsius), serous then mucopurulent nasal and ocular discharge, necrotic lesions in the mouth (stomatitis), profuse foul-smelling diarrhoea, bronchopneumonia (coughing, laboured breathing); death occurs in 70-80% of unvaccinated naive animals within 1-2 weeks of clinical signs; the remaining survivors shed virus and may introduce disease to other flocks. Vaccination is particularly important because: (1) PPR spreads with extreme speed in a naive flock, making treatment of sick animals impractical as most die before the diagnosis is confirmed; (2) there is no effective antiviral treatment; supportive care only; prevention by vaccination is the only cost-effective approach; (3) the PPR vaccine provides long-lasting immunity (at least 3 years); (4) PPR is a global FAO/OIE priority for eradication by 2030, and sustained vaccination campaigns in Nigerian small ruminant herds are essential for achieving this target.
14. A zoonosis is an infectious disease that is naturally transmissible between vertebrate animals and humans, either directly by contact with the animal or indirectly through contaminated food, water, or arthropod vectors. Public health significance of brucellosis in Nigeria: Brucella abortus infects cattle and causes large-scale abortion outbreaks (abortion storms), while Brucella melitensis infects sheep and goats and causes similar abortions. Humans are infected by: drinking raw unpasteurised milk or consuming fermented milk products (nono, fura de nono) made from the milk of infected cows or goats; direct handling of aborted foetuses, placentas, or vaginal discharges from infected animals without protective gloves; or consuming undercooked meat from infected animals. Human brucellosis causes prolonged undulant fever (temperature rises and falls in waves over weeks to months), severe joint pain, night sweats, weakness, and depression; it is debilitating but rarely fatal; however, it can be extremely difficult to treat (requiring 6 weeks of combined antibiotic therapy) and tends to relapse. In Nigeria where brucellosis is endemic in cattle, raw milk consumption is widespread, and pasteurisation is largely absent in rural areas, brucellosis poses a significant occupational health risk to

Fulani pastoralists, veterinary workers, abattoir staff, and all consumers of uninspected dairy products.

15. Bovine tuberculosis (Mycobacterium bovis) reaches humans by two primary routes: (1) Ingestion of raw unpasteurised milk from an infected cow containing live M. bovis bacilli; this causes primarily extra-pulmonary tuberculosis (TB of the lymph nodes of the gut, mesentery, spine, or joints) rather than the classic pulmonary TB caused by M. tuberculosis; children who drink raw milk are most at risk; in Nigeria where urban dwellers still sometimes buy raw unheated milk from street vendors, this remains a real public health risk. (2) Respiratory transmission: humans in close, prolonged contact with infected cattle (pastoralists, farmers, abattoir workers, veterinary staff) can inhale M. bovis from the air exhaled by diseased cattle and develop pulmonary TB indistinguishable clinically from human pulmonary TB. Control in Nigeria: mandatory abattoir meat inspection and condemnation of carcasses and organs showing tuberculous lesions (the primary detection point in Nigeria where there is no systematic herd-level testing and slaughter programme); pasteurisation of all milk for public sale (required by NAFDAC regulations); the tuberculin skin test (TST) or the interferon-gamma blood test for herd-level screening of dairy herds (conducted by state veterinary authorities in some states); test-positive animals should be quarantined and eventually slaughtered under compensation schemes.

Part 5.3

1. Lifecycle of Haemonchus contortus: adult male and female worms live in the abomasum of sheep or goats; the female is the most fecund parasitic nematode of livestock, producing up to 10,000 eggs per day which are passed in the faeces onto the pasture; on warm moist grass (optimum 25-30 degrees Celsius, as in Nigeria's rainy season), the eggs hatch to L1 larvae within 24-48 hours; L1 moults to L2 and then to the infective L3 larva within 5-7 days; L3 larvae migrate from the faecal pat onto the blades of grass around it; the sheep or goat ingests L3 larvae while grazing; L3 penetrate the abomasal mucosa, undergo 4th (L4) and 5th moult to become adult worms; the prepatent period (egg to egg)

is approximately 18-21 days. Pathogenic effects: Haemonchus is a blood-sucking parasite; each female adult worm consumes approximately 0.05 mL of blood per day; a heavy burden of 500-2,000 worms (common in naive young animals in the humid season) causes clinical haemonchosis: severe normocytic normochromic anaemia (PCV falls below 15%); hypoproteinaemia leading to submandibular oedema (bottle jaw) as plasma protein leaks into tissue spaces; extreme weakness, pale mucous membranes; exercise intolerance; and death from anaemia and hypovolaemia within 2-4 weeks of heavy infection.

2. Transmission: Fasciola gigantica eggs are passed in the faeces of infected cattle, sheep, or goats onto moist, waterlogged ground (fadama, river floodplains, Niger Delta, irrigated fields); the egg hatches to a miracidium larva which must find and penetrate the mud snail Lymnaea natalensis within a few hours or die; inside the snail the parasite undergoes sexual reproduction through sporocyst, redia, and cercariae stages over 6-8 weeks; cercariae emerge from the snail, swim in water, and encyst as metacercariae on grass blades or on the water surface; ruminants ingest metacercariae while grazing on wet pasture; the juvenile fluke migrates through the gut wall and across the peritoneum to enter the liver and bile ducts, causing acute haemorrhagic hepatitis during migration; mature flukes in the bile ducts cause chronic biliary disease, fibrosis, and protein loss. Lifecycle interruption strategies: (1) avoid grazing cattle on permanently waterlogged fadama and floodplain areas during and after the rainy season when metacercariae are most abundant; (2) drain or fence off permanently wet snail-harbouring areas around water points; (3) control the Lymnaea snail population using copper sulphate applied to wet areas at 20-30 kg/ha (kills snails but also affects aquatic organisms); (4) treat animals annually with fasciolicides (albendazole at 7.5-10 mg/kg DM; closantel; triclabendazole for early immature fluke); strategic treatment in November-December after the peak fluke season reduces fluke burdens before animals enter the dry season.
3. Any three tick species with one disease each: (1) Amblyomma variegatum (the bont tick; adult stage found mainly on the ears, dewlap, and udder of cattle): transmits Heartwater (Ehrlichia ruminantium) which causes high fever, nervous signs (circling, paddling, convulsions), and high mortality in cattle, sheep, and goats; also associated with dermatophilosis (lumpy wool disease) by creating skin wounds that allow entry of

Dermatophilus congolensis. (2) Rhipicephalus (Boophilus) microplus (the cattle tick; a one-host tick completing its entire life cycle on cattle): transmits Babesiosis (caused by Babesia bovis and B. bigemina); Babesia destroys red blood cells causing severe haemolytic anaemia, high fever, icterus (jaundice), and characteristic red urine (haemoglobinuria = "redwater fever"); mortality can exceed 50% in naive exotic and crossbred cattle. (3) Hyalomma spp. (a two-host tick found across northern Nigeria): transmits Theileria annulata causing tropical theileriosis in cattle (severe anaemia, high fever, enlarged lymph nodes); also implicated in Rift Valley Fever transmission to humans during outbreaks.

4. Benzimidazoles: albendazole (broad-spectrum against roundworms and liver fluke Fasciola; given as oral drench at 7.5 mg/kg; cheap and widely available in Nigeria). Macrocyclic lactones: ivermectin (very broad-spectrum against roundworms, botfly larvae Oestrus ovis, and mange mites; given subcutaneously at 0.2 mg/kg in cattle and sheep; also available as a pour-on; does not treat liver fluke). Levamisole: levamisole hydrochloride (effective against mature and developing roundworms; given subcutaneously or orally; also acts as an immunostimulant, improving the animal's own immune response to helminths). Salicylanilides/closantel: closantel (highly effective against Haemonchus contortus and liver fluke Fasciola simultaneously; excellent choice for the dual-infection common in Nigerian humid zone and Niger Delta; given orally or by injection at 5-10 mg/kg).
5. Anthelmintic resistance is the ability of a worm population (Haemonchus, Trichostrongylus, or other nematode) to survive and reproduce after exposure to a dose of anthelmintic drug that would normally kill susceptible worms; it develops when the rare resistant worms in a population survive treatment, breed, and pass their resistance genes to progeny, progressively increasing the proportion of resistant worms. Three strategies: (1) FAMACHA targeted selective treatment: rather than treating all animals on a fixed schedule, assess individual animals for anaemia using the FAMACHA scoring card (comparing the colour of the eye conjunctiva to a reference card with five levels from red/healthy to white/severely anaemic); treat only animals scoring 3, 4, or 5; animals scoring 1 or 2 are left untreated and their susceptible worm populations serve as a genetic refuge diluting the proportion of resistant alleles in the worm population. (2) Rotate

anthelmintic drug classes: never use the same drug class for more than 2 consecutive years; rotating between benzimidazoles, macrocyclic lactones, levamisole, and closantel in successive treatment rounds prevents any single drug from selecting predominantly resistant survivors. (3) Dose accurately on body weight: under-dosing (for example, estimating body weight by eye and consistently underestimating it) exposes worms to sub-lethal drug concentrations that kill only the most susceptible individuals, leaving partially resistant worms to survive and breed; always use a weigh tape or scale to determine body weight before calculating the anthelmintic dose.

Part 5.4

1. Subcutaneous (SC) injection: pick up a fold (tent) of loose skin between the thumb and forefinger at the side of the neck or just behind the shoulder where the skin is thin and loose; insert the needle (16-18 gauge for cattle; 19-21 gauge for small ruminants) at approximately 30 to 45 degrees to the skin surface and parallel to the skin fold, so the tip is between the skin layers and not in the underlying muscle; if no resistance is felt as the plunger is depressed and no swelling is visible outside the skin fold, the needle is correctly placed subcutaneously; inject the drug; withdraw the needle and apply gentle pressure for a few seconds. Intramuscular (IM) injection: choose the injection site (neck muscle, between the poll and shoulder in the triangle of muscle above the cervical vertebrae; or the hindquarter muscle in the biceps femoris); part the hair with the thumb; insert the needle (16-18 gauge) perpendicular to the skin surface (90 degrees) to the full length of the needle; aspirate briefly to check there is no blood return (which would indicate intravascular placement); if no blood, inject the drug; withdraw and apply gentle pressure; inject no more than 10-20 mL per IM site in cattle (5-10 mL per site in sheep and goats).
2. Drenching (oral administration via a drenching gun): calculate the correct drug dose on accurate body weight; draw the correct volume of drug into the drenching gun; restrain the animal (halter the head or place it against a fence); insert the drenching gun nozzle into the corner of the mouth; slide it over the back of the tongue (not into the trachea);

depress the plunger to deliver the drug; hold the head horizontal (not elevated) during administration to allow the animal to swallow naturally. Pour-on administration: some macrocyclic lactone anthelmintics (ivermectin pour-on) and some acaricides are applied to the dorsal midline of the animal (from the poll to the tailhead); the product is poured in a thin line along this surface from a calibrated applicator gun; the drug is absorbed through the skin over several hours; no restraint required beyond holding the animal still; advantage: easy to apply without requiring injection skill or cooperation; disadvantage: absorption may be reduced in wet conditions (heavy rain) and on animals with heavy mud or grease on the back.

3. Dehorning of calves under 3 weeks of age: first confirm the horn bud by palpating the top of the head for the small firm raised disc of tissue under the skin at each horn site; the horn buds are not yet attached to the skull at this age. Hot iron disbudder method: heat the electric or gas-heated disbudder to full temperature (the tip should glow orange-red); restrain the calf in a calf restrainer or have an assistant hold it securely with the head still; apply a few drops of local anaesthetic (lidocaine 2%) around the horn bud and wait 2-3 minutes if the calf appears painful; hold the hot iron firmly over the horn bud and apply steady downward pressure for 10 to 15 seconds (rotating slightly) until a uniform copper-brown ring is visible around the entire base of the bud; this destroys the germinal tissue (corium) from which the horn grows; apply a wound spray or iodine to the site; ensure the entire ring is uniformly treated; incomplete treatment leaves a scur (deformed horn remnant). Caustic paste (potassium hydroxide) method: clip the hair around the horn bud; apply petroleum jelly (Vaseline) in a ring around the bud to protect the surrounding skin; apply caustic paste (a pea-sized amount) directly to the centre of the horn bud using a gloved finger or applicator; do not over-apply; keep the calf separate from its dam for 1 hour after application to prevent the dam from licking the paste (chemical burns to the mouth); the paste chemically destroys the germinal tissue over 24 to 48 hours.
4. Five types of health records: (1) Individual animal register: permanent record of each animal on the farm including tag number, species, breed, sex, date of birth, dam and sire identification, and date of purchase or birth on farm; this is the master reference linking all other records to specific animals. (2) Treatment record: for every sick or injured animal, record the date, animal tag number, clinical signs and diagnosis, drug name, dose,

route of administration, person who administered treatment, and outcome (recovered, died, sold, or still under treatment); this allows tracking of treatment success rates and drug efficacy. (3) Vaccination record: for every vaccination session, record the date, vaccine name and manufacturer, batch number and expiry date, number and identity of animals vaccinated, dose administered, route, and calculated date for the next vaccination; essential for regulatory compliance. (4) Mortality record: for every death, record the date, animal tag number, age, estimated body weight, probable or confirmed cause of death (from postmortem examination), and whether the carcass was disposed of safely; a pattern of increasing mortality in a specific age group or pen is the earliest signal of a herd-level disease problem. (5) Production record: for dairy herds, individual cow milk yield at each milking; for breeding herds, litter size at birth, birth weight, weaning weight, and 6-month or yearling weight for each calf, lamb, or kid; these records allow early identification of underperforming animals for culling and superior animals for breeding.

5. Four uses of farm health records: (1) Disease surveillance: systematic review of treatment records, mortality records, and production data over time reveals patterns that indicate emerging disease problems before they become serious outbreaks; for example, a sudden cluster of respiratory disease treatments in the same pen over 2 weeks signals an emerging infectious pneumonia requiring investigation; without records the farmer may attribute the problem to bad luck rather than a management or biosecurity failure. (2) Regulatory compliance: Nigerian agricultural regulations require proof of vaccination, treatment history, and disease-free status for obtaining livestock movement permits between states, for export health certificates, for participation in government livestock improvement programmes, and for claiming insurance payments when animals die of notifiable diseases; farms without records cannot access any of these official processes. (3) Financial management: comparing total annual drug and veterinary costs against total production value per animal allows calculation of the disease burden cost per animal and assessment of the cost-effectiveness of prevention versus treatment; for example, if vaccination against CBPP costs NGN 500 per animal per year but an unvaccinated outbreak costs NGN 20,000 per animal in deaths and production losses, the vaccination return on investment is obvious and quantifiable. (4) Farm improvement: comparing

disease incidence rates between different housing types (raised pen vs earth floor), different feeding regimes (concentrated vs roughage only), or between different seasons allows the manager to identify which management factors are associated with higher or lower disease rates and make evidence-based changes to reduce future losses.

## References and Attributions [Series 5]

Textual References (Books and External Sources)


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3. Njoku, P. C., & Obioha, F. C. (2010). Livestock production in Nigeria (3rd ed.). University of Nigeria Press.
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Figures, Plates, Tables, and Boxes

1. Figure 5.1: Cattle vaccination exercise in Nigeria Attribution: AI generated. Suggested OER search string: "cattle vaccination Nigeria farm cold chain vaccine cool box OER photograph".
2. Figure 5.2: FMD clinical signs in cattle Attribution: AI generated. Suggested OER search string: "foot and mouth disease FMD cattle vesicles tongue lameness clinical signs OER photograph".
3. Figure 5.3: Tick infestation and plunge dip tank Attribution: AI generated. Suggested OER search string: "tick infestation cattle ear Nigeria Amblyomma plunge dip tank OER photograph".

4. Box 5.1: Seasonal veterinary procedures calendar Attribution: AI generated. Suggested OER search string: "Nigerian ruminant farm veterinary calendar vaccination deworming seasonal procedures OER box".