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AGE 302

RUMINANT ANIMAL PRODUCTION

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Series 1: Concepts, Conformation, and Breeds of Ruminant Animals

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Introduction

Ruminant animals, which include sheep, goats, beef cattle, and dairy cattle, form a critical component of agricultural production in Nigeria. These animals are valued for their ability to convert roughages and fibrous plant materials into meat, milk, hides, and other products that support livelihoods, nutrition, and commerce. Understanding their basic concepts, conformation, and breeds is the starting point for any serious study of ruminant animal production.

This Series is designed to equip you with foundational knowledge on ruminant animal production. We begin with the definition, classification, and economic importance of ruminants, then examine their conformation and the significance of body structure in production performance. We then explore the major breeds of sheep, goats, beef cattle, and dairy cattle found in Nigeria, highlighting their distinguishing features and selection criteria.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- SLO 1.1 define ruminant animals and classify them by type (Linked to Part 1.1),
- SLO 1.2 describe the economic importance of ruminant animals in Nigeria (Linked to Part 1.1),
- SLO 1.3 identify the general characteristics of ruminant animals (Linked to Part 1.1),
- SLO 1.4 explain the meaning and importance of conformation in ruminants (Linked to Part 1.2),
- SLO 1.5 identify major body parts and their functional roles in ruminant production (Linked to Part 1.2),
- SLO 1.6 describe how ruminant conformation is judged and scored (Linked to Part 1.2),
- SLO 1.7 identify common breeds of sheep and goats in Nigeria (Linked to Part 1.3),
- SLO 1.8 describe the characteristics and uses of sheep and goat breeds (Linked to Part 1.3),
- SLO 1.9 identify common breeds of beef and dairy cattle in Nigeria (Linked to Part 1.4),

- SLO 1.10 compare and contrast beef and dairy cattle breeds on key production traits (Linked to Part 1.4), and
- SLO 1.11 apply breed selection criteria to match breeds to production goals (Linked to Part 1.3, 1.4).

1.1 Overview of Ruminant Animals

1.1.1 Definition and classification of ruminants

Ruminant animals are herbivores with a specialised multi-chambered stomach that allows them to digest fibrous plant materials through a process called **rumination**, or chewing of the cud. The four stomach compartments are the rumen, reticulum, omasum, and abomasum. Ruminants are broadly classified into large ruminants, such as cattle and buffaloes, and small ruminants, such as sheep and goats. In Nigeria, all four groups are economically important and widely kept under various management systems ranging from nomadic herding to intensive farming.

Ruminants are further classified by their primary production purpose: meat-type, milk-type, dual-purpose, and fibre-producing animals. This classification guides farmers in selecting appropriate breeds and management practices for their specific production goals. Understanding the classification of ruminants enables producers to make informed decisions regarding species choice, feeding regimes, and market targeting.

Fill in the blank: Ruminant animals digest fibrous materials through a process called _____.

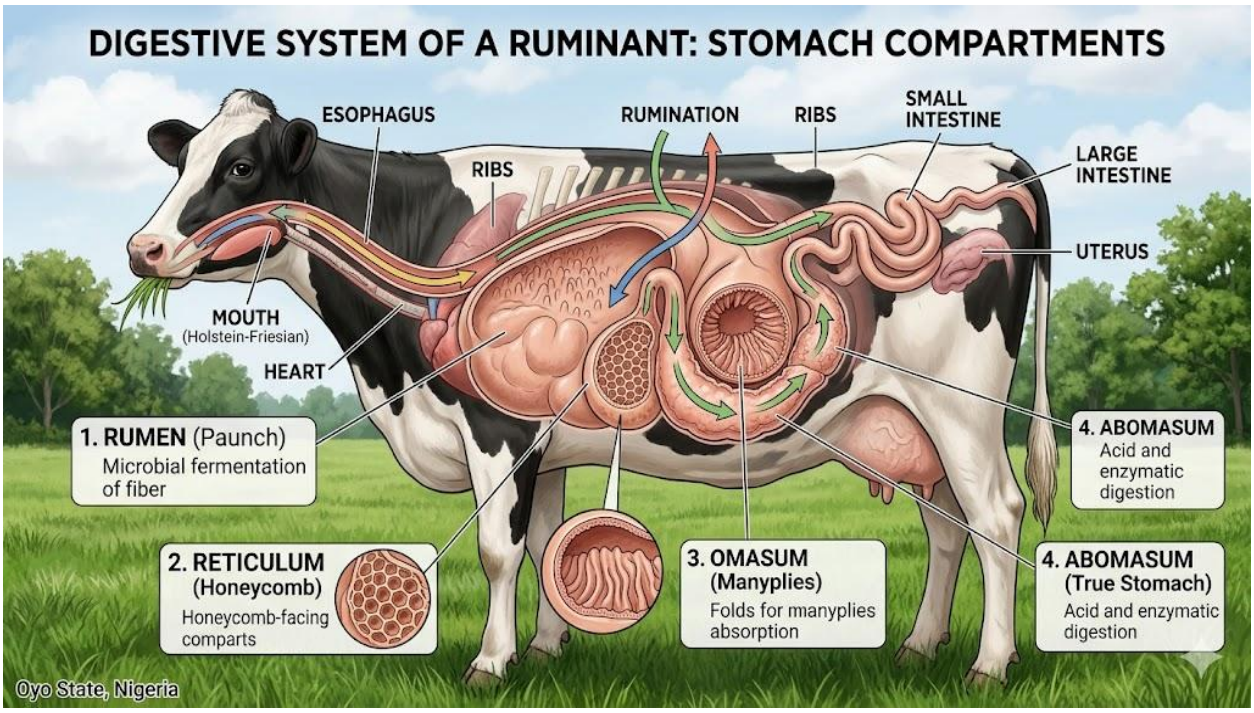

Figure 1.1: The four stomach compartments of a ruminant animal

1.1.2 Economic importance of ruminants in Nigeria

Ruminant animals contribute significantly to Nigeria's agricultural economy and the food security of rural households. Cattle, sheep, and goats provide meat, milk, hides, and skins that supply local and export markets. Livestock farming also generates employment for herders, traders, butchers, and processors throughout the value chain. Dung from ruminants is used as organic manure, improving soil fertility and reducing input costs for crop farmers.

Beyond subsistence use, ruminant production supports cultural practices such as bride price payment, festivals, and religious observances, giving these animals social as well as economic value. Nigeria ranks among the leading producers of ruminant livestock in sub-Saharan Africa, and there is growing commercial interest in improving herd productivity through better breed selection, nutrition, and health management.

Fill in the blank: In Nigeria, dung from ruminants is used as _____ to improve soil fertility.

1.1.3 General characteristics of ruminant animals

All ruminants share several common characteristics that distinguish them from non-ruminant livestock. They possess a **cloven hoof**, a split or divided hoof that provides traction on varied terrain. They have a **dental pad** on the upper jaw instead of front incisors, which, combined with a mobile lower jaw, enables effective grazing and browsing. Their multi-chambered digestive system hosts microbial populations that ferment cellulose and other complex carbohydrates, extracting nutrients unavailable to simple-stomached animals.

Ruminants also have a characteristic behaviour of regurgitating partially digested food and re-chewing it, which is known as chewing the cud. This behaviour typically occurs during rest periods and is a sign of good digestive health. Other shared traits include horns or horn-bearing structures in many breeds, efficient water utilisation compared to monogastrics, and adaptability to low-quality roughage diets.

Fill in the blank: The split hoof found in ruminants is called a _____ hoof.

Characteristic	Description	Production Significance
Cloven hoof	Hooves split into two toes	Provides stability on varied terrain, enabling grazing in diverse environments
Dental pad	Tough pad in upper jaw replacing front teeth	Allows efficient grazing and tearing of grasses, reducing feed wastage
Rumination	Process of regurgitating and re-chewing cud	Improves digestion of fibrous feeds, maximizing nutrient extraction
Multi-chambered stomach	Four compartments: rumen, reticulum, omasum, abomasum	Enables microbial fermentation, protein synthesis, and efficient feed utilization

Table 1.1: Key characteristics of ruminant animals and their production significance

Pilot questions 1.1

1. Define ruminant animals and name the four stomach compartments.
2. Classify ruminants by size and by production purpose.
3. State three ways in which ruminants are economically important in Nigeria.
4. Describe two general characteristics shared by all ruminants.

5. Explain the process of rumination and its significance in digestion.

1.2 Conformation of Ruminant Animals

1.2.1 Meaning and importance of conformation

Conformation refers to the overall shape, structure, and proportions of an animal's body. A well-conformed ruminant has body parts that are properly balanced and suited to its production purpose. Conformation assessment allows farmers and animal scientists to predict an animal's productive potential, structural soundness, and fitness for breeding. Animals with good conformation tend to be more efficient feeders, have fewer health problems, and produce higher-quality outputs.

The importance of conformation extends to breed improvement programmes, livestock shows, and commercial production. In cattle, for instance, a well-developed loin and hindquarters indicate good meat-producing potential, while a capacious udder with well-attached teats indicates dairy suitability. Understanding conformation enables producers to make better selection and culling decisions, ultimately improving herd productivity over successive generations.

Fill in the blank: Conformation refers to the overall shape, structure, and _____ of an animal's body.

1.2.2 Body parts and their functional significance

Ruminants are assessed for conformation from the head to the tail. The head should reflect breed character, with a broad muzzle for efficient grazing. The neck should be moderate in length and blend smoothly into the shoulders. The withers should be level and prominent, while the back must be straight and strong to support heavy body weight and facilitate movement. The loin, rump, and hindquarters are critical areas for evaluating meat production potential.

The legs should be straight, well-boned, and set squarely under the body to support weight and provide mobility. In dairy cattle, the udder is a primary point of evaluation: it should be well attached, evenly quartered, and have properly placed teats. The feet should be well-shaped and free from defects that could cause lameness. Each body region provides clues about the animal's health, productivity, and suitability for specific production systems.

Fill in the blank: In dairy cattle, the _____ is a primary conformation point for evaluating milk production potential.

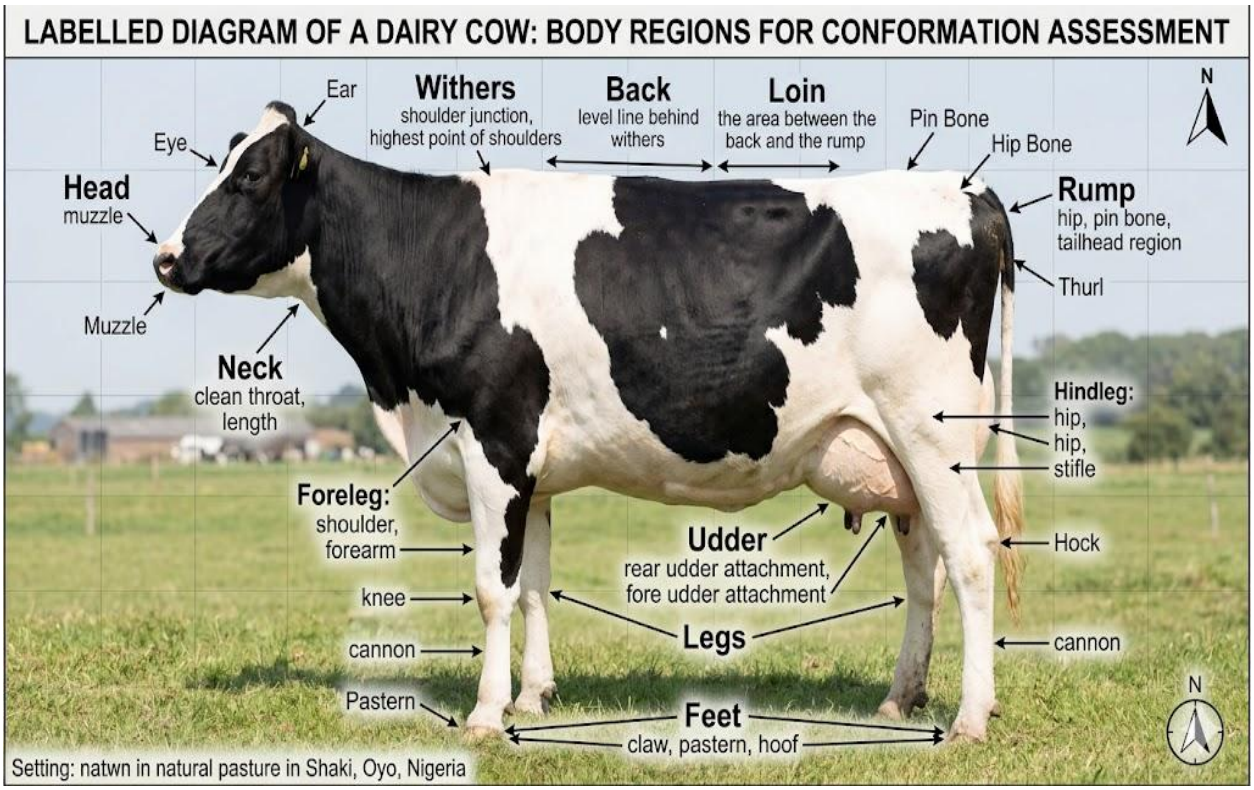

Figure 1.2: Body parts of a ruminant animal used in conformation assessment

1.2.3 Judging and scoring ruminant conformation

Conformation judging involves systematically evaluating an animal against a breed standard or ideal type. Judges assess each body region and assign scores based on how closely the animal conforms to the desired traits. Scoring systems vary by species and breed association, but most use a numerical scale where higher scores indicate closer conformity to the ideal. In cattle, linear

scoring systems are widely used to measure traits such as stature, chest width, body depth, and udder attachment objectively.

Practical conformation judging is carried out at livestock shows, on-farm selection, and in breed registration programmes. Producers learn to handle animals correctly, observe them from multiple angles, and compare individuals within a group. Common faults noted during judging include sickle-hocked legs, weak pasterns, shallow body, uneven udder, and poor front attachment. Avoiding animals with such defects improves the genetic quality and performance of the herd.

Fill in the blank: In livestock judging, each body region is assessed against a _____ standard.

Conformation Fault	Description	Production Implications
Sickle-hocked legs	Hind legs curve too far under the body	Leads to reduced mobility, lameness, and poor grazing efficiency
Weak pasterns	Pastern joints slope excessively and lack strength	Causes difficulty in standing for long periods, reducing feeding and milking performance
Shallow body	Narrow chest and limited body depth	Limits feed intake capacity, resulting in lower growth and milk yield
Uneven udder	One side of the udder larger or poorly developed	Reduces milking efficiency, increases mastitis risk, and lowers overall milk production
Splayed feet	Toes spread outward instead of pointing forward	Causes instability, higher risk of injury, and reduced ability to walk long distances for grazing

Box 1.1: Common conformation faults in ruminants and their production implications

Pilot questions 1.2

1. Define conformation and explain its importance in ruminant production.
2. Name four body regions evaluated during conformation assessment.
3. Describe the ideal characteristics of the udder in a dairy cow.
4. What is a linear scoring system and how is it used in cattle?

5. List three common conformation faults found in ruminants.

1.3 Breeds of Sheep and Goats

1.3.1 Common breeds of sheep in Nigeria

The predominant sheep breeds in Nigeria include the **Yankasa**, the most widely distributed breed in the northern states, known for its white coat, dark patches on the face, and good meat conformation. The **Uda** is a tall, long-legged breed with a bicoloured coat of black and white or brown, found mainly in the Sahel region and valued for its adaptability to arid conditions. The **Balami** is the largest Nigerian sheep breed, white-coated with a convex nasal profile, and favoured for meat production and ceremonial use.

Other breeds include the Ouda and various West African Dwarf (WAD) sheep found in the southern forest zone, which are small but highly prolific and trypanotolerant. WAD sheep are important for small-scale farmers in humid areas where trypanosome challenge limits the survival of larger exotic breeds. Breed selection in sheep should consider the production environment, intended purpose, and availability of feed resources.

Fill in the blank: The _____ is the most widely distributed sheep breed in northern Nigeria.

Plate 1.1: Common sheep breeds in Nigeria: Yankasa, Uda, and Balami

1.3.2 Common breeds of goats in Nigeria

The **Red Sokoto (Maradi) goat** is the most commercially important goat breed in Nigeria, prized for its reddish coat and high-quality leather used in producing the famous Moroccan leather. It is well adapted to the arid and semi-arid zones of northwestern Nigeria. The **Sahel goat** is tall and slender, adapted to harsh Saharan conditions, and kept primarily for meat and milk. The **West African Dwarf (WAD) goat** is small, prolific, and trypanotolerant, making it the dominant goat type in southern Nigeria's humid forest zone.

The Kano Brown and Bornu White goats are additional breeds recognised in the north, valued for their meat and skin qualities. Goat breeds are generally more adaptable than sheep and cattle to resource-poor environments, making them important livestock for smallholder farmers. Selection of goat breeds should consider adaptability, growth rate, prolificacy, and the intended product, whether meat, milk, or fibre.

Fill in the blank: The Red Sokoto goat is prized for its high-quality _____ used in leather production.

1.3.3 Breed characteristics and selection criteria

When selecting sheep and goat breeds, producers consider growth rate, body weight at maturity, prolificacy (litter size), adaptation to local climate, disease resistance, and feed conversion efficiency. Indigenous breeds such as Yankasa, WAD sheep, and WAD goats are better adapted to tropical conditions and local disease challenges, though they may have lower productivity than exotic breeds. Crossbreeding is often used to combine the hardiness of local breeds with the productivity of exotic ones.

Selection criteria also include conformation traits, temperament, reproductive efficiency, and market preferences. In southern Nigeria, WAD breeds command good prices due to their adaptability, while in the north, larger breeds such as Uda and Balami are preferred for high-value festivals and ceremonies. Understanding these market dynamics helps producers align breed choice with profitability and sustainability goals.

Fill in the blank: The practice of combining local and exotic breeds to improve productivity is called _____.

Breed Name	Region	Coat Colour	Production Purpose	Notable Characteristic
West African Dwarf Goat	Southern Nigeria (humid forest zone)	Predominantly black, brown, or white	Meat and milk	High resistance to trypanosomiasis (sleeping sickness)
Red Sokoto Goat (Maradi)	Northern Nigeria (semi-arid zone)	Uniform reddish-brown	Skin (leather) and meat	Produces high-quality leather (“Morocco leather”)
Sahelian Goat	Northern Nigeria (Sahel region)	White or light brown	Meat and milk	Tall, long-legged, adapted to arid climate
Balami Sheep	Northeastern Nigeria	White coat	Meat and wool	Large body size, suited for semi-arid grazing
Uda Sheep	Northern Nigeria	White body with black/brown head and legs	Meat	Distinctive piebald colour pattern

Yankasa Sheep	Central and Northern Nigeria	White with black patches around eyes and ears	Meat and wool	Hardy and widely distributed across Nigeria
West African Dwarf Sheep	Southern Nigeria	Varied (black, brown, white)	Meat	Small size, tolerant to humid forest conditions

Table 1.2: Comparison of common sheep and goat breeds in Nigeria

Pilot questions 1.3

1. Name three common sheep breeds in Nigeria and state one feature of each.
2. Describe the Red Sokoto goat and explain its commercial importance.
3. Why are WAD goats important in southern Nigeria?
4. List four criteria used in selecting sheep and goat breeds.
5. Explain why crossbreeding is practised between local and exotic breeds.

1.4 Breeds of Beef and Dairy Cattle

1.4.1 Common breeds of beef cattle in Nigeria

The dominant beef cattle breed in Nigeria is the **White Fulani (Bunaji)**, a large-framed, white-coated Zebu breed widely distributed across the northern states and valued for its drought tolerance, disease resistance, and beef quality. The **Sokoto Gudali** is a heavy, hump-shouldered breed with good muscling, favoured for beef production in the northwest. The **Adamawa Gudali** is another Gudali variant adapted to the northeast, recognised for its deep body and good meat conformation.

Other breeds include the Keteku, a natural crossbreed between zebu and taurine cattle found in the Middle Belt, and the N'dama, a taurine breed confined to the humid southwest owing to its

trypanotolerance. Exotic beef breeds such as Simmental and Charolais have been introduced through crossbreeding programmes to improve growth rates and carcass quality. Nigerian beef cattle production remains predominantly extensive, relying on natural pastures.

Fill in the blank: The _____ is the most widely distributed beef cattle breed in Nigeria.

Plate 1.2: White Fulani (Bunaji) cattle: the dominant beef breed in Nigeria

1.4.2 Common breeds of dairy cattle in Nigeria

Pure dairy cattle breeds are less common in Nigeria than beef breeds, but the **Friesian (Holstein)** has been introduced and kept in government farms and some commercial operations for its high milk yield. The **Brown Swiss** and **Jersey** are also used in crossbreeding programmes to improve milk production in local cattle. The Jersey is particularly valued for its high butterfat content, which suits butter and cheese processing.

Crossbreeds between White Fulani and Friesian (known locally as Friesian-Bunaji crosses) are the most practical dairy animals for Nigerian conditions, combining the local breed's heat tolerance and disease resistance with the Friesian's milk productivity. The Wadara and Shuwa

Arab cattle in the northeast also have some dairy value. Increasing commercial dairy production in Nigeria requires investment in improved breeds, feed, veterinary care, and cold-chain infrastructure.

Fill in the blank: The _____ breed is favoured for its high butterfat content in dairy production.

1.4.3 Comparison of beef and dairy breed characteristics

Beef and dairy cattle breeds differ markedly in body type, conformation, and production focus. Beef breeds are characterised by a blocky, muscular body with a wide, deep chest, well-developed hindquarters, and a broad loin. Their skin and hide tend to be thick. Dairy breeds, in contrast, are angular and lean, with a prominent ribcage, wide-set hip bones, and a well-developed, capacious udder. The wedge-shaped body of dairy cattle reflects energy partitioning toward milk rather than muscle.

In terms of temperament, dairy breeds tend to be more docile and responsive to regular milking routines, while many beef breeds are more independent and suitable for extensive range management. Dual-purpose breeds, such as the Gudali and some crossbreeds, offer moderate performance in both milk and beef. When selecting between beef and dairy breeds, producers must consider market demand, available feed, management capacity, and climate to optimise returns.

Fill in the blank: Dairy cattle breeds are characterised by an angular body type and a well-developed, capacious _____.

Feature	Beef Cattle	Dairy Cattle
Body Shape	Blocky, compact, broad frame	Angular, wedge-shaped, refined frame
Muscling	Heavy muscling, thick flesh	Light muscling, lean body
Udder	Small, less developed	Large, well-developed for milk production
Primary Product	Meat (beef)	Milk

Management System	Extensive grazing, feedlots	Intensive management, regular milking routines
Nigerian Breed Examples	White Fulani (Bunaji), Muturu	Sokoto Gudali, Friesian (imported/exotic dairy breed)

Box 1.2: Key differences between beef and dairy cattle breeds

Pilot questions 1.4

1. Name three beef cattle breeds found in Nigeria and state one distinguishing feature of each.
2. Why is the White Fulani the most widely kept beef breed in Nigeria?
3. Describe two dairy cattle breeds used in Nigeria and explain their importance.
4. Distinguish between the body conformation of beef and dairy cattle breeds.
5. What factors should a producer consider when choosing between beef and dairy breeds?

Series Summary

This Series has introduced you to the foundational concepts of ruminant animal production in Nigeria. We began by defining ruminant animals, examining their classification by size and production purpose, and highlighting their economic importance in supporting livelihoods, nutrition, and national agricultural output. We then explored the general characteristics that distinguish ruminants from other livestock, including their multi-chambered stomach, cloven hooves, and rumination behaviour.

We proceeded to examine conformation, explaining what it means, why it matters, and how it is assessed through judging and scoring. The major body regions and their functional significance in both beef and dairy production were identified. The Series then covered the common breeds of sheep, goats, beef cattle, and dairy cattle in Nigeria, describing their distinguishing features and the criteria used in selecting appropriate breeds for different production environments and market

goals. By completing this Series, you are now equipped with the knowledge to identify ruminant species, assess conformation, and make informed breed selection decisions.

Glossary of Terms

- **Abomasum:** The fourth and true digestive stomach compartment of ruminants, equivalent to the stomach of non-ruminants.
- **Balami:** A large, white-coated sheep breed found in northern Nigeria, valued for meat production.
- **Cloven hoof:** A divided or split hoof characteristic of ruminant animals, providing traction on varied terrain.
- **Conformation:** The overall shape, structure, and proportions of an animal's body, used to assess productive potential and soundness.
- **Crossbreeding:** The mating of animals from two different breeds to combine desirable traits, such as local hardiness with exotic productivity.
- **Dual-purpose breed:** A livestock breed selected for satisfactory performance in both meat and milk production.
- **Friesian (Holstein):** A high-yielding dairy cattle breed of European origin, introduced into Nigeria for milk production.
- **Red Sokoto (Maradi) goat:** A reddish-coated goat breed from northwestern Nigeria, prized for high-quality leather and meat.
- **Rumen:** The first and largest stomach compartment of ruminants, where microbial fermentation of fibrous feed occurs.
- **Rumination:** The process by which ruminants regurgitate partially digested food, re-chew it, and re-swallow it to aid digestion.
- **Trypanotolerance:** The natural ability of certain livestock breeds to survive and remain productive in areas where tsetse-transmitted trypanosomiasis is endemic.
- **Uda:** A tall, bicoloured Sahelian sheep breed adapted to arid conditions in northern Nigeria.
- **West African Dwarf (WAD):** A group of small, prolific, and trypanotolerant sheep and goat breeds found in the humid zones of West Africa.

- **White Fulani (Bunaji):** The most widely distributed beef cattle breed in Nigeria, known for its drought tolerance and disease resistance.
- **Yankasa:** The most common sheep breed in northern Nigeria, characterised by its white coat and dark facial markings.

Concept Check Questions [Series 1]

Objective Questions

1. Define ruminant animals. (Linked to SLO 1.1)
2. Which of the following is NOT a stomach compartment of a ruminant? a) Rumen b) Reticulum c) Duodenum d) Omasum (Linked to SLO 1.1)
3. The most widely distributed sheep breed in Nigeria is: a) Uda b) Balami c) Yankasa d) Red Sokoto (Linked to SLO 1.7)
4. Conformation in ruminants refers to the animal's overall shape, structure, and _____. (Linked to SLO 1.4)
5. The _____ cattle breed is favoured for its high milk yield in Nigerian dairy programmes. (Linked to SLO 1.9)

Short Answer Questions

6. Explain the economic importance of ruminant animals in Nigeria. (Linked to SLO 1.2)
7. Describe two general characteristics of ruminant animals. (Linked to SLO 1.3)
8. What is the importance of conformation assessment in ruminant production? (Linked to SLO 1.4)
9. Identify two common goat breeds in Nigeria and state one feature of each. (Linked to SLO 1.7)
10. State two differences between beef and dairy cattle conformation. (Linked to SLO 1.10)

Long Answer Questions

11. Discuss the classification of ruminant animals and explain the economic importance of each class in Nigeria. (Linked to SLO 1.1, SLO 1.2)

12. Describe the conformation traits used to evaluate ruminant animals, and explain how these traits relate to production performance. (Linked to SLO 1.4, SLO 1.5, SLO 1.6)
13. Compare and contrast the common breeds of sheep, goats, and cattle in Nigeria, highlighting their characteristics and suitability for different production environments. (Linked to SLO 1.7, SLO 1.8, SLO 1.9, SLO 1.10)

Answers to Concept Check Questions [Series 1]

Objective Questions

1. Ruminant animals are herbivores with a multi-chambered stomach that digest fibrous plant material through rumination.
2. Correct answer: c) Duodenum.
3. Correct answer: c) Yankasa.
4. Proportions.
5. Friesian (Holstein).

Short Answer Questions

6. Ruminants provide meat, milk, hides, and skins for local and export markets. They also generate employment along the value chain and supply organic manure for crop production.
7. Ruminants have a multi-chambered stomach for digesting fibrous materials, and they exhibit rumination by regurgitating and re-chewing partially digested feed.
8. Conformation assessment helps producers predict productive potential, identify structurally sound animals, and make better selection and culling decisions to improve herd quality.
9. The Red Sokoto goat is reddish-coated and valued for high-quality leather. The WAD goat is small, prolific, and trypanotolerant, suited to humid southern zones.
10. Beef cattle are blocky and heavily muscled with wide hindquarters, while dairy cattle are angular and lean with a well-developed udder and prominent ribcage.

Long Answer Questions

11. Basic response: Ruminants are classified as large (cattle, buffalo) and small (sheep, goats), and by production purpose into meat, milk, fibre, and dual-purpose types. Each class contributes to Nigeria's food security and economy through provision of meat, milk, hides, and employment.
12. Value-added response: Large ruminants such as cattle dominate beef and dairy markets, while small ruminants are critical for smallholder livelihoods, cultural practices, and the export leather trade. The dual-purpose classification maximises returns in resource-limited settings where specialisation is not viable.
13. Basic response: Conformation assessment covers the head, neck, back, loin, hindquarters, legs, and udder. Well-conformed animals tend to be healthier, more productive, and structurally sound.
14. Value-added response: In beef cattle, wide hindquarters and a deep loin indicate good meat yield. In dairy cattle, a capacious, well-attached udder predicts higher milk output. Leg and foot structure affect longevity and mobility, which in turn influence lifetime productivity. Linear scoring systems allow objective, repeatable measurement of these traits.
15. Basic response: Nigeria's major sheep breeds are Yankasa, Uda, and Balami; goat breeds include Red Sokoto, WAD, and Sahel goat; beef cattle include White Fulani, Sokoto Gudali, and N'dama; dairy breeds include Friesian and Friesian crosses.
16. Value-added response: WAD breeds thrive in humid environments due to trypanotolerance, while Sahelian breeds suit arid zones. Beef breeds are muscular and extensive-management-friendly, whereas dairy breeds require intensive care and good nutrition. Crossbreeding bridges the gap between local adaptability and exotic productivity, making it the most practical approach for improving Nigerian ruminant herds.

Answers to Pilot Questions [Series 1]

Part 1.1: Overview of Ruminant Animals

1. Ruminant animals are herbivores with a multi-chambered stomach. The four compartments are the rumen, reticulum, omasum, and abomasum.
2. By size: large ruminants (cattle, buffalo) and small ruminants (sheep, goats). By production purpose: meat-type, milk-type, dual-purpose, and fibre-producing.
3. Ruminants provide meat and milk for food, hides and skins for leather, organic manure for crop production, employment along the value chain, and cultural value for ceremonies.

4. All ruminants have a cloven hoof and a dental pad on the upper jaw. They also exhibit rumination, re-chewing regurgitated feed to complete digestion.
5. Rumination is the process of regurgitating partially digested food, re-chewing it, and re-swallowing it. It increases the surface area of fibrous feed for microbial fermentation, improving nutrient extraction.

Part 1.2: Conformation of Ruminant Animals

1. Conformation is the overall shape, structure, and proportions of an animal's body. It is important because it allows producers to predict productive potential, identify sound animals, and make better selection decisions.
2. Four body regions evaluated are: head and neck, back and loin, hindquarters and rump, and legs and feet.
3. The ideal dairy cow udder should be well attached to the abdomen, evenly quartered, capacious, and have properly spaced teats that facilitate milking.
4. A linear scoring system is a method of objectively measuring specific conformation traits on a numerical scale, used in cattle to assess traits such as stature, chest width, and udder attachment.
5. Three common conformation faults are: sickle-hocked legs, weak pasterns, and uneven udder attachment.

Part 1.3: Breeds of Sheep and Goats

1. Yankasa: white coat with dark facial patches, most common in northern Nigeria. Uda: tall, bicoloured, adapted to arid Sahelian conditions. Balami: largest Nigerian sheep, white-coated, used for meat and ceremonies.
2. The Red Sokoto goat is a reddish-coated breed from northwestern Nigeria. It is commercially important because its skin produces high-quality leather used in making fine Moroccan-style leather goods.
3. WAD goats are small, prolific, and trypanotolerant, enabling them to survive in the humid southern zones where tsetse fly-transmitted trypanosomiasis limits the survival of larger breeds.

4. Four selection criteria are: adaptability to local climate, growth rate and body weight, disease resistance, and feed conversion efficiency.
5. Crossbreeding is practised to combine the hardiness and disease resistance of local breeds with the higher productivity of exotic breeds, producing animals that perform well in tropical conditions.

Part 1.4: Breeds of Beef and Dairy Cattle

1. White Fulani: large-framed, white-coated, drought-tolerant. Sokoto Gudali: heavy-shouldered, well-muscled, suited to beef. N'dama: taurine breed, trypanotolerant, confined to humid southwest.
2. The White Fulani is widely kept because it is well adapted to the Nigerian environment, tolerant of drought and heat, resistant to local diseases, and produces acceptable beef quality under extensive management.
3. The Friesian (Holstein) is a high-yielding dairy breed introduced for commercial milk production. The Jersey is valued for its high butterfat content, which suits dairy processing into butter and cheese.
4. Beef cattle are blocky and heavily muscled, especially in the hindquarters and loin, while dairy cattle are angular, lean, and wedge-shaped with a large, well-attached udder.
5. A producer should consider market demand for beef or milk, available feed and water resources, climate and disease environment, management capacity, and financial input requirements.

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Figures, Plates, Tables, and Boxes

- Figure 1.1: The four stomach compartments of a ruminant animal Attribution: AI generated. Suggested OER search string: "ruminant stomach compartments diagram rumen reticulum omasum abomasum OER".
- Table 1.1: Key characteristics of ruminant animals and their production significance Attribution: AI generated. Suggested OER search string: "ruminant animal characteristics table cloven hoof dental pad rumination OER".
- Figure 1.2: Body parts of a ruminant animal used in conformation assessment Attribution: AI generated. Suggested OER search string: "ruminant cow body parts conformation assessment diagram labelled OER".
- Box 1.1: Common conformation faults in ruminants and their production implications Attribution: AI generated. Suggested OER search string: "ruminant conformation faults sickle hock weak pasterns udder defects OER box".
- Plate 1.1: Common sheep breeds in Nigeria: Yankasa, Uda, and Balami Attribution: AI generated. Suggested OER search string: "Nigerian sheep breeds Yankasa Uda Balami photos OER".
- Table 1.2: Comparison of common sheep and goat breeds in Nigeria Attribution: AI generated. Suggested OER search string: "Nigerian sheep goat breeds comparison table Yankasa Uda WAD Red Sokoto OER".
- Plate 1.2: White Fulani (Bunaji) cattle: the dominant beef breed in Nigeria Attribution: AI generated. Suggested OER search string: "White Fulani Bunaji cattle Nigeria beef breed OER image".

- Box 1.2: Key differences between beef and dairy cattle breeds Attribution: AI generated. Suggested OER search string: "beef dairy cattle breed differences body conformation udder management OER box".

Course code: AGE 302

Course title: Ruminant Animal Production

Course credit load: 2 Units

Series 2: Establishment and Management of Ruminant Herds

- **Part 2.1: Planning and Establishing a Ruminant Herd**
  - Sub Part 2.1.1: Factors to consider before establishing a herd
  - Sub Part 2.1.2: Classes of ruminant herds
  - Sub Part 2.1.3: Procurement and introduction of foundation stock
- **Part 2.2: Sheep and Goat Herd Management**
  - Sub Part 2.2.1: Flock structure and record keeping
  - Sub Part 2.2.2: Routine management practices for sheep and goats
  - Sub Part 2.2.3: Reproductive management of sheep and goats
- **Part 2.3: Beef Cattle Herd Management**
  - Sub Part 2.3.1: Herd structure and stocking rate
  - Sub Part 2.3.2: Routine management practices for beef cattle
  - Sub Part 2.3.3: Calf management and weaning
- **Part 2.4: Dairy Cattle Herd Management**
  - Sub Part 2.4.1: Dairy herd structure and production records
  - Sub Part 2.4.2: Dry cow management and transition period

- Sub Part 2.4.3: Lactating cow management and milk let-down

Introduction

Establishing and managing a ruminant herd requires careful planning, sound knowledge of species-specific requirements, and consistent application of management practices. Whether the enterprise involves sheep, goats, beef cattle, or dairy cattle, the principles of herd establishment and day-to-day management determine the productivity, health, and profitability of the operation. A poorly planned herd can result in high mortality, low output, and financial loss.

This Series guides you through the key decisions and practices involved in setting up and running ruminant herds in Nigeria. We begin with the planning process and factors that influence herd establishment, then examine management practices specific to sheep and goat flocks, followed by beef cattle herds, and conclude with the specialised demands of dairy cattle management. The knowledge in this Series builds directly on the breeds and conformation covered in Series 1.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- SLO 2.1 identify the key factors to consider before establishing a ruminant herd (Linked to Part 2.1),
- SLO 2.2 distinguish between the different classes of ruminant herds (Linked to Part 2.1),
- SLO 2.3 describe the process of procuring and introducing foundation stock (Linked to Part 2.1),
- SLO 2.4 explain flock structure and the importance of record keeping in sheep and goat management (Linked to Part 2.2),

- SLO 2.5 describe routine management practices for sheep and goats (Linked to Part 2.2),
- SLO 2.6 explain reproductive management practices for sheep and goat flocks (Linked to Part 2.2),
- SLO 2.7 describe the structure and stocking rate of a beef cattle herd (Linked to Part 2.3),
- SLO 2.8 outline routine management practices for beef cattle (Linked to Part 2.3),
- SLO 2.9 describe calf management and weaning practices in beef herds (Linked to Part 2.3),
- SLO 2.10 explain dairy herd structure and the importance of production records (Linked to Part 2.4),
- SLO 2.11 describe dry cow and transition cow management (Linked to Part 2.4), and
- SLO 2.12 explain the management of lactating cows and milk let-down (Linked to Part 2.4).

2.1 Planning and Establishing a Ruminant Herd

2.1.1 Factors to consider before establishing a herd

Before starting a ruminant enterprise, a producer must evaluate several critical factors to ensure viability and sustainability. Land availability and quality determine the carrying capacity of the farm: the area must be sufficient to provide pasture, exercise space, and housing for the intended herd size. Water supply is equally important, as ruminants require clean, reliable water daily. Access to feed inputs, veterinary services, and markets for livestock products must also be assessed.

Financial resources determine the scale of the operation and the breeds that can be kept. Exotic or high-producing breeds require greater investment in feed, housing, and health management than indigenous breeds. The producer's management skill and labour availability are also key

considerations. A clear business plan that projects income from product sales against costs of establishment and operation is essential before committing resources to any ruminant enterprise.

Fill in the blank: The number of animals a given area of land can support is referred to as its _____ capacity.

Factor	Explanation
Land	Adequate grazing land is essential for feed availability and herd expansion.
Water	Reliable water sources are needed for drinking, cleaning, and overall animal health.
Feed	Availability of pasture, crop residues, and supplementary feed ensures proper nutrition.
Finance	Sufficient capital is required for purchasing stock, housing, feed, and veterinary services.
Markets	Access to markets guarantees income from meat, milk, hides, and other products.
Veterinary Access	Regular veterinary care prevents disease outbreaks and improves productivity.
Management Skill	Skilled herd management ensures efficient breeding, feeding, and health monitoring.

Table 2.1: Key factors to consider before establishing a ruminant herd

2.1.2 Classes of ruminant herds

Ruminant herds are classified by their primary purpose. A **breeding herd** is maintained to produce offspring for sale or replacement, with selection focused on reproductive performance and genetic quality. A **production herd** is managed for commercial output, such as beef, milk, or fibre, with emphasis on growth rate, milk yield, or fleece quality. A **nucleus herd** is kept specifically for breed improvement, supplying superior sires and dams to commercial producers.

In Nigeria, most smallholder farmers maintain mixed-purpose herds that serve both subsistence and sale.

Research and demonstration herds are maintained by government agencies and universities to generate and disseminate production technologies. Understanding the class of herd being operated helps the producer set appropriate goals, select suitable breeds, and adopt the right management system. Each class has distinct recording, feeding, and health management requirements that must be clearly understood before the enterprise is started.

Fill in the blank: A herd kept specifically for breed improvement and supplying superior genetics is called a _____ herd.

2.1.3 Procurement and introduction of foundation stock

Foundation stock are the initial animals used to start a herd. They should be sourced from reputable farms, breed societies, or government multiplication centres where health records and performance data are available. Before purchase, animals should be inspected for good conformation, freedom from visible disease, and adequate body condition score. Selecting animals of known parentage and production history reduces the risk of introducing genetic or health problems into the new herd.

Newly purchased animals must be quarantined for a minimum of two to four weeks before mixing with resident stock. During quarantine, they should be examined by a veterinarian, treated for internal and external parasites, vaccinated against common diseases, and allowed to adjust to the new feed and environment gradually. Proper introduction procedures reduce stress-related losses and prevent the spread of diseases from incoming animals to the established herd.

Fill in the blank: Newly purchased animals should be _____ for at least two to four weeks before mixing with existing stock.

Pilot questions 2.1

1. State four factors a farmer must consider before establishing a ruminant herd.

2. Distinguish between a breeding herd and a production herd.
3. What is a nucleus herd and what is its purpose?
4. Describe the process of selecting foundation stock for a new herd.
5. Why is quarantine important when introducing new animals into an existing herd?

2.2 Sheep and Goat Herd Management

2.2.1 Flock structure and record keeping

A well-structured sheep or goat flock consists of clearly defined animal classes: **breeding does or ewes**, **replacement females**, **bucks or rams**, **growing stock**, and **culls**. The ratio of males to females is typically one buck or ram per 20 to 30 females under natural mating. Maintaining a clear flock structure allows the producer to monitor productivity, plan culling and replacement, and manage feed allocation efficiently.

Record keeping is indispensable in any commercial flock. Essential records include individual identification numbers, birth dates, parentage, litter size, body weights at key stages, health treatments, and reproductive history. Good records allow the producer to identify high-performing animals for retention and low performers for culling, detect disease trends early, and meet the documentation requirements of breed societies or certification programmes. Simple paper records or mobile applications can be used effectively on small farms.

Fill in the blank: The typical male-to-female ratio under natural mating in sheep and goats is one male per _____ females.

Record	Explanation
Individual ID	Unique identification (ear tag, tattoo, or microchip) for tracking each animal.

Birth Date	Records age for growth monitoring, breeding decisions, and culling schedules.
Parentage	Documents sire and dam to aid genetic improvement and avoid inbreeding.
Litter Size	Notes number of kids/lambs born per birth, useful for fertility and productivity analysis.
Body Weights	Regular weight records to monitor growth rate and feed efficiency.
Reproductive Events	Includes mating dates, pregnancy checks, and kidding/lambing records for herd planning.
Health Treatments	Vaccinations, deworming, and disease treatments to track herd health history.
Mortality	Records deaths, causes, and ages to identify health or management issues.

Box 2.1: Essential flock records for sheep and goat management

2.2.2 Routine management practices for sheep and goats

Routine management of sheep and goats includes a range of practices carried out on a daily, monthly, or seasonal basis. Animals must be fed and watered daily, with the quantity and quality of feed adjusted for physiological state: pregnant and lactating females, growing stock, and mature males all have different nutritional requirements. Pastures should be rotated to prevent overgrazing and reduce internal parasite burdens. Supplementary feeding is necessary during dry seasons when pasture quality declines.

Other routine practices include hoof trimming every three to four months to prevent lameness, body condition scoring to monitor nutritional status, deworming based on faecal egg counts rather than calendar schedules, dipping or spraying to control external parasites, and vaccination against clostridial diseases, peste des petits ruminants (PPR), and other locally important

diseases. Regular health checks and prompt treatment of sick animals reduce mortality and maintain flock productivity.

Fill in the blank: The disease controlled by vaccinating sheep and goats with PPR vaccine is called _____.

Figure 2.1: Annual routine management calendar for a sheep and goat flock

2.2.3 Reproductive management of sheep and goats

Effective reproductive management is central to flock productivity. Most Nigerian sheep and goat breeds are non-seasonal breeders, meaning they can cycle and conceive throughout the year, which enables up to three lambings or kiddingsevery two years. The gestation period is approximately 147 to 155 days for sheep and 145 to 152 days for goats. Bucks and rams should be evaluated for breeding soundness before the mating season, including assessment of libido, semen quality, and physical condition.

Flushing, the practice of increasing feed allowance two to three weeks before and during mating, improves ovulation rate and litter size in both sheep and goats. Pregnancy diagnosis through

observation of return to oestrus or by ultrasound enables the producer to plan housing, feeding, and supervision at parturition. Colostrum intake within the first six hours of birth is critical for kid and lamb survival. Proper drying, navel disinfection, and early suckling of newborns reduce neonatal mortality significantly.

Fill in the blank: The practice of increasing feed allowance before mating to improve ovulation rate is called _____.

Pilot questions 2.2

1. Describe the ideal structure of a commercial sheep or goat flock.
2. State five types of records that should be kept in a sheep or goat enterprise.
3. List four routine management practices carried out in a sheep or goat flock.
4. What is flushing and why is it practised in sheep and goat management?
5. Describe three steps to take at parturition to reduce neonatal mortality in lambs and kids.

2.3 Beef Cattle Herd Management

2.3.1 Herd structure and stocking rate

A beef cattle herd is organised into **breeding cows**, **replacement heifers**, **bulls**, **growing steers**, and **cull animals**. Under natural service, one bull is typically maintained per 20 to 25 cows, depending on the bull's age and condition. **Stocking rate** refers to the number of animal units per hectare of pasture and must be calibrated to the carrying capacity of the land to prevent overgrazing and pasture degradation.

In Nigeria's predominantly extensive system, White Fulani and Gudali herds are managed by Fulani pastoralists who adjust stocking density through seasonal migration. Ranching systems require more deliberate stocking rate management, with periodic assessment of pasture biomass and condition. Overstocking leads to soil compaction, erosion, and reduced forage availability,

ultimately reducing animal productivity. Rotational grazing, where pastures are divided into paddocks grazed in sequence, helps maintain adequate forage cover throughout the year.

Fill in the blank: The number of animal units that can be supported per hectare of pasture is called the _____ rate.

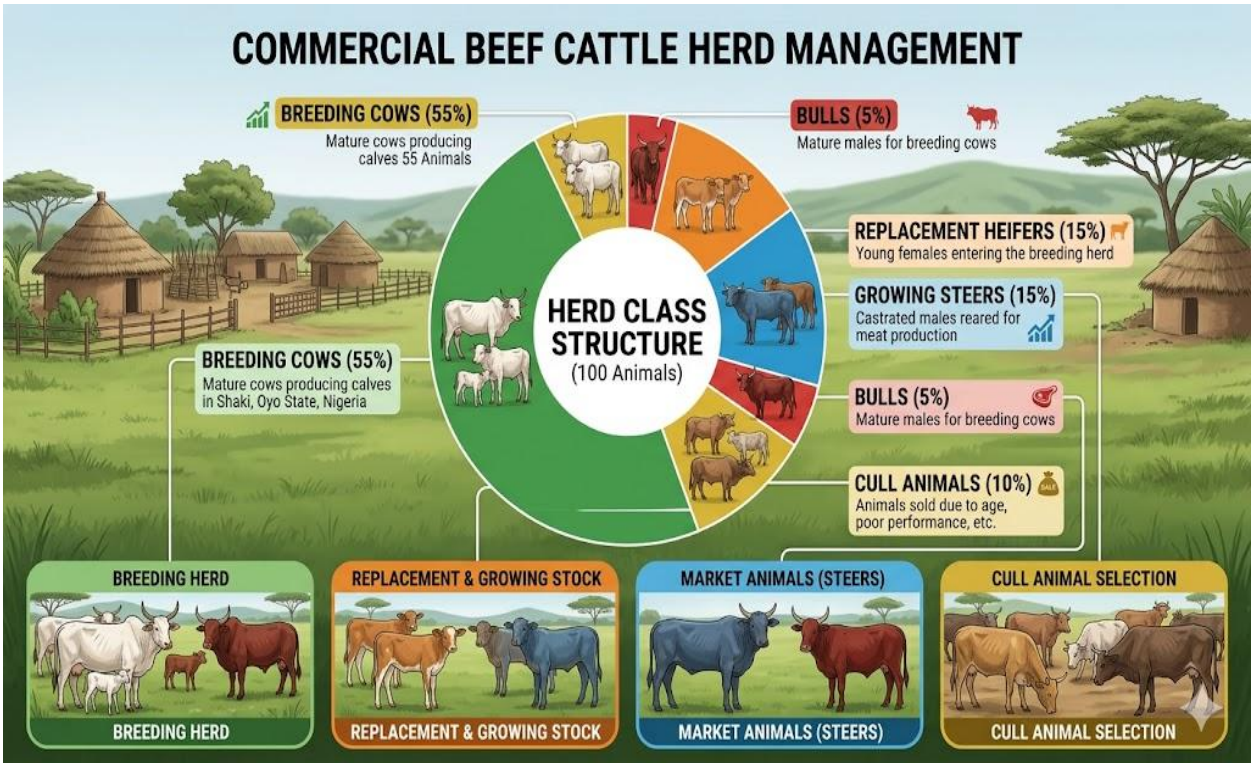

Figure 2.2: Structure of a commercial beef cattle herd

2.3.2 Routine management practices for beef cattle

Daily management of beef cattle includes providing adequate pasture or fodder, clean water, and mineral supplements, particularly during the dry season when pasture quality is poor. Animals should be observed daily for signs of illness, injury, or nutritional deficiency. Regular body condition scoring guides feeding decisions and identifies animals that need additional supplementation. Deworming, tick control, and vaccination against haemorrhagic septicaemia, blackleg, and foot-and-mouth disease are essential components of the health programme.

Castration of male calves not intended for breeding improves temperament, reduces fighting injuries, and enhances meat quality by reducing toughness associated with intact male hormones.

Dehorning, where practised, reduces injury to herd mates and handlers. Branding or ear tagging provides individual identification. Weighing at weaning, yearling age, and before sale monitors growth performance and allows comparison of individuals and groups, informing culling and selection decisions.

Fill in the blank: Castrating male calves not intended for breeding improves temperament and enhances _____ quality.

2.3.3 Calf management and weaning

Calf management begins at birth. The calf should receive colostrum within the first two to six hours to acquire passive immunity from the mother. The navel cord should be disinfected with iodine solution to prevent navel ill. Calves should be identified by ear tag or brand within the first week of life. Body weight at birth and at monthly intervals thereafter should be recorded to monitor growth rate and detect health problems early.

Weaning in beef cattle typically occurs at five to seven months of age, when the calf can efficiently consume solid feed. Abrupt weaning causes stress in both cow and calf, so a two-fence method, where cow and calf can see and smell each other but cannot suckle, is sometimes used to ease the transition. Post-weaning nutrition must be adequate to maintain growth momentum. Weaned calves should be vaccinated, dewormed, and introduced gradually to the grazing management system of the main herd.

Fill in the blank: The two-fence weaning method allows cow and calf to remain in close proximity while preventing _____.

Step	Action	Purpose
Colostrum feeding	Ensure calf receives colostrum within first 6 hours	Provides antibodies for immunity and early nutrition
Navel disinfection	Dip navel cord in iodine solution	Prevents infection and promotes healing
Identification	Tag, tattoo, or brand calf	Enables record keeping and herd management

Weight recording	Measure birth weight	Tracks growth and feed efficiency
Vaccination	Administer recommended vaccines	Protects against common calf diseases
Deworming	Give anti-parasitic treatment	Controls internal parasites for healthy growth
Weaning	Gradually separate calf from dam at 6–8 months	Prepares calf for independent feeding and herd integration

Box 2.2: Step-by-step calf management from birth to weaning in beef cattle

Pilot questions 2.3

1. Describe the class structure of a commercial beef cattle herd.
2. What is stocking rate and why must it be carefully managed?
3. List four routine management practices for beef cattle.
4. Explain the importance of colostrum for newborn calves.
5. Describe the two-fence weaning method and explain its advantage over abrupt weaning.

2.4 Dairy Cattle Herd Management

2.4.1 Dairy herd structure and production records

A dairy herd comprises **lactating cows**, **dry cows**, **heifers in calf**, **growing heifers**, and **bulls or AI semen**. The goal of dairy herd management is to achieve a high proportion of lactating cows at any given time, which requires tight reproductive management and low culling rates. The ideal

calving interval is 12 to 13 months, meaning cows should conceive within three months of calving.

Production records are the backbone of dairy management. Every cow must have a milk recording sheet showing daily, weekly, and lactation yields. Additional records include calving dates, dry-off dates, reproductive events, body condition scores, feed intake, and health treatments. These records allow the manager to calculate cost of production per litre of milk, identify high-producing cows for retention, and flag cows with declining performance for culling or investigation.

Fill in the blank: The ideal calving interval in a dairy herd is _____ months.

Record Type	Information Captured	Recording Frequency
Milk Yield	Daily milk volume per cow	Recorded **daily**
Calving	Date of calving, calf ID, dam ID	Recorded **at each calving event**
Dry-off	Date cow is dried off before next calving	Recorded **per lactation cycle**
Body Condition Score (BCS)	Assessment of cow's fat reserves	Recorded **monthly**
Reproduction	Heat detection, insemination dates, pregnancy checks	Recorded **at each reproductive event**
Feeding	Type and quantity of feed provided	Recorded **daily/weekly**
Health Treatments	Vaccinations, deworming, disease treatments	Recorded **at each treatment**

Table 2.2: Essential production and management records for a dairy herd

2.4.2 Dry cow management and transition period

Drying off is the process of stopping milk production approximately six to eight weeks before the expected calving date, allowing the udder to rest and regenerate milk secretory cells. Cows should be dried off abruptly or by gradual milking reduction depending on yield level. At dry-off, a long-acting intramammary antibiotic dry cow tube should be infused into each teat canal to prevent or treat subclinical mastitis and protect the udder during the non-lactating period.

The transition period covers the three weeks before and three weeks after calving. During this time, the cow undergoes major metabolic changes and is highly susceptible to metabolic diseases such as milk fever (hypocalcaemia), ketosis, and displaced abomasum. Nutritional management during the transition is critical: a negative energy balance must be minimised by providing high-quality feed and ensuring adequate intakes. Close monitoring of appetite, body condition, and milk production in early lactation helps detect and treat transition diseases promptly.

Fill in the blank: The non-lactating period before the next calving, lasting six to eight weeks, is called the _____ period.

2.4.3 Lactating cow management and milk let-down

Lactating cows have the highest nutritional demands of any physiological group in the dairy herd. Feed must supply sufficient energy, protein, minerals, and vitamins to support both milk production and body maintenance. In high-yielding cows, the peak of lactation (five to eight weeks after calving) coincides with the greatest risk of negative energy balance, during which the cow draws on body reserves. Gradual increase of concentrate feed after calving, known as steaming up, helps meet peak demand.

Milk let-down is the release of milk from the alveoli of the udder in response to the hormone oxytocin. It is triggered by the tactile stimulation of teat cleaning, udder washing, or the presence of the calf. A consistent pre-milking routine of two to three minutes' duration stimulates oxytocin release and maximises milk recovery. Stress, pain, or disruption of routine inhibits oxytocin release and reduces milk yield. Gentle, quiet handling and a regular milking schedule are therefore essential management tools in a dairy operation.

Fill in the blank: The hormone responsible for milk let-down in the dairy cow is _____.

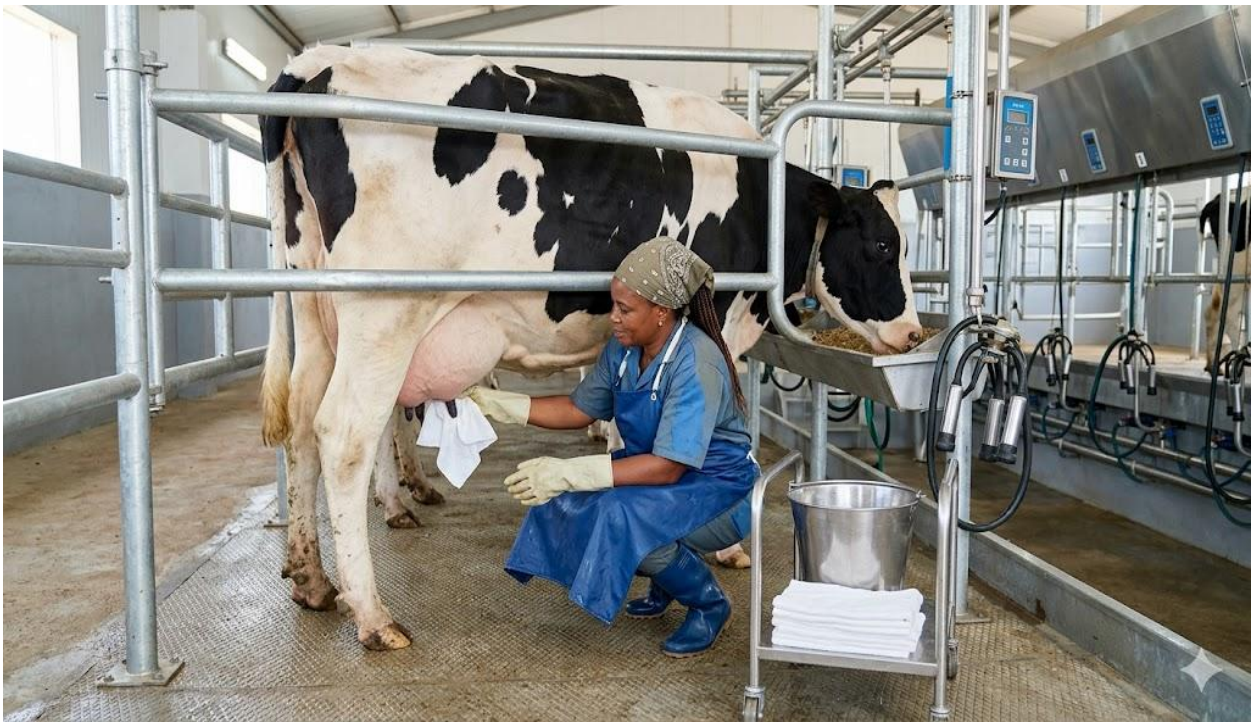

Plate 2.1: Pre-milking udder preparation to stimulate milk let-down

Pilot questions 2.4

1. Describe the class structure of a dairy herd and state the ideal calving interval.
2. List five types of production records maintained in a dairy enterprise.
3. Explain the purpose of drying off and describe how it is done.
4. What is the transition period and why is it critical in dairy cow management?
5. Explain the process of milk let-down and describe the management practices that support it.

Series Summary

This Series has provided a comprehensive overview of how ruminant herds are established and managed in Nigeria. We began with the planning phase, examining the land, water, financial, and management factors that must be in place before a herd is started, and described the classes of herds and the correct procedure for procuring and introducing foundation stock. We then explored sheep and goat flock management, covering flock structure, record keeping, routine practices, and reproductive management including flushing and neonatal care.

Moving to beef cattle, we examined herd structure, stocking rate, routine health and husbandry practices, and the detailed process of calf management from birth through weaning. The Series concluded with dairy cattle management, covering herd structure, production records, dry cow and transition management, and the physiology and practice of milk let-down. Together, these topics equip you with the practical management knowledge needed to run a productive and sustainable ruminant enterprise.

Glossary of Terms

- **Body condition score:** A numerical assessment of the fat cover and muscle mass of a ruminant animal, used to monitor nutritional status and guide feeding decisions.
- **Breeding herd:** A herd maintained primarily to produce offspring for sale or replacement, with selection focused on reproductive performance and genetic quality.
- **Calving interval:** The period in days or months between successive calvings of a cow, used as a measure of reproductive efficiency.
- **Carrying capacity:** The maximum number of animals that a unit of land can support on a sustained basis without degrading the pasture resource.
- **Colostrum:** The first milk produced by a dam after parturition, rich in antibodies, vitamins, and nutrients that provide passive immunity to the newborn.

- **Dry cow:** A cow that has been deliberately taken off milking to allow the udder to rest and regenerate before the next lactation.
- **Flushing:** The practice of increasing the energy intake of ewes or does two to three weeks before mating to improve ovulation rate and litter size.
- **Foundation stock:** The initial group of animals used to establish a new herd, selected for health, performance, and genetic quality.
- **Milk let-down:** The release of milk from the alveoli of the udder in response to the hormone oxytocin, triggered by pre-milking stimulation.
- **Nucleus herd:** A herd maintained specifically for breed improvement, supplying genetically superior sires and dams to commercial producers.
- **Oxytocin:** A hormone released from the pituitary gland in response to teat stimulation, causing contraction of myoepithelial cells and milk let-down.
- **Quarantine:** The temporary isolation of newly acquired animals to prevent introduction of disease into an existing herd.
- **Stocking rate:** The number of animal units maintained per unit area of pasture, used to assess the balance between animal numbers and forage availability.
- **Transition period:** The three weeks before and three weeks after calving, during which a dairy cow undergoes major metabolic changes and is at highest risk of metabolic disease.
- **Weaning:** The process of separating young animals from their mothers and transitioning them entirely to solid feed.

Concept Check Questions [Series 2]

Objective Questions

1. Define carrying capacity. (Linked to SLO 2.1)

2. Which of the following is NOT a class of ruminant herd? a) Breeding herd b) Nucleus herd c) Quarantine herd d) Production herd (Linked to SLO 2.2)
3. The ideal calving interval for a dairy cow is: a) 6 months b) 9 months c) 12 to 13 months d) 18 months (Linked to SLO 2.10)
4. The hormone responsible for milk let-down in dairy cattle is _____. (Linked to SLO 2.12)
5. The practice of increasing feed allowance before mating to improve ovulation rate is called _____. (Linked to SLO 2.6)

Short Answer Questions

6. Identify four factors a farmer must consider before establishing a ruminant herd. (Linked to SLO 2.1)
7. Explain why record keeping is important in sheep and goat flock management. (Linked to SLO 2.4)
8. Describe the importance of colostrum for newborn calves and kids. (Linked to SLO 2.9)
9. What is the transition period and why is careful management during this period important? (Linked to SLO 2.11)
10. Explain how stocking rate affects beef cattle productivity and pasture condition. (Linked to SLO 2.7)

Long Answer Questions

11. Discuss the planning and procurement process involved in establishing a ruminant herd, emphasising the factors that determine success. (Linked to SLO 2.1, SLO 2.2, SLO 2.3)
12. Compare the management of sheep and goat flocks with that of beef cattle herds, highlighting similarities and key differences in routine practices. (Linked to SLO 2.5, SLO 2.8)

13. Describe the management of a dairy cow from dry-off through the transition period and into peak lactation, explaining the physiological basis for each management practice. (Linked to SLO 2.11, SLO 2.12)

Answers to Concept Check Questions [Series 2]

Objective Questions

1. Carrying capacity is the maximum number of animals a unit of land can support on a sustained basis without degrading the pasture resource.
2. Correct answer: c) Quarantine herd.
3. Correct answer: c) 12 to 13 months.
4. Oxytocin.
5. Flushing.

Short Answer Questions

6. Four factors to consider are: land availability and quality, reliable water supply, access to feed and markets, and adequate financial resources and management skill.
7. Record keeping enables the producer to identify high- and low-performing animals, plan culling and replacements, monitor disease trends, and meet documentation requirements of breed societies or certification programmes.
8. Colostrum provides the newborn with antibodies for passive immunity, as well as concentrated energy, protein, vitamins, and minerals needed in the first hours of life. Failure to receive colostrum within two to six hours greatly increases the risk of disease and death.

9. The transition period is the three weeks before and after calving. During this time the cow is highly susceptible to metabolic diseases such as milk fever and ketosis. Nutritional management, close monitoring, and prompt treatment during this period are essential to prevent production losses.

10. Overstocking degrades pasture through overgrazing, soil compaction, and erosion, reducing forage availability and animal growth rates. Maintaining the correct stocking rate preserves pasture quality and supports consistent animal productivity.

Long Answer Questions

11. Basic response: Before establishing a herd, a producer must assess land, water, feed, finances, markets, and management capacity. Foundation stock should be sourced from reputable farms, inspected for health and conformation, and quarantined before mixing with existing animals.

12. Value-added response: The class of herd chosen (breeding, production, or nucleus) shapes all subsequent management decisions. A nucleus herd demands rigorous performance recording and genetic evaluation, while a commercial production herd focuses on output efficiency. A well-written business plan that anticipates costs and revenues reduces the risk of enterprise failure.

13. Basic response: Both sheep and goat flocks and beef herds require daily feeding and watering, routine health interventions (vaccination, deworming, parasite control), and individual identification. Record keeping and regular body condition scoring are practised in both systems.

14. Value-added response: Key differences lie in reproductive management and herd structure. Sheep and goats can have two or more parturitions per year and commonly produce twins, requiring close supervision at lambing or kidding. Beef cattle produce one calf per year under extensive management, with calf management from birth to weaning as the primary production focus. Dairy cattle require additional specialised management including milking routines, milk recording, and dry cow therapy.

15. Basic response: At dry-off (six to eight weeks before calving), milking is stopped and dry cow antibiotic tubes are infused to protect the udder. During the transition period, high-quality feed minimises negative energy balance. After calving, concentrate feed is gradually increased to meet peak milk demand.

16. Value-added response: The physiological basis for dry-off management is udder regeneration and mastitis prevention. During the transition, the cow's immune function is suppressed and calcium metabolism shifts abruptly, explaining the risk of milk fever. Milk let-down depends on oxytocin release, which is inhibited by stress: therefore, gentle handling, a consistent routine, and pre-milking udder preparation are not merely good practice but are physiologically necessary for maximising milk yield.

Answers to Pilot Questions [Series 2]

Part 2.1: Planning and Establishing a Ruminant Herd

1. Four factors are: availability of adequate land with good pasture, reliable clean water supply, access to feed inputs and veterinary services, and sufficient financial resources.
2. A breeding herd is maintained to produce offspring for sale or replacement, with focus on reproductive performance. A production herd is managed to generate commercial outputs such as beef or milk, with focus on growth rate or milk yield.
3. A nucleus herd is a small, genetically elite herd maintained specifically to improve breed quality. Its purpose is to supply superior sires and dams to commercial producers in a breed improvement programme.
4. Foundation stock should be sourced from reputable farms with available health and performance records. Animals should be inspected for good conformation, absence of disease, and adequate body condition before purchase.
5. Quarantine prevents newly purchased animals from transmitting diseases to the existing herd. During this period, animals are examined, treated for parasites, vaccinated, and acclimatised before being introduced to the main herd.

Part 2.2: Sheep and Goat Herd Management

1. A commercial flock should include breeding does or ewes, replacement females, bucks or rams (at one per 20 to 30 females), growing stock, and cull animals in clearly defined proportions.
2. Five essential records are: individual identification number, birth date and parentage, litter size, body weight at key stages, and health treatment history.
3. Four routine practices are: daily feeding and watering adjusted to physiological stage, regular hoof trimming, deworming based on faecal egg counts, and vaccination against PPR and clostridial diseases.

4. Flushing is the practice of increasing energy intake two to three weeks before and during mating. It is practised because it improves ovulation rate and increases litter size, boosting flock productivity.
5. Three steps to reduce neonatal mortality are: ensure the kid or lamb receives colostrum within two to six hours of birth, disinfect the navel cord with iodine solution, and ensure the newborn is dried and kept warm to prevent hypothermia.

Part 2.3: Beef Cattle Herd Management

1. A commercial beef herd includes breeding cows, replacement heifers, one bull per 20 to 25 cows, growing steers, and cull animals. The breeding cow group typically forms the largest proportion of the herd.
2. Stocking rate is the number of animal units supported per hectare of pasture. It must be carefully managed because overstocking causes overgrazing, pasture degradation, and reduced forage availability, leading to poor animal performance.
3. Four routine practices are: daily provision of feed, water, and mineral supplements; body condition scoring; vaccination against haemorrhagic septicaemia and blackleg; and deworming and tick control.
4. Colostrum is the first milk produced after calving. It is rich in antibodies that confer passive immunity on the calf, protecting it against infectious diseases in the first weeks of life before its own immune system matures.
5. In the two-fence weaning method, cow and calf are separated by two fences with a gap between them, allowing sensory contact without suckling. This reduces stress in both animals compared to complete separation, resulting in less weight loss and fewer injuries.

Part 2.4: Dairy Cattle Herd Management

1. A dairy herd comprises lactating cows, dry cows, heifers in calf, growing heifers, and bulls or AI semen. The ideal calving interval is 12 to 13 months, requiring cows to conceive within three months of calving.

2. Five production records are: daily and lactation milk yield, calving and dry-off dates, body condition score, reproductive events (service, pregnancy diagnosis), and health treatments.
3. Drying off stops milk production six to eight weeks before calving to allow the udder to rest and regenerate milk secretory cells. It is done by abrupt cessation of milking or gradual reduction of milking frequency, followed by infusion of dry cow antibiotic tubes.
4. The transition period is the three weeks before and after calving. It is critical because the cow undergoes major metabolic changes, is at highest risk of diseases such as milk fever and ketosis, and her nutritional management directly affects milk yield in the subsequent lactation.
5. Milk let-down is the release of milk from udder alveoli in response to oxytocin. Management practices that support it include a consistent pre-milking routine of two to three minutes, gentle udder washing, and calm, stress-free handling, all of which promote oxytocin release and maximise milk recovery.

References and Attributions [Series 2]

Textual References (Books and External Sources)

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Figures, Plates, Tables, and Boxes

- Table 2.1: Key factors to consider before establishing a ruminant herd Attribution: AI generated. Suggested OER search string: "ruminant herd establishment planning factors table land water finance OER".
- Box 2.1: Essential flock records for sheep and goat management Attribution: AI generated. Suggested OER search string: "sheep goat flock records management individual ID birth parentage body weight OER box".
- Figure 2.1: Annual routine management calendar for a sheep and goat flock Attribution: AI generated. Suggested OER search string: "sheep goat annual management calendar vaccination deworming hoof trimming OER diagram".
- Figure 2.2: Structure of a commercial beef cattle herd Attribution: AI generated. Suggested OER search string: "beef cattle herd structure classes breeding cows heifers bulls steers proportions OER diagram".
- Box 2.2: Step-by-step calf management from birth to weaning in beef cattle Attribution: AI generated. Suggested OER search string: "beef calf management birth weaning colostrum navel vaccination deworming OER box".
- Table 2.2: Essential production and management records for a dairy herd Attribution: AI generated. Suggested OER search string: "dairy herd production records milk yield calving dry-off body condition OER table".
- Plate 2.1: Pre-milking udder preparation to stimulate milk let-down Attribution: AI generated. Suggested OER search string: "dairy cow milking pre-milking udder washing milk let-down OER image".

Course code: AGE 302

Course title: Ruminant Animal Production

Series 3: Feeding Ingredients, Nutrition, and Breeding of Ruminants

- **Part 3.1: Feed Ingredients Used in Ruminant Nutrition**
  - Sub Part 3.1.1: Roughages and their nutritive value
  - Sub Part 3.1.2: Concentrate feeds and feed supplements
  - Sub Part 3.1.3: Non-conventional feed resources in Nigeria
- **Part 3.2: Nutritional Requirements and Feeding of Ruminants**
  - Sub Part 3.2.1: Nutrient requirements by class and physiological state
  - Sub Part 3.2.2: Formulating and balancing rations for ruminants
  - Sub Part 3.2.3: Common nutritional disorders in ruminants
- **Part 3.3: Reproduction in Ruminant Animals**
  - Sub Part 3.3.1: Reproductive anatomy and the oestrous cycle
  - Sub Part 3.3.2: Mating systems and pregnancy in ruminants
  - Sub Part 3.3.3: Parturition and post-partum management
- **Part 3.4: Reproductive Technologies in Ruminant Production**
  - Sub Part 3.4.1: Artificial insemination
  - Sub Part 3.4.2: Oestrus synchronisation and embryo transfer
  - Sub Part 3.4.3: Genetic improvement through reproductive technologies

Introduction

Feeding and reproduction are the two most critical biological processes governing the productivity and profitability of any ruminant enterprise. A well-fed animal grows faster, reproduces more efficiently, and resists disease more effectively than a poorly nourished one. Understanding what ruminants eat, how their digestive system processes various feed ingredients, and how to formulate balanced rations forms the nutritional foundation of sound herd management.

Equally important is an understanding of reproduction, from the basic anatomy of the reproductive tract and the oestrous cycle, through mating systems and pregnancy management, to the application of modern reproductive technologies such as artificial insemination and embryo transfer. This Series covers both areas in depth, equipping you with the knowledge to optimise nutrition and reproduction in sheep, goats, and cattle enterprises in Nigeria.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- SLO 3.1 classify the feed ingredients used in ruminant nutrition and describe their nutritive value (Linked to Part 3.1),
- SLO 3.2 identify concentrate feeds, supplements, and non-conventional feed resources available in Nigeria (Linked to Part 3.1),
- SLO 3.3 describe the nutrient requirements of ruminants by class and physiological state (Linked to Part 3.2),
- SLO 3.4 explain the principles of ration formulation and balancing for ruminants (Linked to Part 3.2),
- SLO 3.5 identify and describe common nutritional disorders in ruminants (Linked to Part 3.2),

- SLO 3.6 describe the reproductive anatomy and oestrous cycle of ruminant animals (Linked to Part 3.3),
- SLO 3.7 explain the mating systems used in ruminant production and describe pregnancy management (Linked to Part 3.3),
- SLO 3.8 describe parturition and post-partum management in ruminants (Linked to Part 3.3),
- SLO 3.9 explain the procedure and advantages of artificial insemination in ruminants (Linked to Part 3.4),
- SLO 3.10 describe oestrus synchronisation and embryo transfer techniques (Linked to Part 3.4), and
- SLO 3.11 evaluate the role of reproductive technologies in genetic improvement of ruminant herds (Linked to Part 3.4).

3.1 Feed Ingredients Used in Ruminant Nutrition

3.1.1 Roughages and their nutritive value

Roughages are bulky, fibrous feeds that form the basis of ruminant diets. They are characterised by high crude fibre content (above 18 percent dry matter) and relatively low energy density compared to concentrates. Roughages are divided into **dry roughages**, such as hay, straw, and crop residues, and **green roughages**, such as fresh pasture grasses, legume forages, and silage. In Nigeria, common roughage sources include guinea grass (**Panicum maximum**), elephant grass (**Pennisetum purpureum**), and legumes such as **Stylosanthes** and **Centrosema**.

The nutritive value of roughages varies widely with species, stage of growth, and preservation method. Young, leafy forages are higher in protein and digestibility than mature, stemmy ones. Legume forages generally contain more crude protein (12 to 20 percent dry matter) than grasses (6 to 12 percent). Hay retains much of the original nutritive value of the crop when made

correctly, while crop residues such as rice straw and groundnut haulms are low in protein but serve as dry-season maintenance feeds. Silage made from maize or sorghum preserves nutritive value better than sun-dried hay under humid conditions.

Fill in the blank: Roughages are characterised by crude fibre content above _____ percent dry matter.

Feed Name	Dry Matter %	Crude Protein %	Primary Use
Groundnut haulms	~85–89	~11.9	Protein-rich forage; improves milk yield and growth
Cowpea haulms	~85–89	~9–10	Legume-based forage; balances fiber and protein
Cowpea husks	~85–89	~7–8	By-product feed; moderate fiber, supplementary roughage
Sorghum grain husks	~85	~4.9	Low-protein filler roughage; maintains rumen function
Sorghum brewers' grain (dusa)	~89.5	~6–7	Energy-rich by-product; used to supplement diets
Natural grasses **(e.g., Andropogon gayanus)**	~58–75	~6.2	Grazed forage; bulk feed for maintenance
Browse plants **(e.g., Ficus spp.)**	~70–85	~18–23	Evergreen shrubs; high-protein supplement, especially in dry season

Table 3.1: Common roughage feed ingredients for ruminants in Nigeria

3.1.2 Concentrate feeds and feed supplements

Concentrate feeds are feeds with low fibre content (below 18 percent crude fibre) and high energy or protein density. They are divided into **energy concentrates**, such as maize, sorghum, millet, cassava, and wheat offal, and **protein concentrates**, such as groundnut cake, cottonseed

cake, soyabean meal, palm kernel cake, and blood meal. In ruminant feeding, concentrates are used to supplement roughage diets, particularly for animals with elevated nutritional demands such as lactating cows, growing stock, and animals being finished for slaughter.

Feed supplements include minerals, vitamins, and feed additives that are required in small quantities but are critical for health, reproduction, and production. Macro-minerals such as calcium, phosphorus, sodium, and magnesium must be provided in adequate amounts, especially for lactating animals and growing stock. Trace minerals including zinc, copper, selenium, and iodine are required in minute quantities but deficiency causes serious production and health problems. Salt licks and mineral blocks are practical ways of delivering mineral supplements to grazing ruminants.

Fill in the blank: Groundnut cake, soyabean meal, and cottonseed cake are examples of _____ concentrate feeds.

3.1.3 Non-conventional feed resources in Nigeria

Non-conventional feed resources are locally available materials not traditionally included in ruminant rations but which have nutritional value and can reduce feed costs. In Nigeria, these include agro-industrial by-products such as brewers' dried grains, cassava peels, cocoa pod husks, pineapple bran, and molasses. Brewers' dried grains are rich in bypass protein and fibre, making them suitable for ruminant supplementation. Molasses is a palatable energy source from sugar cane processing, often used as a binder in feed blocks and to encourage intake of low-quality roughages.

Browse plants such as Leucaena, Gliricidia, and Moringa are important non-conventional protein sources in the humid and sub-humid zones of Nigeria. Moringa leaves in particular have high crude protein (25 to 30 percent dry matter) and a good amino acid profile. However, anti-nutritional factors in some by-products, such as tannins in cocoa pod husk and cyanogenic glycosides in cassava peels, must be managed through processing, drying, or limiting inclusion rates to ensure safe use in ruminant rations.

Fill in the blank: Leucaena, Gliricidia, and Moringa are examples of _____ plants used as non-conventional protein sources for ruminants.

Feed Resource	Nutrient Value	Processing Notes
Brewers' dried grains	High in protein and fiber; moderate energy	Dry properly to prevent mold; feed as supplement to roughages
Cassava peels	Rich in carbohydrates (energy source)	Sun-dry or ferment to reduce cyanide content before feeding
Cocoa pod husks	Moderate fiber, low protein; contains minerals	Dry and grind; may require detoxification to reduce anti-nutritional factors
Molasses	High in sugars; excellent energy source	Mix with other feeds to improve palatability; avoid excessive use to prevent diarrhea
Moringa leaves	High protein, vitamins, and minerals	Harvest fresh or dry; chop finely for easy intake; can be mixed into concentrates

Box 3.1: Non-conventional feed resources for ruminants in Nigeria

Pilot questions 3.1

1. Define roughages and give three examples found in Nigeria.
2. Distinguish between energy concentrates and protein concentrates, giving two examples of each.
3. Why are legume forages preferred over grasses as protein sources in ruminant diets?
4. Name three non-conventional feed resources used in ruminant feeding in Nigeria.
5. What are anti-nutritional factors and how can their effects be managed in ruminant feeds?

3.2 Nutritional Requirements and Feeding of Ruminants

3.2.1 Nutrient requirements by class and physiological state

The nutrient requirements of ruminants vary significantly with species, body weight, age, sex, and physiological state. Maintenance requirements are the minimum nutrients needed to keep an animal alive and healthy without any productive output. Production requirements are additional nutrients needed above maintenance for growth, pregnancy, lactation, or work. Lactating animals have the highest nutrient demands of all physiological groups, requiring up to three times their maintenance needs at peak milk production.

Pregnant animals require additional energy and protein during the last trimester when foetal growth is most rapid. Growing animals need adequate protein and energy to deposit lean tissue and bone. Mature, non-pregnant, non-lactating animals require only maintenance-level feeding. In practice, producers adjust feeding levels and diet quality to match the physiological state of each animal group, avoiding both underfeeding, which reduces production, and overfeeding, which wastes resources and may cause metabolic disorders.

Fill in the blank: The nutrients required to keep an animal alive without any productive output are called _____ requirements.

3.2.2 Formulating and balancing rations for ruminants

A **ration** is the total amount of feed provided to an animal in 24 hours. A **balanced ration** supplies all required nutrients, including energy, protein, minerals, vitamins, and water, in the correct amounts and proportions for the animal's physiological state. Ration formulation begins with knowing the animal's nutrient requirements (from feeding standards such as NRC tables) and the nutrient composition of available feed ingredients (from feed composition tables). The simplest method of balancing a ration is the **Pearson square**, which is used to combine two feeds to meet a target crude protein level.

More complex rations involving multiple ingredients are balanced using simultaneous equations or computer-based linear programming software. Practical ration formulation for smallholder ruminant producers in Nigeria typically involves combining a roughage base (grass or crop residue) with a protein-energy supplement at a ratio guided by the animal's requirement and the

roughage quality. Feed cost per unit of nutrient should always be considered to ensure the ration is economically viable as well as nutritionally adequate.

Fill in the blank: The simple graphical method used to combine two feeds to meet a target protein level is called the Pearson _____.

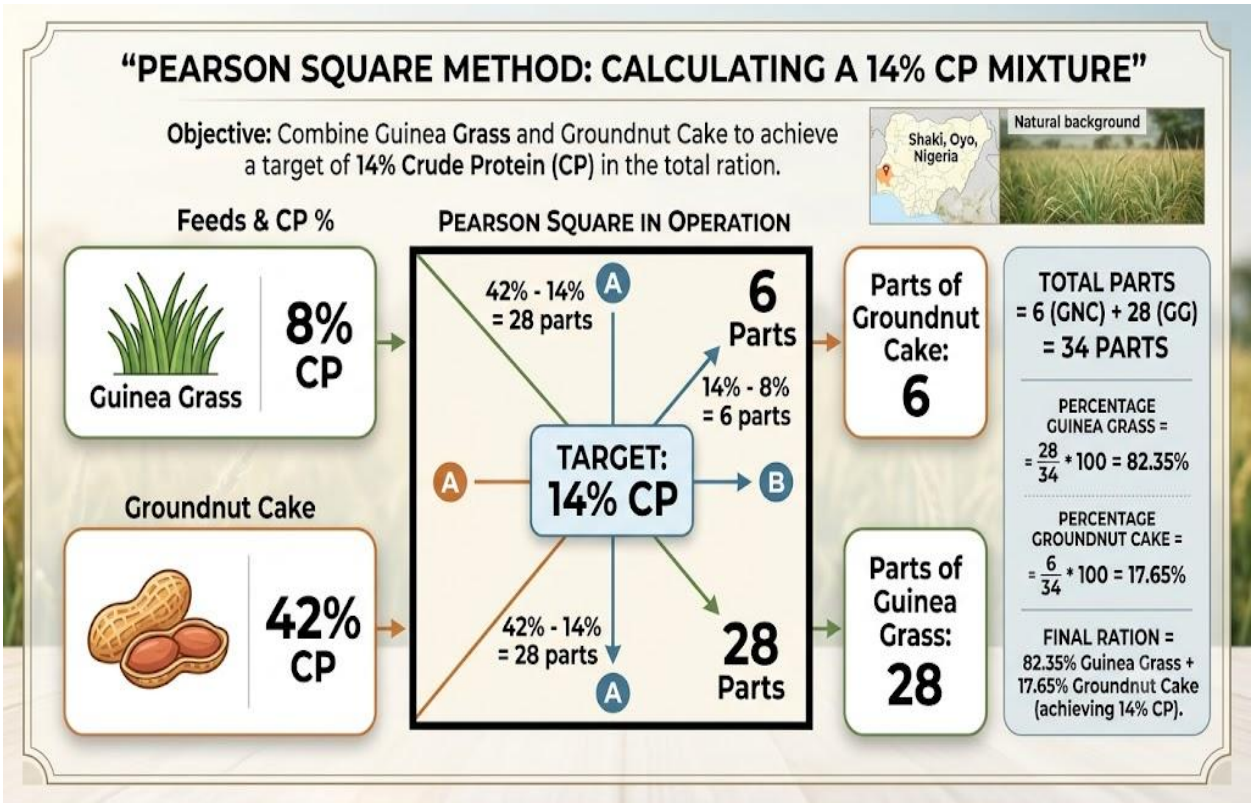

Figure 3.1: The Pearson square method for ruminant ration balancing

3.2.3 Common nutritional disorders in ruminants

Nutritional disorders arise when the diet fails to supply adequate quantities or correct proportions of nutrients. **Bloat** (ruminal tympany) occurs when gas accumulates in the rumen faster than it can be expelled, usually from excessive consumption of lush legume pastures or wet, finely ground concentrates. **Grass tetany** (hypomagnesaemia) results from magnesium deficiency, typically in cattle grazing young, rapidly growing grasses in spring, causing muscular tremors and convulsions. **Milk fever** (hypocalcaemia) affects high-producing dairy cows around calving

due to the sudden demand for calcium for colostrum and milk, causing weakness and recumbency.

Ketosis results from a negative energy balance in early lactation, when the cow mobilises excess body fat, producing ketone bodies that accumulate in the blood. Symptoms include reduced appetite, drop in milk yield, and a sweet acetone odour in the breath and milk. Urolithiasis (urinary stones) occurs mainly in male sheep and goats on high-phosphorus concentrate diets with inadequate water intake. Prevention of all these disorders relies on correct ration formulation, appropriate feeding management, and ensuring adequate mineral supplementation throughout the production cycle.

Fill in the blank: Ruminal tympany, commonly known as _____, results from excessive gas accumulation in the rumen.

Disorder	Nutrient Involved	Species Affected	Main Cause	Clinical Signs	Prevention
Bloat	Excess gas (fermentation gases)	Cattle, sheep, goats	Rapid fermentation of lush legumes or grains	Distended left abdomen, discomfort, labored breathing	Avoid sudden diet changes, provide anti-bloat agents, graze mixed pastures
Grass Tetany	Magnesium deficiency	Cattle, sheep	Grazing lush pastures low in Mg, high in K	Muscle tremors, staggering, convulsions, sudden death	Supplement Mg (licks, concentrates), avoid high-risk pastures
Milk Fever	Calcium deficiency	Dairy cows (post-calving)	Sudden Ca demand for milk production	Weakness, inability to stand, cold ears, coma	Provide Ca supplements before/after calving, balanced diet

Ketosis	Energy imbalance (glucose deficiency)	Dairy cows (early lactation)	High milk yield with inadequate energy intake	Loss of appetite, weight loss, acetone smell in breath/milk	Increase energy density of diet, propylene glycol drench, good transition feeding
Urolithiasis	Mineral imbalance (phosphorus, calcium)	Rams, bucks, wethers	High-concentrate diets, low water intake	Straining to urinate, abdominal pain, bladder rupture	Balanced Ca:P ratio, adequate water, avoid excess concentrates

Table 3.2: Common nutritional disorders in ruminants

Pilot questions 3.2

1. Distinguish between maintenance requirements and production requirements in ruminant nutrition.
2. Describe the Pearson square method and explain when it is used.
3. What is a balanced ration and what are the key components it must supply?
4. Describe two nutritional disorders common in dairy cattle and state how each is prevented.
5. Explain why lactating animals have the highest nutritional requirements in a ruminant herd.

3.3 Reproduction in Ruminant Animals

3.3.1 Reproductive anatomy and the oestrous cycle

The female reproductive tract of ruminants consists of the ovaries, oviducts (fallopian tubes), uterine horns, uterus body, cervix, and vagina. The ovaries produce ova and the hormones oestrogen and progesterone. The uterus provides the environment for foetal development, while the cervix acts as a barrier to infection and plays a role in semen deposition during natural mating and AI. The male reproductive tract includes the testes, epididymis, vas deferens, accessory sex glands, and penis, with the testes producing both spermatozoa and testosterone.

The **oestrous cycle** is the recurring series of hormonal and physiological events that prepare the female reproductive tract for mating and, if mating occurs, for pregnancy. The cycle length is approximately 17 days in sheep and goats and 21 days in cattle. **Oestrus** (heat) is the period of sexual receptivity during which the female will accept the male, lasting 24 to 36 hours in cattle and 24 to 48 hours in sheep and goats. Ovulation occurs 10 to 12 hours after the end of oestrus in cattle and near the end of oestrus in sheep and goats.

Fill in the blank: The average oestrous cycle length in cattle is _____ days.

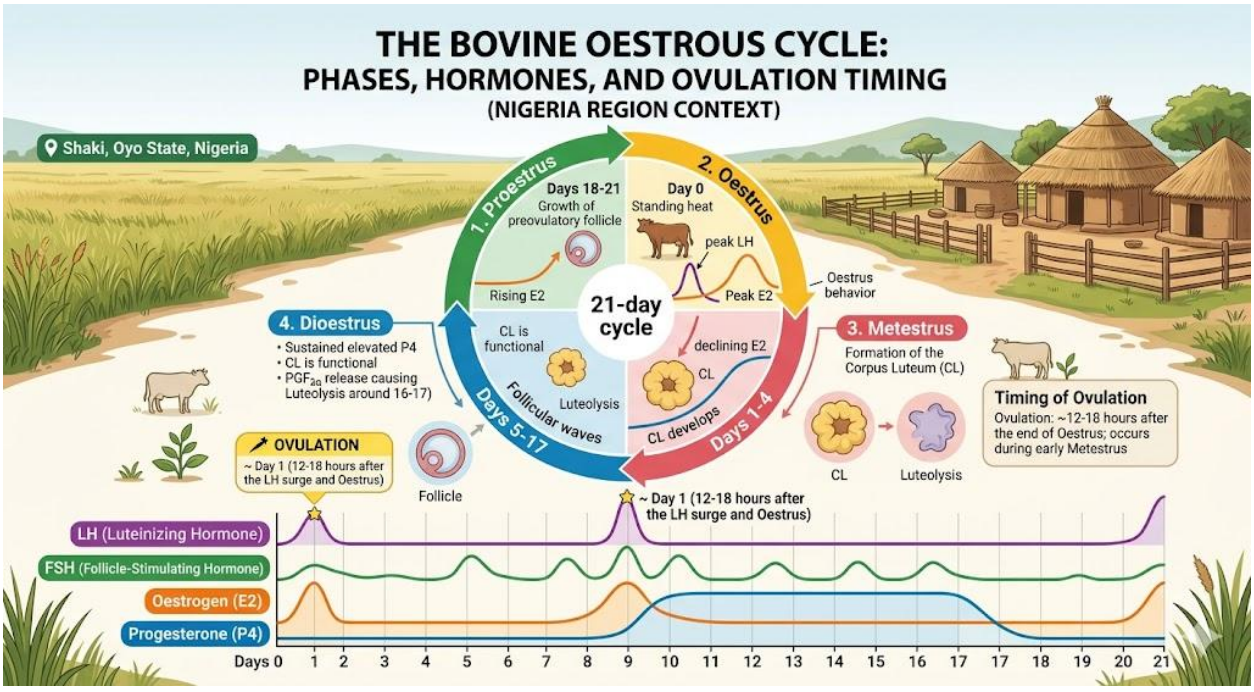

Figure 3.2: The oestrous cycle of the cow showing hormonal changes and ovulation timing

3.3.2 Mating systems and pregnancy in ruminants

Ruminants may be mated using **natural service**, where the male runs with the female group (pasture mating) or is introduced only when females are detected in oestrus (hand mating). Natural service is simple and requires no special equipment but offers limited control over paternity and risks transmission of venereal diseases. **Artificial insemination (AI)** allows one superior male to sire thousands of offspring annually, enables use of semen from distant or deceased sires, and reduces disease transmission. AI is covered in more detail in Part 3.4.

Pregnancy in ruminants is confirmed by observation of failure to return to oestrus, rectal palpation, or ultrasound examination. Gestation length averages 147 to 155 days in sheep, 145 to 152 days in goats, and 280 to 285 days in cattle. During pregnancy, nutritional management must be adjusted for foetal growth, particularly in the last trimester. Steaming up, the provision of additional concentrate feed in the last six weeks of pregnancy, prepares the dam for the energy demands of parturition and early lactation.

Fill in the blank: The average gestation length in cattle is _____ to 285 days.

3.3.3 Parturition and post-partum management

Parturition (giving birth) in ruminants progresses through three stages: the **preparatory stage**, during which the cervix dilates and the foetus is positioned for delivery; the **expulsion stage**, during which uterine contractions expel the foetus; and the **placental stage**, during which the placenta (afterbirth) is expelled, normally within two to six hours of delivery. Retained placenta (failure of the placenta to be expelled within 12 to 24 hours) is a common post-partum complication in cattle that requires veterinary attention.

Post-partum management focuses on ensuring the dam resumes normal reproductive cycling as quickly as possible. The interval from calving or kidding to first oestrus (post-partum anoestrus) is influenced by nutrition, suckling stimulus, and season. In beef cows, suckling by the calf suppresses LH secretion and delays the return to oestrus. Early weaning or controlled suckling can shorten this interval. Adequate post-partum nutrition, health monitoring, and timely treatment of uterine infections (metritis) are essential to restore reproductive performance in the next cycle.

Fill in the blank: Failure of the placenta to be expelled within 12 to 24 hours after parturition is called _____ placenta.

Pilot questions 3.3

1. Name the main organs of the female ruminant reproductive tract and state the function of each.
2. Describe the oestrous cycle of the cow, including cycle length, oestrus duration, and time of ovulation.
3. Compare natural service and artificial insemination as mating systems in ruminant production.
4. What is steaming up and why is it practised in the last trimester of pregnancy?
5. Describe the three stages of parturition in ruminants and name one post-partum complication.

3.4 Reproductive Technologies in Ruminant Production

3.4.1 Artificial insemination

Artificial insemination (AI) is the manual deposition of semen into the female reproductive tract using a pipette or AI gun rather than through natural mating. The procedure involves detecting oestrus accurately, thawing frozen semen straws from liquid nitrogen storage, loading the semen into an AI gun, and depositing the semen into the body of the uterus or the cervical canal by rectal-vaginal or speculum technique. In cattle, the recto-vaginal (Cassou) technique is standard: the operator's left hand enters the rectum to manipulate the cervix while the right hand guides the AI gun through the vagina and cervix.

The advantages of AI are numerous: it multiplies the use of genetically superior sires, reduces the cost and risk of maintaining bulls, eliminates the spread of venereal diseases through mating, allows use of imported or exotic genetics without transporting live animals, and facilitates

accurate recording of parentage. The main limitations are the need for accurate oestrus detection, trained personnel and specialised equipment, reliable cold chain for semen storage, and reduced conception rates compared to natural service if technique or timing is poor.

Fill in the blank: In the recto-vaginal AI technique in cattle, the operator's hand enters the _____ to manipulate the cervix.

Plate 3.1: Artificial insemination in cattle using the recto-vaginal technique

3.4.2 Oestrus synchronisation and embryo transfer

Oestrus synchronisation involves the use of hormonal protocols to bring a group of females into oestrus at the same time, enabling mass AI on a fixed schedule without the need for individual oestrus detection. Common synchronisation agents include prostaglandin F2-alpha (PGF2a), progesterone-releasing devices (CIDR), and gonadotrophin-releasing hormone (GnRH). Synchronisation programmes are widely used in commercial dairy herds and AI programmes to improve reproductive efficiency and reduce labour in oestrus detection.

Embryo transfer (ET) is the process of collecting fertilised embryos from a genetically superior donor female and transferring them into recipient females (surrogates) of lower genetic merit for gestation and birth. A donor cow can yield 6 to 10 embryos per flush cycle, allowing a single superior cow to produce far more offspring than is possible through natural pregnancy. ET is used in nucleus herds and elite breed improvement programmes to rapidly multiply superior genotypes.

Fill in the blank: The device inserted into the vagina to release progesterone for oestrus synchronisation is called a _____.

3.4.3 Genetic improvement through reproductive technologies

Reproductive technologies accelerate genetic improvement by increasing the selection intensity and reducing the generation interval in ruminant populations. AI enables the use of proven sires whose genetic merit has been estimated through progeny testing, selecting bulls with estimated breeding values (EBVs) for high milk yield, growth rate, or disease resistance. By using superior sires across large numbers of females, AI spreads favourable genes rapidly through a commercial population.

Embryo transfer combined with sexed semen allows producers to maximise the number of offspring from elite females while choosing the sex of offspring for specific production goals. In Nigeria, these technologies are being progressively introduced through government programmes and commercial AI service providers. Their widespread adoption requires investment in training, cold chain infrastructure, and recording systems to capture performance data for genetic evaluation. Long-term, the integration of genomic selection with AI and ET will further accelerate the rate of genetic gain in Nigerian ruminant herds.

Fill in the blank: The genetic merit of a sire estimated from the performance of its offspring is called an estimated breeding _____.

Aspect	Artificial Insemination	Embryo Transfer
Purpose	To improve genetics by introducing semen from superior sires	To multiply offspring from genetically superior females

Procedure	Semen collected from bull and deposited into cow's reproductive tract	Embryos collected from donor cow and implanted into recipient cows
Offspring per Year	Limited to number of cows inseminated with semen	Multiple calves possible from one superior cow via recipients
Main Advantage	Low cost, easy to apply widely	Rapid multiplication of elite genetics
Limitation	Genetic progress depends on female quality; fewer offspring per dam	Technically demanding, expensive, requires skilled personnel
Use in Nigeria	Widely practiced in cattle breeding programs (e.g., White Fulani, Sokoto Gudali)	Limited use due to cost and expertise constraints, mainly in research and elite herds

Box 3.2: Comparison of artificial insemination and embryo transfer as ruminant reproductive technologies

Pilot questions 3.4

1. Describe the procedure for artificial insemination in cattle using the recto-vaginal technique.
2. State four advantages of artificial insemination over natural service.
3. What is oestrus synchronisation and why is it used in commercial herds?
4. Describe the embryo transfer process and explain its significance in breed improvement.
5. Explain how AI and embryo transfer contribute to genetic improvement of Nigerian ruminant herds.

Series Summary

This Series has examined two of the most important biological foundations of ruminant animal production: nutrition and reproduction. We began by classifying feed ingredients into roughages, concentrates, and supplements, describing their nutritive value and identifying non-conventional feed resources available in Nigeria. We then explored the nutrient requirements of ruminants at different physiological stages, the principles of ration formulation using the Pearson square, and the common nutritional disorders that arise when feeding management fails.

In the reproduction section, we described the anatomy of the male and female reproductive tracts, the oestrous cycle, and the management of mating, pregnancy, and parturition in sheep, goats, and cattle. The Series concluded with reproductive technologies, covering artificial insemination, oestrus synchronisation, and embryo transfer, and evaluating their role in accelerating genetic improvement in Nigerian ruminant herds. Together, these topics provide the nutritional and reproductive knowledge needed to optimise performance and profitability in any ruminant enterprise.

Glossary of Terms

- **Artificial insemination (AI):** The manual deposition of semen into the female reproductive tract using an AI gun rather than through natural mating.
- **Balanced ration:** A daily feed allowance that supplies all required nutrients in the correct amounts and proportions for an animal's physiological state.
- **Bloat:** A digestive disorder in ruminants caused by excessive gas accumulation in the rumen, also called ruminal tympany.
- **Browse plants:** Shrubs and trees whose leaves and young shoots are eaten by ruminants, often used as non-conventional protein supplements.
- **Concentrate:** A feed ingredient with low fibre content and high energy or protein density, used to supplement roughage-based ruminant diets.

- **Embryo transfer (ET):** The collection of fertilised embryos from a genetically superior donor female and their transfer into recipient surrogate females for gestation.
- **Estimated breeding value (EBV):** A numerical estimate of the genetic merit of an individual animal for a specific trait, based on its own performance and that of its relatives.
- **Flushing:** The practice of increasing the energy intake of ewes or does before mating to improve ovulation rate and litter size.
- **Gestation:** The period of pregnancy from fertilisation to parturition, averaging 280 to 285 days in cattle and 147 to 152 days in sheep and goats.
- **Ketosis:** A metabolic disorder in early-lactation dairy cows caused by negative energy balance, resulting in accumulation of ketone bodies in the blood.
- **Maintenance requirements:** The minimum nutrients needed to sustain life and normal body functions in a non-productive animal at a stable body weight.
- **Oestrous cycle:** The recurring series of hormonal and physiological events that prepare the female ruminant for mating, averaging 21 days in cattle and 17 days in sheep and goats.
- **Oestrus synchronisation:** The use of hormonal protocols to bring a group of females into oestrus simultaneously, enabling batch AI without individual heat detection.
- **Roughage:** A bulky, fibrous feed ingredient with high crude fibre content, forming the dietary base for ruminant animals.
- **Steaming up:** The practice of increasing concentrate feeding in the last six weeks of pregnancy to prepare the dam for parturition and early lactation.

Concept Check Questions [Series 3]

Objective Questions

1. Define roughages. (Linked to SLO 3.1)
2. Which of the following is a protein concentrate? a) Maize b) Sorghum c) Groundnut cake d) Cassava (Linked to SLO 3.1)
3. The average oestrous cycle length in cattle is: a) 10 days b) 17 days c) 21 days d) 28 days (Linked to SLO 3.6)
4. The ruminant nutritional disorder caused by magnesium deficiency is called _____. (Linked to SLO 3.5)
5. In the recto-vaginal AI technique in cattle, semen is deposited into the body of the _____. (Linked to SLO 3.9)

Short Answer Questions

6. Distinguish between roughages and concentrates, giving two examples of each. (Linked to SLO 3.1)
7. Explain why lactating animals have the highest nutrient requirements in the ruminant herd. (Linked to SLO 3.3)
8. Describe the Pearson square method of ration balancing. (Linked to SLO 3.4)
9. State three advantages of artificial insemination over natural service. (Linked to SLO 3.9)
10. What is embryo transfer and how does it contribute to genetic improvement? (Linked to SLO 3.10, SLO 3.11)

Long Answer Questions

11. Discuss the feed ingredients available for ruminant nutrition in Nigeria, classifying them by type and evaluating their nutritive value and limitations. (Linked to SLO 3.1, SLO 3.2)

12. Describe the nutritional requirements of ruminants at different physiological stages and explain the principles of balanced ration formulation. (Linked to SLO 3.3, SLO 3.4)
13. Compare natural service and artificial insemination as mating systems, and evaluate the role of oestrus synchronisation and embryo transfer in accelerating genetic improvement of Nigerian ruminant herds. (Linked to SLO 3.7, SLO 3.9, SLO 3.10, SLO 3.11)

Answers to Concept Check Questions [Series 3]

Objective Questions

1. Roughages are bulky, fibrous feeds with crude fibre content above 18 percent dry matter, forming the dietary base for ruminant animals.
2. Correct answer: c) Groundnut cake.
3. Correct answer: c) 21 days.
4. Grass tetany (hypomagnesaemia).
5. Uterus.

Short Answer Questions

6. Roughages are high-fibre, bulky feeds such as guinea grass and groundnut haulms. Concentrates are low-fibre, high-energy or high-protein feeds such as maize (energy) and groundnut cake (protein).
7. Lactating animals must produce milk in addition to maintaining their own body functions. At peak lactation, energy and protein demands can reach two to three times the maintenance level, making lactation the most nutritionally demanding physiological state.
8. The Pearson square involves placing the target crude protein level in the centre of a square and the two feed ingredient protein levels at the left corners. The differences across the diagonals give the proportions in which the two feeds must be combined to achieve the target.

9. Three advantages are: one superior sire can produce thousands of offspring annually; venereal disease transmission is eliminated; and semen from superior or exotic sires can be used without transporting live animals.

10. Embryo transfer involves collecting fertilised embryos from a genetically superior donor female and implanting them into surrogate recipients. It multiplies the number of offspring from elite females, accelerating the spread of superior genetics through the population.

Long Answer Questions

11. Basic response: Nigerian ruminant feeds include roughages (guinea grass, elephant grass, groundnut haulms, rice straw), energy concentrates (maize, cassava), protein concentrates (groundnut cake, soyabean meal), and non-conventional resources (brewers' dried grains, Moringa, molasses).

12. Value-added response: Legume forages outperform grasses in protein content but may cause bloat if grazed exclusively. Crop residues such as rice straw are low in protein and require supplementation to support production. Anti-nutritional factors in some by-products limit inclusion rates and require processing. A diversified feeding strategy combining locally available roughages with agro-industrial by-products reduces costs while meeting nutritional needs.

13. Basic response: Nutrient requirements increase from maintenance through growth, pregnancy, and lactation. Balanced rations are formulated by matching feed ingredient nutrients to animal requirements, using methods such as the Pearson square for two-ingredient combinations.

14. Value-added response: Physiological grouping of animals allows targeted feeding: dry cows need only maintenance, late-pregnant animals need steaming up, and lactating cows need high-energy, high-protein diets. Common errors include overfeeding dry cows (causing fat cow syndrome) and underfeeding lactating animals (causing excessive body condition loss and delayed return to oestrus). Regular body condition scoring links feeding management to reproductive and production outcomes.

15. Basic response: Natural service is simple and inexpensive but limits the sire's influence and risks venereal disease. AI multiplies superior genetics, eliminates disease transmission, and allows use of exotic semen. Oestrus synchronisation removes the need for daily heat detection, enabling batch AI. Embryo transfer maximises genetic contributions from elite females.
16. Value-added response: In Nigeria, the combination of AI with oestrus synchronisation is the most practical entry point for genetic improvement, as it requires less infrastructure than ET. Long-term genetic gain depends on performance recording to identify superior animals, progeny testing to estimate EBVs, and a functioning AI service delivery network. Government and private sector investment in cold chain infrastructure and AI technician training are prerequisite for scaling these technologies.

Answers to Pilot Questions [Series 3]

Part 3.1: Feed Ingredients Used in Ruminant Nutrition

1. Roughages are bulky, high-fibre feeds with crude fibre above 18 percent dry matter. Three Nigerian examples are guinea grass, elephant grass, and groundnut haulms.
2. Energy concentrates supply mainly energy and include maize and cassava. Protein concentrates supply mainly protein and include groundnut cake and soyabean meal.
3. Legume forages contain 12 to 20 percent crude protein dry matter, compared to 6 to 12 percent in grasses. They also fix atmospheric nitrogen, improving soil fertility, and are more digestible than mature grass.
4. Three non-conventional feed resources are: brewers' dried grains, Moringa leaves, and molasses.
5. Anti-nutritional factors are naturally occurring compounds that reduce nutrient availability or cause harm, such as tannins in cocoa pod husk and cyanogenic glycosides

in cassava peels. They can be managed by sun-drying, soaking, heating, or limiting the inclusion rate in the ration.

Part 3.2: Nutritional Requirements and Feeding of Ruminants

1. Maintenance requirements are the minimum nutrients needed for life without any productive output. Production requirements are the additional nutrients needed above maintenance for growth, lactation, pregnancy, or work.
2. The Pearson square is a simple graphical method for combining two feed ingredients to achieve a target nutrient level, typically crude protein. It is used when formulating two-ingredient supplements or complete feeds for ruminants.
3. A balanced ration is the total daily feed allowance that supplies energy, protein, minerals, vitamins, and water in the correct amounts and proportions for the animal's physiological state and production level.
4. Milk fever results from hypocalcaemia at calving and is prevented by avoiding excess calcium in the dry cow diet and providing calcium drenches or injections around parturition. Ketosis results from energy deficit in early lactation and is prevented by ensuring adequate energy intake before and after calving.
5. Lactating animals must produce milk in addition to maintaining body functions and (if pregnant again) supporting foetal growth. At peak yield, energy and protein demands reach two to three times maintenance, making lactation the most nutritionally demanding state in the production cycle.

Part 3.3: Reproduction in Ruminant Animals

1. The main female organs are: ovaries (produce ova and hormones), oviducts (transport ova and site of fertilisation), uterine horns and uterus (site of foetal development), cervix (barrier to infection, semen deposition site), and vagina (birth canal).

2. The oestrous cycle in the cow averages 21 days. Oestrus (heat) lasts 24 to 36 hours, during which the cow accepts the male. Ovulation occurs approximately 10 to 12 hours after the end of oestrus.
3. Natural service is simple and requires no equipment but limits sire use and risks venereal disease. AI allows use of superior sires across many females, eliminates disease transmission, and enables exotic genetics to be used, but requires trained personnel, equipment, and accurate oestrus detection.
4. Steaming up is the provision of additional concentrate feed in the last six weeks of pregnancy. It prepares the dam for the high energy demands of parturition and early lactation, reduces the risk of metabolic disorders, and supports adequate colostrum production.
5. The three stages are: preparatory (cervix dilates, foetus positions), expulsion (uterine contractions deliver foetus), and placental (placenta expelled within two to six hours). One common post-partum complication is retained placenta, where the placenta is not expelled within 12 to 24 hours.

Part 3.4: Reproductive Technologies in Ruminant Production

1. The procedure: detect oestrus, thaw frozen semen in warm water, load semen straw into the AI gun, insert the operator's left hand into the rectum to grasp the cervix, guide the AI gun through the vagina with the right hand, pass the gun through the cervix, and deposit semen into the uterine body.
2. Four advantages are: one sire produces thousands of offspring annually; venereal disease transmission is prevented; exotic or imported genetics can be used without live animal transport; and parentage records are more accurate than with pasture mating.
3. Oestrus synchronisation uses hormonal protocols (PGF2a, CIDR, GnRH) to bring a group of females into oestrus simultaneously. It is used in commercial herds to enable fixed-time AI without daily heat detection, reducing labour and improving reproductive management efficiency.

4. In embryo transfer, a donor female is superovulated with hormones and mated or inseminated. Embryos are collected non-surgically from the uterus and transferred into synchronised recipient females. It allows one elite cow to produce 6 to 10 offspring per flush cycle, rapidly multiplying superior genotypes for breed improvement.
5. AI spreads superior sire genetics across thousands of dams, raising the average genetic merit of the population. ET maximises contributions from elite females. Together, using sires and dams with high EBVs for economically important traits such as milk yield and growth rate, these technologies can substantially increase the rate of genetic gain per generation in Nigerian ruminant herds.

References and Attributions [Series 3]

Textual References (Books and External Sources)

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Figures, Plates, Tables, and Boxes

- Table 3.1: Common roughage feed ingredients for ruminants in Nigeria Attribution: AI generated. Suggested OER search string: "ruminant roughage feed ingredients Nigeria grass legume straw nutritive value table OER".

- Box 3.1: Non-conventional feed resources for ruminants in Nigeria Attribution: AI generated. Suggested OER search string: "non-conventional ruminant feed resources Nigeria brewers grains cassava cocoa molasses Moringa OER box".
- Figure 3.1: The Pearson square method for ruminant ration balancing Attribution: AI generated. Suggested OER search string: "Pearson square ration balancing ruminant crude protein guinea grass groundnut cake OER diagram".
- Table 3.2: Common nutritional disorders in ruminants Attribution: AI generated. Suggested OER search string: "ruminant nutritional disorders bloat grass tetany milk fever ketosis urolithiasis table OER".
- Figure 3.2: The oestrous cycle of the cow showing hormonal changes and ovulation timing Attribution: AI generated. Suggested OER search string: "bovine oestrous cycle phases hormones LH FSH oestrogen progesterone ovulation diagram OER".
- Plate 3.1: Artificial insemination in cattle using the recto-vaginal technique Attribution: AI generated. Suggested OER search string: "artificial insemination cattle recto-vaginal technique AI gun technician OER image".
- Box 3.2: Comparison of artificial insemination and embryo transfer as ruminant reproductive technologies Attribution: AI generated. Suggested OER search string: "artificial insemination embryo transfer ruminant comparison advantage limitation Nigeria OER box".

Course code: AGE 302

Course title: Ruminant Animal Production

Course credit load: 2 Units

Series 4: Housing, Equipment, Milking, and Young Stock Management

- **Part 4.1: Housing for Ruminant Animals**
  - Sub Part 4.1.1: Principles and objectives of ruminant housing
  - Sub Part 4.1.2: Types of housing systems for sheep, goats, and cattle
  - Sub Part 4.1.3: Design features and materials for ruminant housing in Nigeria
- **Part 4.2: Equipment Used in Ruminant Enterprises**
  - Sub Part 4.2.1: Feeding and watering equipment
  - Sub Part 4.2.2: Restraint, handling, and health management equipment
  - Sub Part 4.2.3: Equipment maintenance and safety
- **Part 4.3: Milking Techniques and Milk Handling**
  - Sub Part 4.3.1: Principles of milking and milk quality
  - Sub Part 4.3.2: Hand milking technique and milking routine
  - Sub Part 4.3.3: Machine milking and milk handling after harvesting
- **Part 4.4: Young Stock Management**
  - Sub Part 4.4.1: Care of the newborn from birth to one week
  - Sub Part 4.4.2: Weaning and post-weaning management

- Sub Part 4.4.3: Growth monitoring and target weights for replacement stock

Introduction

The physical environment in which ruminants are kept directly affects their comfort, health, and productivity. Appropriate housing protects animals from adverse weather, reduces disease pressure, facilitates management routines, and contributes to the safety of both animals and handlers. Equally, having the right equipment for feeding, watering, restraint, and health management is essential for the efficient day-to-day operation of any ruminant enterprise.

This Series covers the practical infrastructure and management skills needed for successful ruminant production. We begin with housing, examining its principles, types, and design features suited to Nigerian conditions. We then describe the equipment required in a ruminant enterprise and principles of its maintenance. The Series continues with milking, covering technique, hygiene, and milk handling, and concludes with the specialised care of young stock from birth through weaning and on to replacement age.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- SLO 4.1 state the principles and objectives of ruminant housing (Linked to Part 4.1),
- SLO 4.2 describe the types of housing systems used for sheep, goats, and cattle (Linked to Part 4.1),
- SLO 4.3 identify appropriate design features and materials for ruminant housing in Nigeria (Linked to Part 4.1),
- SLO 4.4 identify feeding, watering, and health management equipment used in ruminant enterprises (Linked to Part 4.2),

- SLO 4.5 describe principles of equipment maintenance and safety (Linked to Part 4.2),
- SLO 4.6 explain the principles of milking and milk quality in ruminant production (Linked to Part 4.3),
- SLO 4.7 describe the correct hand milking technique and pre- and post-milking routine (Linked to Part 4.3),
- SLO 4.8 explain machine milking procedures and correct milk handling after harvesting (Linked to Part 4.3),
- SLO 4.9 describe the care of newborn ruminants from birth to one week of age (Linked to Part 4.4),
- SLO 4.10 explain weaning and post-weaning management of young ruminants (Linked to Part 4.4), and
- SLO 4.11 describe growth monitoring and target weights for replacement stock (Linked to Part 4.4).

4.1 Housing for Ruminant Animals

4.1.1 Principles and objectives of ruminant housing

The primary objective of housing ruminant animals is to provide a safe, comfortable environment that supports maximum productivity at minimum cost. Good housing protects animals from rain, direct sun, cold winds, and predators, all of which cause stress and reduce production. It also facilitates feeding, watering, and health management by keeping animals in a defined space where they can be easily observed, handled, and treated. Adequate housing reduces the incidence of respiratory diseases, lameness, and injury.

The key principles guiding ruminant housing design are adequate space allowance per animal, good ventilation to remove moisture and ammonia, ease of cleaning and disinfection, durability against weather and animal behaviour, and affordability using locally available materials. In Nigeria's tropical climate, ventilation and shade are far more critical than insulation against cold.

Housing must be oriented to maximise cross-ventilation while minimising direct rainfall entry, and should allow for easy expansion as the herd grows.

Fill in the blank: In Nigeria's tropical climate, the most critical design consideration for ruminant housing is _____ and shade.

4.1.2 Types of housing systems for sheep, goats, and cattle

Ruminant housing systems range from fully extensive (no housing) to fully intensive (permanent confinement). In **extensive systems**, animals roam freely on rangelands or communal pastures with no constructed shelter, which is common for White Fulani cattle under traditional Fulani management. **Semi-intensive systems** provide night housing and supplementary feeding while allowing daytime grazing; this is the most common system for smallholder sheep, goat, and cattle producers in Nigeria. **Intensive systems** confine animals full-time in constructed housing with all feed and water provided, and are used mainly for dairy cattle, fattening operations, and peri-urban livestock production.

For sheep and goats, raised slatted-floor pens are widely recommended in humid zones of Nigeria because the slats allow dung and urine to fall through, keeping the animals dry and reducing internal parasite burdens. For cattle, open-sided barns with concrete floors and drainage channels are most practical. Separate pens are needed for different animal classes: pregnant females, lactating dams, young stock, males, and sick animals. Isolation pens for newly arrived or sick animals are an essential biosecurity feature.

Fill in the blank: Raised slatted-floor pens are recommended for sheep and goats in humid zones because they keep animals dry and reduce _____ burdens.

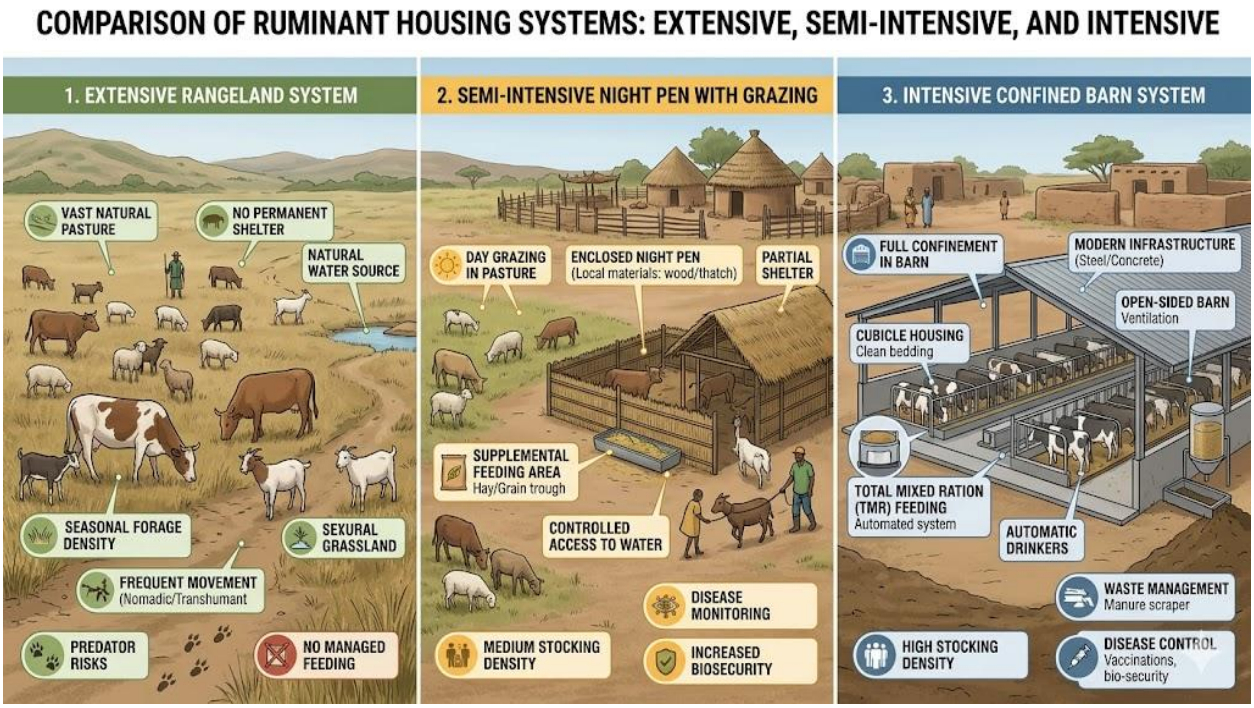

Figure 4.1: Types of ruminant housing systems: extensive, semi-intensive, and intensive

4.1.3 Design features and materials for ruminant housing in Nigeria

A standard ruminant pen in Nigeria is typically rectangular, oriented east to west to minimise direct sun exposure on the long sides. The roof should have wide overhangs to prevent rain splash into the pen and should be made of corrugated iron, asbestos, or thatch depending on availability and cost. Walls may be open or constructed of wire mesh, bamboo, or block to a height of one metre, with open space above for ventilation. The floor may be earthen (compacted and cambered for drainage), concrete, or raised wooden slats.

Space allowances vary by species and class: beef cattle require 4 to 6 square metres per animal in a loose housing barn, dairy cows 6 to 8 square metres in a stall, and sheep and goats 0.8 to 1.5 square metres per adult animal. Feeding troughs should be placed along one wall, with a trough length of 30 to 45 centimetres per small ruminant and 60 to 75 centimetres per adult cow. Water troughs must be easily accessible, cleanable, and sized to meet daily water requirements of all animals in the pen simultaneously.

Fill in the blank: A ruminant pen in Nigeria is typically oriented _____ to west to minimise direct sun exposure on the long sides.

Animal Category	Space Allowance	Trough Length
Beef Cattle	3.5 – 4.0 m² per head	60 – 75 cm per head
Dairy Cows	6.0 – 7.0 m² per cow	70 – 80 cm per cow
Sheep	0.8 – 1.0 m² per head	30 – 40 cm per head
Goats	0.8 – 1.0 m² per head	30 – 40 cm per head
Young Stock (Calves/Lambs/Kids)	1.5 – 2.0 m² per head	40 – 50 cm per head

Table 4.1: Recommended space allowances and trough lengths for ruminant housing

Pilot questions 4.1

1. State four objectives of housing ruminant animals.
2. Distinguish between extensive, semi-intensive, and intensive housing systems for ruminants.
3. Why are raised slatted-floor pens recommended for sheep and goats in humid zones of Nigeria?
4. Describe the recommended orientation and roofing materials for a ruminant pen in Nigeria.
5. State the recommended floor space per adult dairy cow and per adult small ruminant.

4.2 Equipment Used in Ruminant Enterprises

4.2.1 Feeding and watering equipment

Feeding equipment for ruminants includes **feed troughs**, which are elongated containers placed at a height convenient for the animals to access roughage and concentrates without excessive waste. **Hay racks** are suspended frames or wall-mounted holders that present hay or fibrous

roughage above ground level, preventing trampling and contamination with dung. **Feed blocks** containing molasses, urea, minerals, and roughage are placed in the pen for free-choice licking, providing supplementary energy and minerals to grazing animals. **Salt lick holders** or mineral block holders are simple wall-mounted or free-standing frames that keep mineral blocks accessible and prevent them from being soiled.

Watering equipment includes concrete or metal water troughs, automatic ball-valve drinkers, and portable rubber or plastic buckets. Water troughs must be sized to meet the daily water requirements of the herd: a lactating dairy cow may consume 80 to 100 litres per day, while a sheep or goat requires 2 to 5 litres. Troughs should be cleaned daily and positioned to prevent fouling with dung. In water-scarce areas, covered storage tanks or overhead tanks fed by borehole pumps are essential to ensure a reliable supply.

Fill in the blank: Wall-mounted or suspended frames that present hay above ground level to prevent trampling are called hay _____.

4.2.2 Restraint, handling, and health management equipment

Safe and effective animal handling requires proper restraint equipment. A **cattle crush (squeeze chute)** is a narrow metal or wooden enclosure with a head gate that immobilises a cow for examination, vaccination, pregnancy diagnosis, or treatment. A **nose ring or nose lead** is used to control bulls. For small ruminants, a simple **goat stand or milking stand** restrains the animal at a comfortable working height. **Drafting gates and sorting races** allow animals to be sorted into groups efficiently without excessive handling stress.

Health management equipment includes drenching guns for oral administration of anthelmintics, dosing syringes for accurate delivery of liquid medicines, ear tagging pliers and numbered tags for individual identification, burdizzo clamps for bloodless castration, dehorning irons or dehorning saws for horn removal, and dip tanks or spray races for tick and external parasite control. A well-equipped first-aid kit with bandaging materials, antiseptics, thermometer, and syringes is essential on every ruminant farm.

Fill in the blank: A narrow enclosure with a head gate used to immobilise cattle for examination or treatment is called a cattle _____.

Equipment Name	Category	Primary Use	Species
Feed Troughs	Feeding equipment	Holds concentrate or mixed feed	Cattle, sheep, goats
Hay Racks	Feeding equipment	Provides dry forage (hay, straw)	Cattle, sheep, goats
Water Troughs	Watering equipment	Supplies clean drinking water	All ruminants
Cattle Crush	Handling equipment	Restrains cattle for treatment or examination	Beef and dairy cattle
Drenching Gun	Health equipment	Administers liquid medicines or dewormers	Sheep, goats, cattle
Ear Tagging Pliers	Identification equipment	Applies ear tags for animal ID	Sheep, goats, cattle
Burdizzo Clamp	Health/reproductive equipment	Bloodless castration tool	Cattle, sheep, goats
Dip Tank	Health equipment	Immersion bath for ectoparasite control	Sheep, goats, cattle

Table 4.2: Common equipment used in ruminant enterprises and their functions

4.2.3 Equipment maintenance and safety

Regular maintenance of farm equipment prolongs its useful life and prevents accidents. Metal troughs, feed mangers, and water tanks should be inspected weekly for rust, sharp edges, and cracks. Wooden structures should be checked for rot, loose nails, and splinters that could injure animals. Moving parts on cattle crushes, gates, and drafting races must be lubricated and

adjusted to operate smoothly. Drenching guns and dosing syringes should be flushed with clean water after each use, and calibrated regularly to ensure accurate dosing.

Safety rules for equipment use on a ruminant farm include: always restrain animals properly before treatment or examination; never stand directly behind cattle or large ruminants; keep sharp and powered equipment away from children; store chemicals and medicines in locked cabinets; and dispose of used needles and syringes in sharps containers. All farm workers should be trained in the correct and safe use of every piece of equipment on the farm, and a maintenance log should be kept to track repairs and scheduled inspections.

Fill in the blank: Drenching guns and dosing syringes should be flushed with _____ after each use to prevent contamination.

Pilot questions 4.2

1. Name three types of feeding equipment used in a ruminant enterprise and state the function of each.
2. What daily water requirement should be met for a lactating dairy cow?
3. Describe the cattle crush and explain its purpose in ruminant management.
4. List four items that should be included in a ruminant farm first-aid kit.
5. State three safety rules for equipment use on a ruminant farm.

4.3 Milking Techniques and Milk Handling

4.3.1 Principles of milking and milk quality

The objective of milking is to remove all milk from the udder as completely and hygienically as possible at every milking. Incomplete milking leaves residual milk that reduces total yield and increases the risk of mastitis. Milk quality is determined by its composition (fat, protein, lactose, minerals) and hygiene (bacterial count, somatic cell count, absence of adulterants). High-quality

milk has a low total bacterial count (below 100,000 colony-forming units per millilitre) and a somatic cell count below 200,000 cells per millilitre, indicating a healthy udder.

The three main factors that determine milk quality at the farm level are **cow health** (particularly udder health, as mastitis elevates somatic cell count and reduces yield), **milking hygiene** (clean equipment, clean hands, and sanitised teat surfaces), and **rapid cooling of milk** after harvest (to below 4 degrees Celsius within two hours) to inhibit bacterial multiplication. Failure in any of these areas results in milk that is rejected by processors or unsafe for consumption.

Fill in the blank: Milk with a somatic cell count above 200,000 cells per millilitre indicates the presence of _____ in the udder.

4.3.2 Hand milking technique and milking routine

Correct hand milking uses the **full-hand or stripping method**. The milker's thumb and forefinger are closed around the teat base to trap milk in the teat cistern, then the remaining fingers close in sequence from index to little finger, squeezing milk out through the teat orifice. The teat is never pulled or twisted, as this causes pain, inhibits let-down, and damages teat tissue. Each hand alternately milks one teat, maintaining a rhythm of approximately 80 to 100 compressions per minute to match the natural let-down reflex.

The pre-milking routine consists of: assembling clean equipment and the milking bucket; washing hands thoroughly with soap; wiping each teat and teat end with a clean individual towel dampened with warm water or sanitiser; fore-stripping two to three streams from each teat into a strip cup to detect abnormal milk; and commencing milking within one minute of the first teat stimulus to capture the oxytocin-driven let-down. Post-milking teat dipping with an approved iodine or chlorhexidine teat dip seals the teat orifice and reduces mastitis infection between milkings.

Fill in the blank: The practice of dipping teats in sanitiser solution after each milking to seal the teat orifice is called post-milking teat _____.

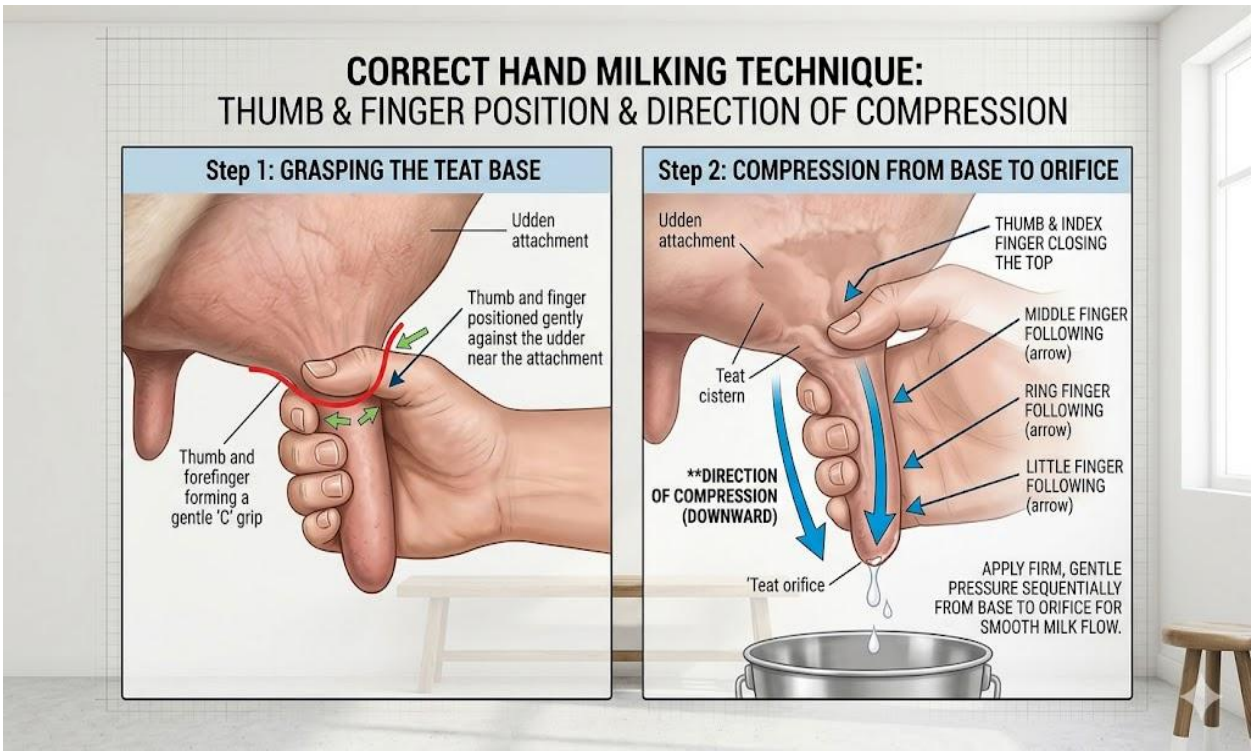

Figure 4.2: Correct hand milking technique using the full-hand method

4.3.3 Machine milking and milk handling after harvesting

Machine milking uses a **milking machine** that applies intermittent vacuum (typically 42 to 50 kilopascals) to the teat cups, alternating between a milking phase (teat end vacuum extracts milk) and a massage phase (liner collapses to restore blood circulation). The key components of a milking machine are the vacuum pump, pulsator, cluster (four teat cups with liners), milk receiver jar, and milk pipeline. Machine milking is faster than hand milking, enables one operator to milk more cows, and reduces hand fatigue in large dairy operations.

After harvesting, milk must be filtered through a clean milk filter to remove visible debris, then cooled rapidly in a bulk milk cooler or submerged in ice water to below 4 degrees Celsius. Milk should be transported in clean, stainless steel or food-grade plastic containers to the processing or sales point as quickly as possible. Equipment in contact with milk (buckets, filters, cluster liners, pipelines) must be rinsed with cold water immediately after milking, washed with hot detergent solution, rinsed with clean water, and sanitised before the next milking. Failure to

clean milking equipment properly is the most common cause of high bacterial counts in raw milk.

Fill in the blank: After milking, milk must be cooled to below _____ degrees Celsius within two hours to inhibit bacterial growth.

Plate 4.1: Machine milking of a dairy cow with a portable milking unit

Pilot questions 4.3

1. State three factors that determine milk quality at the farm level.
2. Describe the correct hand milking technique and explain why the teat must not be pulled or twisted.
3. Outline the pre-milking routine that should be followed before every milking session.
4. Describe the main components of a milking machine and explain how it works.
5. Explain the correct procedure for handling and cooling milk after harvest.

4.4 Young Stock Management

4.4.1 Care of the newborn from birth to one week

The first week of life is the period of highest mortality risk for ruminant young stock. Immediately after birth, the newborn should be cleared of membranes from the nose and mouth to facilitate breathing. If the dam does not lick the offspring clean within a few minutes, the attendant should dry the animal with a clean towel, paying particular attention to the head and chest. The navel cord should be disinfected by dipping in 10 percent iodine solution to prevent navel ill (omphalophlebitis), a bacterial infection that can become systemic and fatal.

Colostrum intake within the first two hours of birth is the single most important management action in the first week of life. A lamb or kid should receive at least 200 millilitres per kilogram of body weight, and a calf 10 percent of its body weight, in colostrum during the first 24 hours. If the dam cannot or will not nurse, colostrum should be hand-milked and fed by bottle or stomach tube. The newborn should be weighed and individually identified within 24 hours. Daily observation for signs of diarrhoea, weakness, failure to suckle, and navel swelling is essential throughout the first week.

Fill in the blank: The navel cord of a newborn ruminant should be disinfected by dipping in _____ percent iodine solution.

Step	Action	Purpose
Clear airways	Remove mucus from nose and mouth	Ensures proper breathing immediately after birth
Drying	Rub calf/lamb/kid with clean cloth or straw	Stimulates circulation and prevents chilling
Navel disinfection	Dip navel cord in iodine solution	Prevents infection and promotes healing
Colostrum feeding	Provide colostrum within first 6 hours	Supplies antibodies and essential nutrients
Weighing	Record birth weight	Monitors growth and feed efficiency

Identification	Tag, tattoo, or record markings	Enables tracking and record keeping
Observation	Monitor behavior, suckling, and activity	Detects early health issues and ensures vitality

Box 4.1: Step-by-step care protocol for a newborn ruminant in the first 24 hours

4.4.2 Weaning and post-weaning management

Weaning is the process of permanently separating young animals from their dams and transitioning them to solid feed. In sheep and goats, weaning typically occurs at 8 to 12 weeks of age when the kid or lamb is consuming adequate solid feed and water independently. In beef cattle, calves are weaned at 5 to 7 months. In dairy operations, calves are often separated from the cow within 24 hours of birth and raised on milk replacer or whole milk by bucket feeding, with weaning occurring at 6 to 8 weeks once the calf is consuming at least 1 kilogram of calf starter concentrate per day.

The post-weaning period is one of the most stressful in young animal life and requires careful management to maintain growth rates. Newly weaned animals should be offered high-quality feed in adequate amounts to compensate for the loss of milk nutrition. Routine health procedures including vaccination, deworming, and vitamin A and D supplementation should be completed at or shortly after weaning. Young stock should be grouped by size and age to reduce competition and bullying at the feed trough. Regular weighing every four weeks monitors growth rate and identifies animals with health problems or nutritional deficiencies.

Fill in the blank: In dairy operations, calves are typically weaned at 6 to 8 weeks when they consume at least _____ kilogram of calf starter concentrate per day.

4.4.3 Growth monitoring and target weights for replacement stock

Replacement stock are young females (heifers, ewe lambs, or doe kids) retained to replace culled animals in the breeding herd. Their management from weaning to first mating must ensure they reach the target body weight for their breed at puberty and first service. In White Fulani heifers, first mating is recommended at a minimum live weight of 250 kilograms, usually achieved at 24

to 30 months under good management. In Yankasa ewes, first mating should occur at 18 to 24 kilograms live weight, typically at 8 to 12 months. WAD does should weigh at least 12 kilograms before first mating.

Growth monitoring involves weighing replacement animals every four weeks and plotting weights against breed-specific growth targets on a weight-for-age chart. Animals falling below target weights receive additional feed supplementation; those growing well are maintained on the standard programme. The average daily gain (ADG) is the key growth performance indicator, calculated by dividing weight change by the number of days between measurements. Failure to achieve target weights by first mating results in small birth weights, difficult kidding or calving, poor milk production, and delayed return to oestrus, all of which reduce lifetime productivity.

Fill in the blank: The key growth performance indicator calculated as weight change divided by days between measurements is called average daily _____.

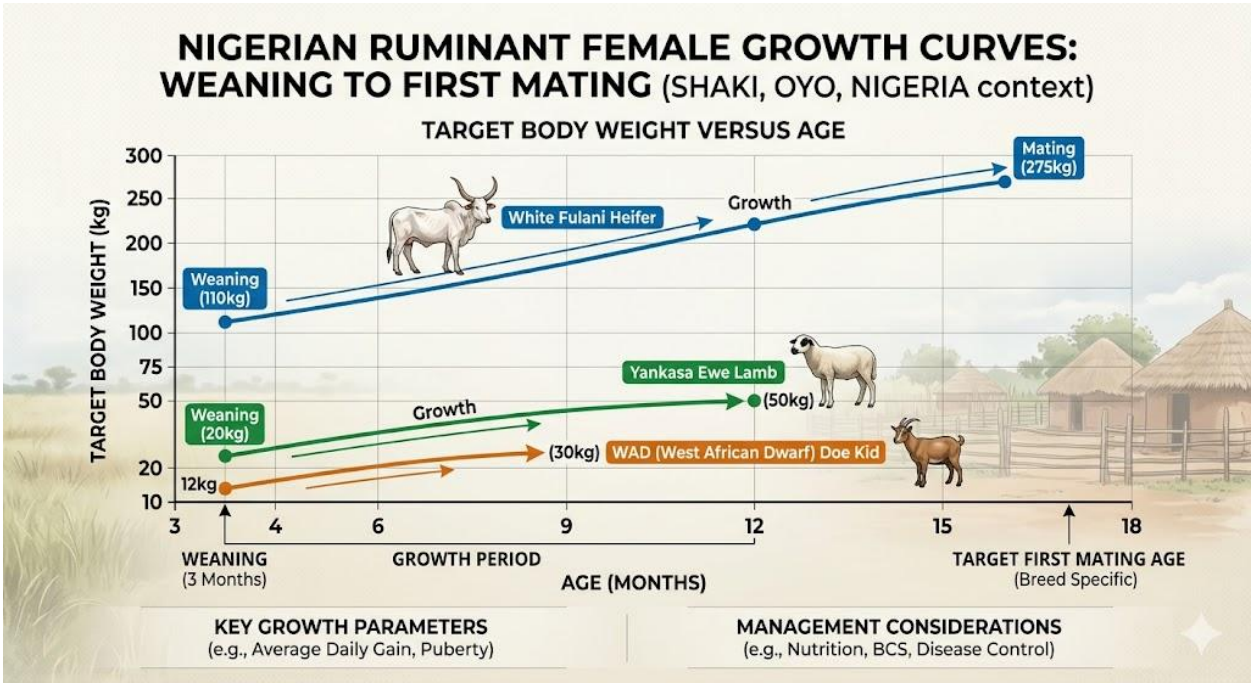

Figure 4.3: Target growth curves for replacement stock in three Nigerian ruminant species

Pilot questions 4.4

1. Describe the immediate care steps to be taken for a newborn lamb, kid, or calf.
2. Why is colostrum intake within the first two hours of birth critical for young ruminants?
3. At what age and weight are Yankasa ewe lambs and WAD doe kids first mated?
4. Explain what average daily gain is and how it is calculated.
5. Describe the management of replacement heifers from weaning to first mating.

Series Summary

This Series has covered the practical infrastructure and management skills central to productive ruminant enterprises. We began with housing, examining its objectives, the range of systems from extensive to intensive, and the design features and materials appropriate for Nigerian conditions. We described the equipment required for feeding, watering, restraint, and health management, and outlined principles of equipment maintenance and safety.

The milking section explained the principles of milk quality, described the correct hand milking technique and pre- and post-milking routine, and outlined machine milking and milk handling procedures. The Series concluded with young stock management, covering the critical first-week care of newborns, weaning protocols for sheep, goats, and cattle, and the growth monitoring and target weight programmes required to bring replacement stock to first mating in optimal condition. Together, these topics provide the practical knowledge needed to run a well-housed, well-equipped, and productively managed ruminant enterprise.

Glossary of Terms

- **Average daily gain (ADG):** The increase in body weight per day, calculated by dividing the difference between two body weights by the number of days between measurements.

- **Bulk milk cooler:** A refrigerated tank used on dairy farms to rapidly cool and store raw milk after milking until collection by the processor.
- **Cattle crush (squeeze chute):** A narrow metal or wooden enclosure with a head gate used to safely immobilise cattle for examination, vaccination, or treatment.
- **Colostrum:** The first milk produced by the dam after parturition, rich in antibodies, energy, protein, and vitamins essential for newborn immunity and survival.
- **Drenching gun:** A hand-held device used to administer precise volumes of liquid anthelmintics or medicines orally to ruminants.
- **Fore-stripping:** The removal of the first two to three streams of milk from each teat before milking, used to detect abnormal milk and stimulate let-down.
- **Full-hand milking:** A milking technique in which the entire hand closes progressively from teat base to tip to expel milk without pulling or twisting the teat.
- **Hay rack:** A wall-mounted or suspended frame that holds hay or fibrous roughage above ground level to prevent trampling and contamination.
- **Mastitis:** Inflammation of the udder, usually caused by bacterial infection, resulting in elevated somatic cell count, reduced milk yield, and abnormal milk.
- **Navel ill (omphalophlebitis):** A bacterial infection of the navel cord in newborn ruminants that can spread systemically if the navel is not disinfected at birth.
- **Pulsator:** The component of a milking machine that alternates vacuum between the milking and massage phases to extract milk while maintaining teat health.
- **Replacement stock:** Young females retained in the herd to replace culled breeding animals, managed from weaning to first mating to achieve target weights.
- **Semi-intensive housing:** A management system providing night housing and supplementary feeding while allowing animals to graze during the day.
- **Somatic cell count (SCC):** A measure of the number of white blood cells per millilitre of milk, used as an indicator of udder health and mastitis status.

- **Teat dipping:** The application of a sanitising solution to teat ends after each milking to seal the teat orifice and reduce mastitis infection risk.

Concept Check Questions [Series 4]

Objective Questions

1. State two objectives of ruminant housing. (Linked to SLO 4.1)
2. Raised slatted-floor pens are recommended for sheep and goats because they: a) Improve feed conversion b) Reduce internal parasite burdens c) Increase milk yield d) Reduce feed costs (Linked to SLO 4.2)
3. The key growth performance indicator for young ruminants is: a) Body condition score b) Somatic cell count c) Average daily gain d) Calving interval (Linked to SLO 4.11)
4. The hormone responsible for milk let-down during the milking routine is _____. (Linked to SLO 4.6)
5. After milking, raw milk must be cooled to below _____ degrees Celsius within two hours to inhibit bacterial growth. (Linked to SLO 4.8)

Short Answer Questions

6. Describe three key principles that should guide the design of ruminant housing in Nigeria. (Linked to SLO 4.1, SLO 4.3)
7. What is the purpose of fore-stripping before milking and what should be done with the fore-stripped milk? (Linked to SLO 4.7)
8. Explain why the first week of life is the period of highest mortality risk for young ruminants and describe two management actions that reduce this risk. (Linked to SLO 4.9)
9. Describe the post-milking teat dipping procedure and explain its importance. (Linked to SLO 4.7)

10. What is a replacement stock growth monitoring programme and why is it important? (Linked to SLO 4.11)

Long Answer Questions

11. Describe the types of housing systems available for ruminants in Nigeria and discuss the design features and materials appropriate for each system. (Linked to SLO 4.1, SLO 4.2, SLO 4.3)
12. Explain the principles of milk quality in dairy ruminant production and describe in detail the hand milking technique, pre-milking routine, and post-milking milk handling procedure. (Linked to SLO 4.6, SLO 4.7, SLO 4.8)
13. Describe the management of young ruminants from birth through weaning to replacement age, emphasising the key management actions at each stage and the growth targets that must be achieved. (Linked to SLO 4.9, SLO 4.10, SLO 4.11)

Answers to Concept Check Questions [Series 4]

Objective Questions

1. Two objectives are: to protect animals from adverse weather, predators, and stress; and to facilitate feeding, watering, and health management by confining animals in an accessible space.
2. Correct answer: b) Reduce internal parasite burdens.
3. Correct answer: c) Average daily gain.
4. Oxytocin.
5. 4 degrees Celsius.

Short Answer Questions

6. Three key design principles are: adequate ventilation and shade for the tropical climate; sufficient space per animal to prevent overcrowding and disease spread; and ease of cleaning and drainage to maintain hygiene and reduce parasite and pathogen loads.

7. Fore-stripping removes the first two to three streams from each teat to detect abnormal milk (clots, blood, or watery secretion) that indicates mastitis. The fore-stripped milk should be discarded into a strip cup and not mixed with the bulk milk.

8. The first week carries the highest mortality risk because passive immunity from colostrum is the only protection against disease, and the newborn cannot thermoregulate effectively. Two management actions that reduce this risk are ensuring colostrum intake within two hours of birth, and disinfecting the navel cord with iodine solution to prevent navel ill.

9. After milking, each teat is dipped into an approved iodine or chlorhexidine solution using a purpose-made teat dip cup. The solution coats the teat orifice, which remains open for 30 to 60 minutes after milking, killing bacteria on the teat surface and preventing new mastitis infections between milkings.

10. A growth monitoring programme involves weighing replacement animals every four weeks and comparing their weights to breed-specific targets on a weight-for-age chart. It is important because animals that fail to reach target weight by first mating produce smaller offspring, experience more difficult deliveries, yield less milk, and return to oestrus later, reducing lifetime productivity.

Long Answer Questions

11. Basic response: Extensive systems provide no housing; semi-intensive systems provide night pens with daytime grazing; intensive systems confine animals full-time. Design features include east-west orientation, wide roof overhangs, open walls for ventilation, and concrete or slatted floors. Local materials such as wood, bamboo, and corrugated iron are widely used.

12. Value-added response: The choice of housing system is driven by management intensity, species, and available resources. In humid zones, raised slatted floors for small ruminants

are a cost-effective way of reducing parasite burdens without expensive anthelmintics. In intensive dairy operations, cow comfort features such as rubber mattresses and cooling fans directly influence milk yield. Separate pens for different animal classes and an isolation pen for sick or new animals are essential biosecurity investments regardless of system type.

13. Basic response: Milk quality is determined by cow health, milking hygiene, and rapid cooling. Hand milking uses the full-hand technique without pulling or twisting. The pre-milking routine includes washing hands, cleaning teats with individual towels, fore-stripping, and commencing milking within one minute. After milking, milk is filtered and cooled below 4 degrees Celsius.

14. Value-added response: Somatic cell count and total bacterial count are the two key quality parameters monitored by processors. SCC above 200,000 indicates mastitis, while high bacterial counts reflect poor milking hygiene or inadequate cooling. Post-milking teat dipping is the single most cost-effective mastitis prevention practice. Machine milking must include proper cluster attachment timing and prompt removal when milk flow stops to prevent over-milking and liner slip, both of which increase mastitis risk.

15. Basic response: At birth: clear airways, dry, disinfect navel, ensure colostrum intake. Weaning at 8 to 12 weeks for small ruminants and 5 to 7 months for beef calves. Replacement stock are weighed monthly against breed targets until first mating. Average daily gain is the key growth metric.

16. Value-added response: The transition at weaning is the most stressful event in a young ruminant's life and requires high-quality starter feed, grouping by size, and health treatments to prevent growth checks. For replacement heifers, the link between pre-pubertal growth rate and subsequent milk production is well established: heifers that gain weight too slowly before first calving produce less milk in their first lactation and have poorer lifetime productivity. The investment in quality nutrition for replacement stock is therefore a direct investment in future herd performance.

Answers to Pilot Questions [Series 4]

Part 4.1: Housing for Ruminant Animals

1. Four objectives are: protection from adverse weather and predators; facilitation of feeding, watering, and health management; reduction of disease incidence; and provision of a safe environment for both animals and handlers.

2. Extensive systems provide no constructed housing and animals roam freely. Semi-intensive systems provide night housing with daytime grazing, which is the most common smallholder system in Nigeria. Intensive systems confine animals full-time in constructed housing with all inputs provided.

3. Raised slatted floors allow dung and urine to fall through to the ground below, keeping the animals dry and clean. This reduces contact with infective larvae of internal parasites, which develop in moist faeces, thereby lowering parasite burdens without heavy reliance on anthelmintics.

4. The pen should be oriented east to west to minimise direct sun exposure on the long sides throughout the day. Roofing materials include corrugated iron, which is durable and widely available, asbestos sheeting, or thatch for low-cost construction. Wide overhangs are essential to prevent rain splash into the pen.

5. Dairy cows require 6 to 8 square metres per animal in a stall. Adult sheep and goats require 0.8 to 1.5 square metres per animal in a group pen.

Part 4.2: Equipment Used in Ruminant Enterprises

1. Three feeding equipment types are: feed troughs, which hold concentrates and roughage at animal height to reduce waste; hay racks, which present fibrous roughage above ground to prevent trampling and contamination; and mineral block holders, which keep salt licks and mineral blocks accessible and clean.

2. A lactating dairy cow may consume 80 to 100 litres of water per day, and this full requirement must be met through adequate trough capacity and reliable water supply.
3. A cattle crush (squeeze chute) is a narrow enclosure with a head gate that immobilises a cow by limiting forward, backward, and lateral movement. It is used for safe examination, pregnancy diagnosis, vaccination, treatment, and AI procedures that require the cow to be stationary.
4. Four items for a farm first-aid kit are: bandaging materials (gauze, bandage roll, adhesive tape), antiseptic solution, clinical thermometer, and sterile syringes and needles.
5. Three safety rules are: always restrain animals properly before treatment; never stand directly behind large ruminants; and store medicines and chemicals in locked cabinets away from children.

Part 4.3: Milking Techniques and Milk Handling

1. Three factors are: cow health (particularly udder health and mastitis status), milking hygiene (clean equipment, clean hands, sanitised teats), and rapid cooling of milk after harvest.
2. The full-hand technique closes the thumb and forefinger around the teat base to trap milk, then closes the remaining fingers progressively to squeeze milk out. The teat must not be pulled or twisted because doing so causes pain, inhibits oxytocin release and let-down, and damages teat tissue, increasing mastitis risk.
3. The pre-milking routine is: assemble clean equipment and milking bucket; wash hands with soap; wipe each teat with a clean individual damp towel; fore-strip two to three streams into a strip cup to detect abnormal milk; and begin milking within one minute of first teat stimulus.
4. A milking machine applies intermittent vacuum via a pulsator to teat cups fitted with rubber liners. The pulsator alternates between a milking phase (vacuum extracts milk) and a massage phase (liner collapses to restore circulation). Main components are the vacuum pump, pulsator, cluster, milk receiver jar, and pipeline.

5. After milking, filter milk through a clean milk filter to remove debris, then cool rapidly in a bulk cooler or ice bath to below 4 degrees Celsius within two hours. Transport in clean, sealed, food-grade containers to the processor as quickly as possible.

Part 4.4: Young Stock Management

1. Immediate care steps are: clear membranes from nose and mouth to open airways; dry the animal with a clean towel, especially the head and chest; disinfect the navel cord by dipping in 10 percent iodine solution; ensure the newborn suckles or receives colostrum within two hours; and weigh and identify the animal within 24 hours.
2. Colostrum contains high concentrations of immunoglobulins (antibodies) that are absorbed intact through the gut wall only within the first 24 hours of life. These antibodies provide passive immunity against infectious diseases while the newborn's own immune system matures. Failure to receive adequate colostrum within this window dramatically increases the risk of disease and death.
3. Yankasa ewe lambs should be first mated at a live weight of 18 to 24 kilograms, typically achieved at 8 to 12 months of age. WAD doe kids should reach at least 12 kilograms before first mating.
4. Average daily gain (ADG) is the increase in body weight per day. It is calculated by subtracting the initial weight from the final weight and dividing the result by the number of days between the two measurements.
5. From weaning, replacement heifers are grouped by age and size, offered high-quality pasture or forage with concentrate supplementation as needed, weighed every four weeks, and compared against breed target weights. Vaccination, deworming, and mineral supplementation are maintained throughout. First mating is planned for when the heifer reaches the minimum target live weight for the breed, such as 250 kilograms for White Fulani.

References and Attributions [Series 4]

Textual References (Books and External Sources)

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Figures, Plates, Tables, and Boxes

- Figure 4.1: Types of ruminant housing systems: extensive, semi-intensive, and intensive Attribution: AI generated. Suggested OER search string: "ruminant housing systems extensive semi-intensive intensive diagram comparison OER".
- Table 4.1: Recommended space allowances and trough lengths for ruminant housing Attribution: AI generated. Suggested OER search string: "ruminant housing space allowance trough length cattle sheep goat Nigeria table OER".
- Table 4.2: Common equipment used in ruminant enterprises and their functions Attribution: AI generated. Suggested OER search string: "ruminant farm equipment feed trough hay rack cattle crush drenching gun burdizzo dip tank table OER".
- Figure 4.2: Correct hand milking technique using the full-hand method Attribution: AI generated. Suggested OER search string: "hand milking technique full-hand method finger position teat compression diagram OER".

- Plate 4.1: Machine milking of a dairy cow with a portable milking unit Attribution: AI generated. Suggested OER search string: "dairy cow machine milking portable unit teat cups milk receiver vacuum pump OER image".
- Box 4.1: Step-by-step care protocol for a newborn ruminant in the first 24 hours Attribution: AI generated. Suggested OER search string: "newborn ruminant care first 24 hours colostrum navel disinfection weighing identification OER box".
- Figure 4.3: Target growth curves for replacement stock in three Nigerian ruminant species Attribution: AI generated. Suggested OER search string: "ruminant replacement stock growth curve target weight White Fulani heifer Yankasa ewe WAD doe OER diagram".

Course code: AGE 302

Course title: Ruminant Animal Production

Course credit load: 2 Units

Series 5: Diseases, Parasites, Slaughtering, and Marketing of Ruminants

- **Part 5.1: Common Diseases of Ruminant Animals**
  - Sub Part 5.1.1: Viral diseases of sheep, goats, and cattle
  - Sub Part 5.1.2: Bacterial diseases of ruminants
  - Sub Part 5.1.3: Disease prevention and biosecurity measures
- **Part 5.2: Parasites of Ruminant Animals**
  - Sub Part 5.2.1: Internal parasites and their control
  - Sub Part 5.2.2: External parasites and their control
  - Sub Part 5.2.3: Strategic parasite control programmes
- **Part 5.3: Slaughtering of Ruminant Animals**
  - Sub Part 5.3.1: Pre-slaughter handling and ante-mortem inspection
  - Sub Part 5.3.2: Slaughter procedures and post-mortem inspection
  - Sub Part 5.3.3: Carcass evaluation and by-products of slaughter
- **Part 5.4: Marketing of Ruminant Animals and Products**
  - Sub Part 5.4.1: Live animal marketing channels and pricing
  - Sub Part 5.4.2: Marketing of ruminant products: meat, milk, hides, and skins

- Sub Part 5.4.3: Value addition and improving market access for ruminant producers

Introduction

The health of ruminant animals is fundamental to the productivity and profitability of any livestock enterprise. Diseases and parasites are among the most significant constraints to ruminant production in Nigeria, causing mortality, reduced growth rates, poor reproductive performance, and downgraded products. A sound understanding of the common diseases and parasites affecting sheep, goats, and cattle, together with practical prevention and control strategies, is therefore essential knowledge for every ruminant producer.

This Series concludes the course by addressing the final stages of the ruminant production chain. We begin with the major viral and bacterial diseases affecting ruminants in Nigeria, followed by internal and external parasites and strategic control programmes. We then examine the slaughtering process, from pre-slaughter handling through post-mortem inspection to carcass evaluation and by-product utilisation. The Series concludes with the marketing of live animals and ruminant products, and the opportunities for value addition to improve producer returns.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- SLO 5.1 identify the common viral and bacterial diseases of ruminants in Nigeria and describe their signs and control (Linked to Part 5.1),
- SLO 5.2 explain the principles of disease prevention and biosecurity in ruminant enterprises (Linked to Part 5.1),

- SLO 5.3 describe the major internal parasites of ruminants and explain their control (Linked to Part 5.2),
- SLO 5.4 identify the major external parasites of ruminants and describe their control (Linked to Part 5.2),
- SLO 5.5 explain the principles of a strategic parasite control programme (Linked to Part 5.2),
- SLO 5.6 describe pre-slaughter handling and ante-mortem inspection procedures (Linked to Part 5.3),
- SLO 5.7 outline the slaughter procedure and explain the purpose of post-mortem inspection (Linked to Part 5.3),
- SLO 5.8 describe carcass evaluation criteria and identify the by-products of ruminant slaughter (Linked to Part 5.3),
- SLO 5.9 describe the live animal marketing channels and factors affecting ruminant prices in Nigeria (Linked to Part 5.4),
- SLO 5.10 explain the marketing of ruminant products including meat, milk, hides, and skins (Linked to Part 5.4), and
- SLO 5.11 identify opportunities for value addition and improved market access for ruminant producers (Linked to Part 5.4).

5.1 Common Diseases of Ruminant Animals

5.1.1 Viral diseases of sheep, goats, and cattle

Peste des Petits Ruminants (PPR) is the most economically important viral disease of sheep and goats in Nigeria, caused by a morbillivirus. Clinical signs include high fever, nasal and ocular discharge, mouth ulcers, diarrhoea, and high mortality, particularly in young animals. PPR spreads rapidly through direct contact and is controlled by annual vaccination with a live

attenuated PPR vaccine. There is no treatment; supportive therapy reduces secondary bacterial complications. **Foot-and-Mouth Disease (FMD)** affects all cloven-hooved ruminants and is caused by an aphthovirus. Signs include vesicles (blisters) on the feet, mouth, and teats, resulting in lameness, reduced milk yield, and weight loss. FMD is highly contagious and causes enormous economic losses through trade restrictions.

Contagious Bovine Pleuropneumonia (CBPP), caused by **Mycoplasma mycoides** subsp. mycoides, is a serious disease of cattle causing severe pneumonia, pleuritis, and death in up to 50 percent of untreated cases. It is notifiable and subject to government eradication programmes. **Lumpy Skin Disease (LSD)** is a viral disease of cattle characterised by fever and widespread nodular skin lesions, causing hide damage and reduced production. Vaccination is the primary control measure for both CBPP and LSD.

Fill in the blank: The most economically important viral disease of sheep and goats in Nigeria is called _____.

Disease Name	Causative Agent	Species Affected	Main Clinical Signs	Primary Control Method
Peste des Petits Ruminants (PPR)	Morbillivirus (Paramyxoviridae family)	Sheep, goats	Fever, nasal/ocular discharge, mouth ulcers, diarrhea, pneumonia, high mortality	Mass vaccination campaigns, movement control, biosecurity
Foot-and-Mouth Disease (FMD)	Aphthovirus (Picornaviridae family)	Cattle, sheep, goats	Vesicles in mouth/feet, salivation, lameness, reduced milk yield	Vaccination, quarantine, restricted animal movement

Contagious Bovine Pleuropneumonia (CBPP)	Mycoplasma mycoides subsp. mycoides (small colony)	Cattle	Severe pneumonia, coughing, nasal discharge, weight loss, high mortality	Vaccination, culling of infected animals, movement control
Lumpy Skin Disease (LSD)	Capripoxvirus (Poxviridae family)	Cattle	Nodular skin lesions, fever, enlarged lymph nodes, reduced milk/meat yield	Vaccination, vector control, restriction of cattle movement
Rift Valley Fever (RVF)	Phlebovirus (Bunyaviridae family)	Cattle, sheep, goats (also zoonotic)	Fever, abortions, high mortality in young stock, liver damage	Vaccination (where available), mosquito control, restricted grazing in outbreak zones

Table 5.1: Common viral diseases of ruminants in Nigeria

5.1.2 Bacterial diseases of ruminants

Haemorrhagic Septicaemia (HS), caused by **Pasteurella multocida** serotype B or E, is the most important bacterial disease of cattle and buffaloes in Nigeria, occurring mainly in the wet season. Affected animals develop sudden high fever, profuse salivation, laboured breathing, and subcutaneous oedema of the throat, dying within 24 to 48 hours if untreated. Annual vaccination is the primary prevention strategy. **Blackleg**, caused by **Clostridium chauvoei**, affects young cattle between six months and two years of age, causing sudden death with gas-filled swellings in major muscle groups. Vaccination with clostridial multivalent vaccines prevents both diseases.

Brucellosis, caused by **Brucella abortus** in cattle and **Brucella melitensis** in sheep and goats, causes late-term abortion, retained placenta, reduced fertility, and orchitis in males. It is a zoonosis, transmissible to humans through contact with aborted material or consumption of raw milk. Control involves test-and-slaughter programmes, vaccination of heifers with Brucella S19 vaccine, and strict hygiene at parturition. **Contagious Caprine Pleuropneumonia (CCPP)**, caused by **Mycoplasma capricolum** subsp. capripneumoniae, is the goat equivalent of CBPP, causing severe pneumonia and high mortality in goat herds.

Fill in the blank: Haemorrhagic septicaemia is caused by the bacterium _____ multocida.

5.1.3 Disease prevention and biosecurity measures

Disease prevention in ruminant enterprises relies on a combination of vaccination, biosecurity, nutrition, and herd health monitoring. A vaccination calendar should be developed for each farm based on the locally prevalent diseases, with vaccines administered at the correct dose, route, and schedule recommended by the manufacturer and veterinary authorities. Records of all vaccinations should be maintained. Common vaccines used in Nigerian ruminant production include PPR, FMD, HS, blackleg, brucellosis (in heifers), and CBPP vaccines.

Biosecurity measures limit the entry and spread of pathogens within the farm. Key practices include quarantining new animals for a minimum of four weeks before introduction to the main herd, controlling visitor and vehicle access to animal areas, disposing of dead animals by burial or incineration rather than leaving carcasses in the open, maintaining clean water sources, and preventing contact between farm animals and wildlife. A clean-in, clean-out principle applied to housing and equipment, combined with regular disinfection of pens, water troughs, and handling facilities, significantly reduces disease pressure.

Fill in the blank: New animals must be quarantined for a minimum of _____ weeks before introduction to the main herd.

Vaccine	Disease	Species	Age/Timing	Booster Interval	Route

PPR vaccine	Peste des Petits Ruminants	Sheep, goats	At 3–4 months of age	Annual booster	Subcutaneous
FMD vaccine	Foot-and-Mouth Disease	Cattle, sheep, goats	At 6 months of age	Every 6–12 months	Subcutaneous or intramuscular
HS vaccine	Haemorrhagic Septicaemia	Cattle, buffalo	Before rainy season	Annual booster	Subcutaneous
Blackleg vaccine	Clostridial infection (Clostridium chauvoei)	Cattle, sheep	At 3–6 months of age	Annual booster	Subcutaneous
Brucellosis vaccine	Brucella abortus	Cattle	Heifers at 4–8 months	Single dose (no booster)	Subcutaneous
CBPP vaccine	Contagious Bovine Pleuropneumonia	Cattle	At 6 months of age	Annual booster	Subcutaneous

Box 5.1: Recommended vaccination calendar for a ruminant farm in Nigeria

Pilot questions 5.1

1. Describe the clinical signs of PPR and explain how it is controlled in sheep and goat flocks.
2. What is haemorrhagic septicaemia and which season is it most common in Nigeria?
3. Explain why brucellosis is considered a zoonotic disease and describe two control measures.
4. List four biosecurity measures that reduce disease entry and spread on a ruminant farm.
5. Name three diseases for which Nigerian ruminant producers should maintain annual vaccination.

5.2 Parasites of Ruminant Animals

5.2.1 Internal parasites and their control

Gastrointestinal nematodes (roundworms) are the most economically important internal parasites of ruminants in Nigeria. The most pathogenic genera include **Haemonchus contortus** (the barber's pole worm), which causes anaemia by blood-sucking in the abomasum, and **Trichostrongylus** and **Cooperia** species in the small intestine. Signs of heavy infestation include bottle jaw (submandibular oedema), anaemia, weight loss, diarrhoea, and death in severe cases, particularly in young animals. The FAMACHA system, which scores conjunctival pallor to estimate anaemia level, is a practical tool for targeted selective treatment of only the most affected animals.

Liver flukes, particularly **Fasciola gigantica** in tropical Africa, infest the bile ducts and cause chronic liver damage, weight loss, bottle jaw, and reduced production. Their lifecycle involves an aquatic snail intermediate host, so control includes strategic anthelmintic treatment with triclabendazole or closantel, drainage of waterlogged pastures, and snail control with molluscicides. **Tapeworms** (**Moniezia** species) are common in young ruminants on contaminated pastures, causing poor growth though rarely life-threatening. Treatment with albendazole or fenbendazole is effective.

Fill in the blank: The FAMACHA system scores _____ pallor to estimate anaemia level in ruminants infested with Haemonchus.

Parasite Name	Type	Site in Body	Clinical Signs	Anthelmintic Drug
Haemonchus contortus (Barber's pole worm)	Nematode (stomach worm)	Abomasum (true stomach)	Severe anemia, pale mucous membranes, bottle jaw, weakness	Albendazole, Ivermectin

Trichostrongylus spp.	Nematode (intestinal worm)	Small intestine	Diarrhea, weight loss, poor growth	Levamisole, Albendazole
Fasciola gigantica (Liver fluke)	Trematode (fluke)	Liver and bile ducts	Liver damage, anemia, reduced productivity, bottle jaw	Triclabendazole, Oxyclozanide
Moniezia spp. (Tapeworm)	Cestode (tapeworm)	Small intestine	Poor growth, diarrhea, visible proglottids in feces	Niclosamide, Praziquantel

Table 5.2: Common internal parasites of ruminants in Nigeria

5.2.2 External parasites and their control

Ticks are the most important external parasites of ruminants in Nigeria, causing direct damage through blood-sucking and skin irritation, and indirect damage as vectors of tick-borne diseases including East Coast Fever (**Theileria parva**), Babesiosis (**Babesia** spp.), and Anaplasmosis (**Anaplasma marginale**). Common tick species include **Amblyomma variegatum** (tropical bont tick) and **Rhipicephalus** (Boophilus) species. Control relies on regular acaricide application by dipping, spraying, or pour-on formulations, combined with pasture spelling and strategic use of tick-resistant breeds.

Flies cause significant production losses in ruminants. The tsetse fly (Glossina species) transmits trypanosomiasis, a debilitating protozoan disease causing wasting, anaemia, and death in non-tolerant breeds. Control in endemic areas relies on trypanotolerant breeds, trypanocidal drugs (diminazene aceturate or isometamidium chloride), and tsetse control through insecticide-treated targets and sterile insect release programmes. Other economically important flies include the nasal botfly (Oestrus ovis in sheep) and wound-infesting screwworm flies, both causing distress and secondary infections.

Fill in the blank: The tropical bont tick, _____ variegatum, is one of the most important tick species infesting ruminants in Nigeria.

5.2.3 Strategic parasite control programmes

A strategic parasite control programme is a planned, year-round approach to managing parasite burdens that considers the seasonal epidemiology of each parasite, uses diagnostic tools to guide treatment decisions, and minimises the development of anthelmintic resistance. The key components are: regular faecal egg count (FEC) monitoring to assess worm burdens before treatment decisions are made; targeted selective treatment (TST) using FAMACHA scores or body condition scores to treat only the most affected animals rather than the entire flock; strategic timing of treatments at high-risk periods such as early wet season, periparturient, and post-weaning; and rotation of anthelmintic drug classes (macrocyclic lactones, benzimidazoles, and levamisole) to delay resistance development.

For tick control, a strategic programme schedules acaricide treatments based on tick season intensity: more frequent treatment during peak wet-season tick challenge and reduced frequency in dry season, when tick populations are lower. Refugia management, which involves leaving a proportion of untreated animals to dilute resistant tick genes in the population, is an important resistance management strategy. Pasture rotation reduces reinfection with both worms and ticks by breaking the pasture transmission cycle. Integration of nutritional supplementation with parasite control is particularly important, as well-nourished animals mount stronger immune responses to parasites and recover faster from infestations.

Fill in the blank: The practice of treating only the most heavily parasitised animals rather than the entire flock is called targeted _____ treatment.

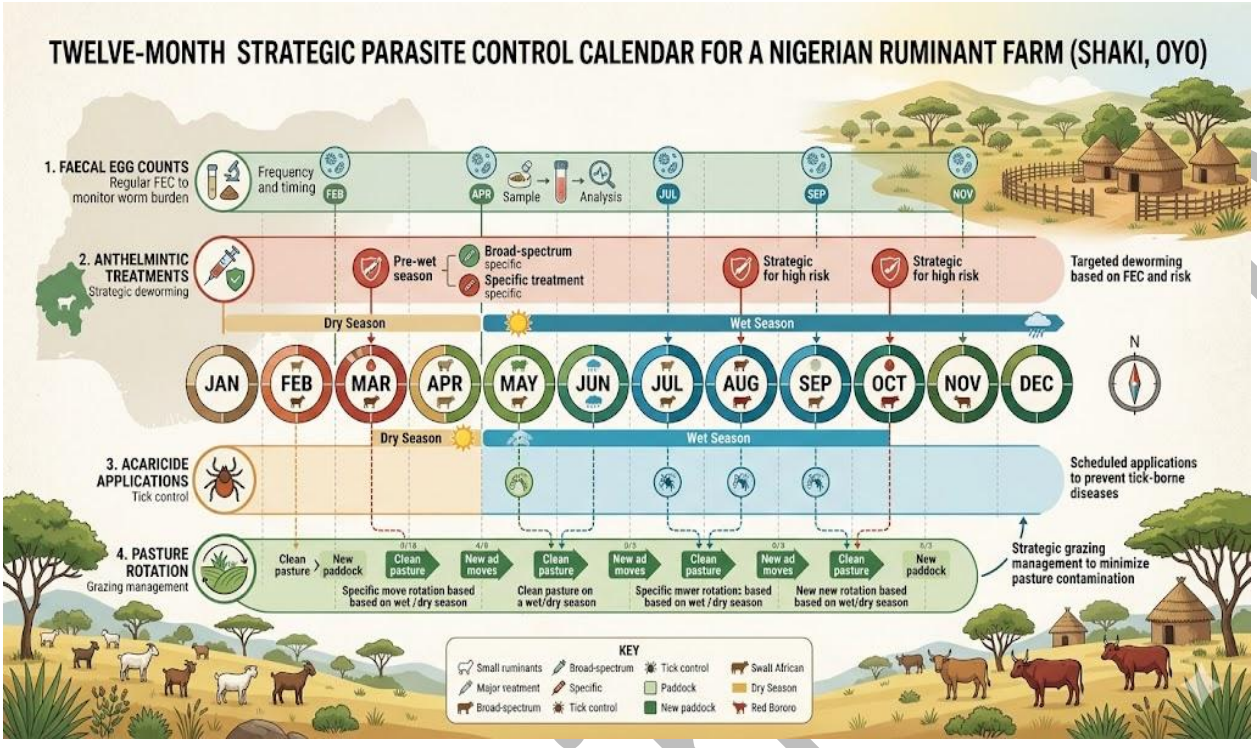

Figure 5.1: Strategic parasite control calendar for a Nigerian ruminant farm

Pilot questions 5.2

1. Describe the damage caused by Haemonchus contortus infestation and explain the FAMACHA system.
2. Name three tick-borne diseases of ruminants and state the tick species responsible for each.
3. Explain how trypanosomiasis is transmitted and describe two control strategies.
4. What is targeted selective treatment and why is it preferred over calendar-based blanket treatment?
5. Describe three components of a strategic parasite control programme for a ruminant farm.

5.3 Slaughtering of Ruminant Animals

5.3.1 Pre-slaughter handling and ante-mortem inspection

Pre-slaughter management significantly affects meat quality and animal welfare. Animals destined for slaughter should be transported with minimal stress, using properly designed vehicles with adequate space, ventilation, and non-slip flooring. Mixing unfamiliar animals during transport causes fighting and bruising that downgrades carcass quality. At the abattoir, animals should be rested for at least 24 hours and provided with clean water before slaughter; this allows glycogen reserves in muscles to be replenished, which is essential for proper post-mortem acidification (rigor mortis) and meat quality development.

Ante-mortem inspection is the examination of live animals by a veterinarian or trained meat inspector before slaughter to identify animals that are unfit for slaughter or require special handling. Animals are observed at rest and in motion for signs of disease, injury, abnormal behaviour, or nutritional distress. Animals with notifiable diseases such as FMD, CBPP, or anthrax are condemned and must not enter the slaughter line. Ante-mortem inspection protects public health by preventing diseased animals from entering the food chain.

Fill in the blank: Animals should be rested for at least _____ hours at the abattoir before slaughter to allow muscle glycogen to be replenished.

5.3.2 Slaughter procedures and post-mortem inspection

Humane slaughter requires that animals be rendered insensible to pain before bleeding. Methods include captive bolt stunning (mechanical or pneumatic) for cattle, and electrical stunning or, in Islamic halal slaughter, swift severance of the jugular vein, carotid artery, and trachea with a very sharp knife while the animal is in a restraint box. Immediate, complete bleeding (**exsanguination**) after stunning or incision is essential for meat hygiene and quality. Incomplete bleeding results in blood retained in tissues, promoting bacterial growth and reducing shelf life.

After bleeding, the carcass is dressed by removing the hide, head, feet, and viscera (evisceration) in a sequence designed to prevent contamination of the carcass with gut contents. Post-mortem inspection is conducted by the meat inspector on the head, viscera, and carcass, looking for

evidence of disease, parasitic lesions (such as cysticercosis cysts or liver fluke damage), abscesses, and contamination. Condemned organs or carcasses are removed from the food chain and disposed of safely. The carcass is then split into halves or quarters for chilling, hanging, and distribution.

Fill in the blank: The removal of internal organs from a slaughtered animal during carcass dressing is called _____.

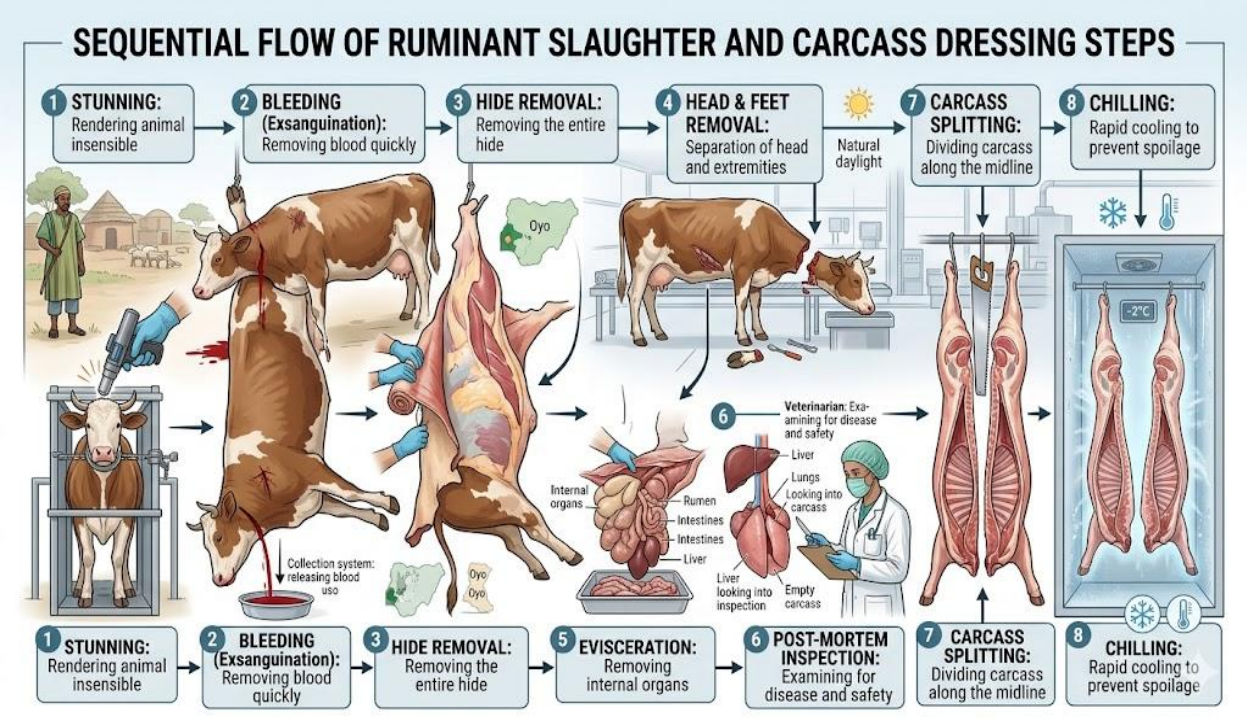

Figure 5.2: Sequential steps of ruminant slaughter and carcass dressing

5.3.3 Carcass evaluation and by-products of slaughter

Carcass quality is evaluated using the **dressing percentage**, which is the carcass weight expressed as a percentage of the live weight before slaughter. Nigerian indigenous cattle have dressing percentages of 45 to 52 percent, while well-finished exotic or crossbred cattle can achieve 55 to 60 percent. Carcasses are graded by conformation (muscle coverage), fatness (subcutaneous fat cover), and weight. A well-muscled, moderately fat carcass commands the highest market price. Carcass weight, carcass length, and the areas of the loin eye muscle are standard objective measurements used in carcass evaluation.

Slaughter by-products (offal) include edible by-products such as liver, kidney, heart, lungs, tripe (rumen and reticulum), intestines, tongue, and blood, all of which are widely consumed and traded in Nigerian markets. Non-edible by-products include hides and skins (processed into leather), bones (used for bone meal and gelatin), horns and hooves (used for glue and buttons), and rumen contents (used as compost or biogas feedstock). Efficient recovery and utilisation of all by-products maximises the economic return from each animal slaughtered and reduces abattoir waste.

Fill in the blank: The carcass weight expressed as a percentage of live weight before slaughter is called the _____ percentage.

Pilot questions 5.3

1. Why is pre-slaughter rest important for meat quality and how long should ruminants rest before slaughter?
2. Describe the purpose of ante-mortem inspection and name two conditions that would result in condemnation.
3. Explain the difference between stunning and halal slaughter and state the requirement common to both.
4. What is dressing percentage and what range is typical for Nigerian indigenous cattle?
5. Name four edible and two non-edible by-products obtained from ruminant slaughter.

5.4 Marketing of Ruminant Animals and Products

5.4.1 Live animal marketing channels and pricing

Live ruminant animals in Nigeria are marketed through a network of periodic markets, permanent livestock markets (such as Kafanchan, Maiduguriand Sokoto in the north), and direct farm-gate sales. The traditional marketing chain typically involves the producer selling to an assembler or broker, who aggregates animals and transports them to terminal wholesale markets,

where urban butchers purchase for slaughter and retail sale to consumers. This long chain absorbs a large share of the final price, leaving producers with a relatively small proportion of the consumer price.

Factors influencing live ruminant prices in Nigeria include season (prices peak during festivals such as Eid-el-Kabir, Christmas, and Sallah, when demand surges), animal sex and age (intact males command higher prices than females for sacrifice purposes), body condition and conformation (heavier, well-finished animals sell at premium prices), breed (improved or crossbred animals are valued higher by commercial buyers), and supply-demand dynamics influenced by disease outbreaks, droughts, and transport costs. Understanding these price drivers enables producers to plan sales timing and finishing programmes to maximise returns.

Fill in the blank: Live ruminant prices in Nigeria peak during festivals such as _____ when demand for sacrifice animals surges.

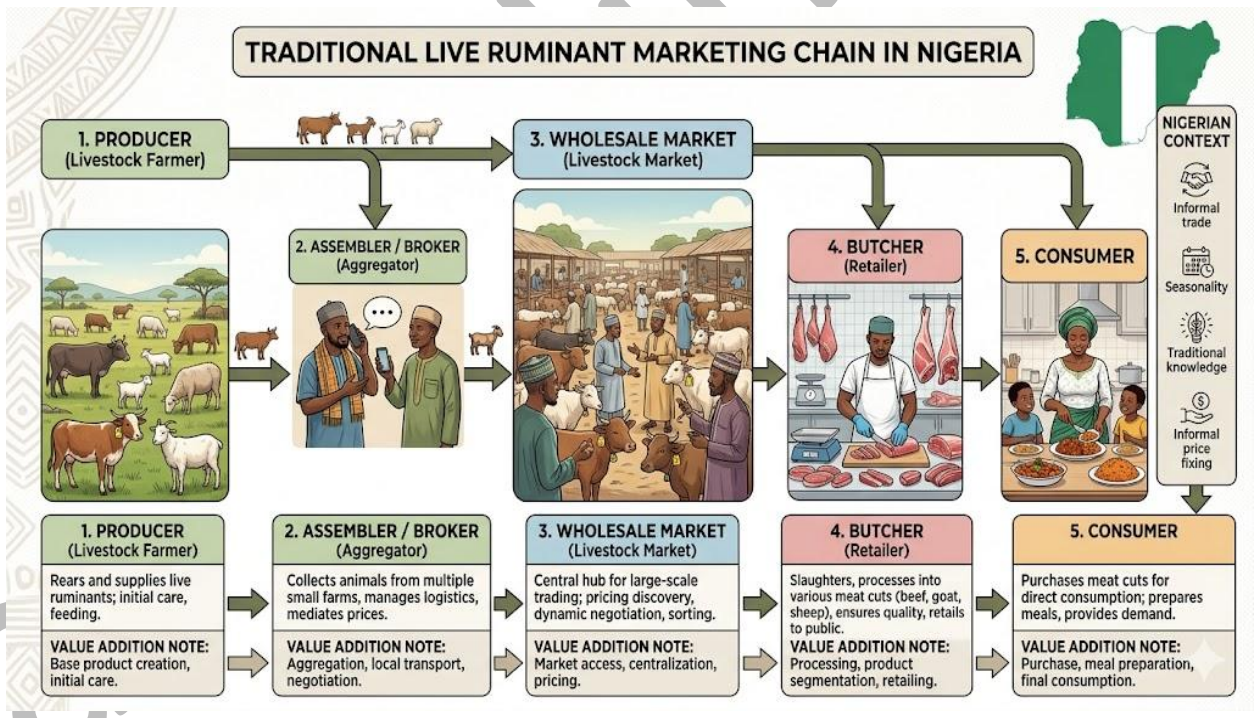

Figure 5.3: The traditional live ruminant marketing chain in Nigeria

5.4.2 Marketing of ruminant products: meat, milk, hides, and skins

Beef and chevon (goat meat) are the primary ruminant meat products traded in Nigeria. Carcasses are sold at abattoir wholesale prices per kilogram and distributed to retailers who sell primal cuts, offal, and processed products. The market for beef is dominated by unrefrigerated sales through open-air butcher stalls, which limits shelf life and increases food safety risks. Cold chain investment at the abattoir and retail levels would significantly extend shelf life, reduce wastage, and open higher-value institutional and export markets.

Milk marketing in Nigeria is largely informal, with raw milk sold directly from the Fulani herd or through roving milk sellers (**mai nono**) in the north, and fermented milk products such as **nono** (fresh yoghurt) and **kindirmo** (thick fermented milk) traded at local markets. Formal dairy processing plants purchase raw milk from smallholder suppliers and process it into pasteurised milk, yoghurt, and cheese for urban markets. **Hides and skins** are collected at abattoirs and tanneries, with Red Sokoto goat skins commanding the highest premium for fine leather export. Bones, horns, and hooves are traded to processors of bone meal, gelatin, and artisanal products.

Fill in the blank: In northern Nigeria, fermented fresh milk sold by roving Fulani traders is known locally as _____.

5.4.3 Value addition and improving market access for ruminant producers

Value addition involves processing or transforming ruminant products to increase their economic value, extend shelf life, and access higher-value markets. Examples include processing raw milk into yoghurt, cheese, and butter; drying and smoking meat to produce kilishi (spiced dried beef) or suya; tanning hides and skins into finished leather; and processing offal into sausages or pet food. Value addition retains more income at the producer or processor level and reduces post-harvest losses, which are significant in the absence of cold chain infrastructure.

Improving market access for ruminant producers requires addressing several structural constraints. Collective marketing through farmer cooperatives or producer groups gives smallholders greater bargaining power and reduces transaction costs. Investment in feeder roads and transport reduces the cost of moving animals and products from production areas to markets. Grading and certification systems that reward producers for quality improve incentives to invest in better management. Mobile price information services and market information systems help

producers make informed selling decisions. Government support through livestock development programmes, veterinary services, and extension can further strengthen the competitiveness of Nigerian ruminant producers in domestic and regional markets.

Fill in the blank: Dried, spiced beef processed and sold in Nigerian markets is known as _____.

Product	Processing Method	Target Market	Benefit
Kilishi (spiced dried beef)	Thinly sliced beef marinated in spices, sun-dried, lightly roasted	Urban consumers, roadside vendors, export niche	High-value meat snack, long shelf life
Yoghurt & Cheese	Milk pasteurized, cultured, fermented, processed into yoghurt or cheese	Schools, supermarkets, restaurants	Diversifies dairy income, improves nutrition
Leather	Hides processed through tanning into leather	Shoe, bag, and garment industries	Generates export revenue, supports local crafts
Bone Meal	Bones crushed, sterilized, ground into powder	Poultry and livestock feed mills	Provides cheap source of calcium and phosphorus
Suya (spiced grilled meat)	Beef skewered, coated with pepper-spice mix, grilled	Street food markets, restaurants	Popular fast food, quick cash turnover

Box 5.2: Value addition opportunities for Nigerian ruminant producers

Pilot questions 5.4

1. Describe the traditional live ruminant marketing chain in Nigeria and identify its main weakness.
2. State four factors that influence the price of live ruminants in Nigerian markets.
3. Describe two ruminant milk products sold in northern Nigeria and explain how they are produced.

4. What is value addition and give three examples of value-added ruminant products in Nigeria.
5. Identify three measures that can improve market access for smallholder ruminant producers.

Series Summary

This Series has completed the course by examining the health, slaughter, and marketing dimensions of ruminant animal production in Nigeria. We began with the major viral diseases, including PPR, FMD, CBPP, and Lumpy Skin Disease, and the principal bacterial diseases such as haemorrhagic septicaemia, blackleg, and brucellosis, describing their clinical signs and control measures. We then addressed the principles of disease prevention through vaccination calendars and biosecurity practices.

The parasitology section covered the economically important internal parasites (gastrointestinal nematodes and liver flukes) and external parasites (ticks and tsetse flies), and described strategic, resistance-aware control programmes integrating faecal egg count monitoring and targeted selective treatment. The slaughter section outlined pre-slaughter handling, ante-mortem and post-mortem inspection, humane slaughter procedures, carcass evaluation, and the recovery of edible and non-edible by-products. The Series concluded with live animal and product marketing, exploring the traditional marketing chain, price determinants, milk and hide markets, and value addition opportunities that can improve producer incomes and strengthen Nigeria's ruminant livestock sector.

Glossary of Terms

- **Ante-mortem inspection:** The examination of live animals by a meat inspector before slaughter to identify those unfit for human consumption or requiring special handling.
- **Anthelmintic:** A drug used to kill or expel internal parasites (helminths) from the gastrointestinal tract or tissues of ruminants.

- **Biosecurity:** A set of management practices designed to prevent the introduction and spread of infectious diseases within a livestock enterprise.
- **Brucellosis:** A zoonotic bacterial disease caused by Brucella species, causing abortion, infertility, and reduced production in ruminants and undulant fever in humans.
- **Dressing percentage:** The weight of the dressed carcass expressed as a percentage of the live body weight before slaughter, used as a measure of slaughter yield.
- **Evisceration:** The removal of internal organs (viscera) from a slaughtered animal during carcass dressing.
- **Exsanguination:** The process of draining blood from a slaughtered animal by severing the major blood vessels, essential for meat hygiene and quality.
- **FAMACHA system:** A targeted selective anthelmintic treatment method that uses conjunctival colour scoring to estimate the degree of anaemia caused by Haemonchus infestation.
- **Foot-and-Mouth Disease (FMD):** A highly contagious viral disease of cloven-hooved ruminants characterised by vesicles on the feet, mouth, and teats.
- **Haemorrhagic septicaemia:** A highly fatal bacterial disease of cattle caused by Pasteurella multocida, characterised by fever, oedema of the throat, and rapid death.
- **Kilishi:** A traditional Nigerian dried, spiced, and sun-dried beef product, representing a form of value addition to fresh beef.
- **Peste des Petits Ruminants (PPR):** A highly contagious and fatal viral disease of sheep and goats caused by a morbillivirus, controlled by annual vaccination.
- **Post-mortem inspection:** The examination of the head, viscera, and carcass of a slaughtered animal by a meat inspector to detect disease, parasitic lesions, or contamination.
- **Targeted selective treatment (TST):** A parasite control strategy in which anthelmintic treatment is applied only to animals identified as carrying high parasite burdens, preserving drug efficacy and reducing resistance.

- **Value addition:** The processing or transformation of raw ruminant products into higher-value goods such as yoghurt, leather, dried meat, or bone meal, increasing producer income and reducing post-harvest losses.

Concept Check Questions [Series 5]

Objective Questions

1. Define PPR. (Linked to SLO 5.1)
2. Which of the following is a zoonotic disease of ruminants? a) PPR b) Blackleg c) Brucellosis d) Lumpy Skin Disease (Linked to SLO 5.1)
3. The FAMACHA system is used to guide treatment for which internal parasite? a) Fasciola gigantica b) Haemonchus contortus c) Moniezia species d) Trichostrongylus (Linked to SLO 5.3)
4. The carcass weight expressed as a percentage of live weight at slaughter is called the _____ percentage. (Linked to SLO 5.8)
5. A traditional dried and spiced beef product that represents value addition in northern Nigeria is called _____. (Linked to SLO 5.11)

Short Answer Questions

6. Describe the clinical signs of haemorrhagic septicaemia and explain how it is prevented. (Linked to SLO 5.1)
7. What is the FAMACHA system and why is targeted selective treatment preferred over blanket treatment? (Linked to SLO 5.3, SLO 5.5)
8. Explain the purpose of ante-mortem inspection and state two conditions that would lead to condemnation of an animal. (Linked to SLO 5.6)
9. State three factors that influence live ruminant prices in Nigerian markets. (Linked to SLO 5.9)

10. Identify two biosecurity measures that prevent disease introduction onto a ruminant farm. (Linked to SLO 5.2)

Long Answer Questions

11. Describe the major viral and bacterial diseases affecting ruminants in Nigeria, outlining the causative agents, clinical signs, and control measures for each. (Linked to SLO 5.1, SLO 5.2)

12. Explain the economic importance of internal and external parasites in ruminant production and describe the principles of a strategic parasite control programme that minimises anthelmintic resistance. (Linked to SLO 5.3, SLO 5.4, SLO 5.5)

13. Describe the complete process from pre-slaughter handling through post-mortem inspection to the marketing and value addition of ruminant products in Nigeria. (Linked to SLO 5.6, SLO 5.7, SLO 5.8, SLO 5.9, SLO 5.10, SLO 5.11)

Answers to Concept Check Questions [Series 5]

Objective Questions

1. PPR (Peste des Petits Ruminants) is a highly contagious and fatal viral disease of sheep and goats caused by a morbillivirus, controlled by annual vaccination.
2. Correct answer: c) Brucellosis.
3. Correct answer: b) Haemonchus contortus.
4. Dressing.
5. Kilishi.

Short Answer Questions

6. Haemorrhagic septicaemia causes sudden high fever, profuse salivation, laboured breathing, and subcutaneous oedema of the throat, with death within 24 to 48 hours if

untreated. It is prevented by annual vaccination with Pasteurella multocida bacterin vaccine before the wet season.

7. The FAMACHA system scores the colour of the lower conjunctiva on a scale of 1 (pink, healthy) to 5 (white, severely anaemic) to estimate Haemonchus burden. Targeted selective treatment is preferred because blanket treatment of all animals accelerates anthelmintic resistance, whereas treating only the most affected animals maintains a refugia population of susceptible worms.

8. Ante-mortem inspection examines live animals before slaughter to protect public health by preventing diseased animals from entering the food chain. Two conditions leading to condemnation are clinical signs of FMD (vesicles on feet and mouth) and signs of anthrax (sudden death with unclotted blood from body orifices).

9. Three factors are: season and festival demand (prices peak during Eid-el-Kabir and Sallah); animal sex and age (intact males for sacrifice command premium prices); and body condition and conformation (heavier, well-finished animals attract higher prices).

10. Two biosecurity measures are: quarantining new animals for a minimum of four weeks before introduction to the main herd; and controlling visitor and vehicle access to animal areas to prevent pathogen entry.

Long Answer Questions

11. Basic response: Major viral diseases include PPR (morbillivirus, sheep and goats, controlled by annual vaccination), FMD (aphthovirus, all cloven-hooved ruminants, vesicles on feet and mouth), CBPP (Mycoplasma, cattle, severe pneumonia), and Lumpy Skin Disease (poxvirus, cattle, skin nodules). Major bacterial diseases include HS (Pasteurella multocida, cattle, throat oedema and rapid death), blackleg (Clostridium chauvoei, young cattle, gas-filled muscle swellings), and brucellosis (Brucella spp., abortion and infertility, zoonosis).

12. Value-added response: Several of these diseases are notifiable and subject to government eradication or control programmes. The economic impact extends beyond direct mortality to include reduced milk and growth performance, trade restrictions on FMD-positive

herds, and public health implications of brucellosis and other zoonoses. A farm vaccination calendar, combined with biosecurity and herd health monitoring, is far more cost-effective than treating outbreaks after they occur.

13. Basic response: Haemonchus contortus causes anaemia through blood-sucking; Fasciola gigantica causes liver damage; ticks transmit Theileria, Babesia, and Anaplasma; tsetse flies transmit trypanosomiasis. A strategic programme uses faecal egg counts to guide treatment timing, targeted selective treatment to reduce resistance selection, and rotation of drug classes.

14. Value-added response: Anthelmintic resistance, particularly to benzimidazoles and macrocyclic lactones, is already widespread in Nigerian ruminant herds, making resistance management a critical concern. The FAMACHA system reduces unnecessary treatments by up to 70 percent compared to calendar dosing, while refugia management preserves susceptible worm populations. For ticks, acaricide resistance is similarly problematic, requiring rotation of chemical classes and integration of non-chemical controls such as tick-resistant breeds and pasture spelling.

15. Basic response: Animals are rested 24 hours before slaughter and inspected ante-mortem. Slaughter uses stunning or halal cut followed by complete exsanguination. Carcass dressing removes hide, head, feet, and viscera. Post-mortem inspection checks for disease. Carcasses are graded by dressing percentage and conformation. Products include beef, offal, hides and skins, and bone meal. Value addition through kilishi, yoghurt, and leather increases producer income.

16. Value-added response: The post-slaughter marketing chain in Nigeria is characterised by limited cold chain infrastructure, resulting in short product shelf life and restricted market reach. Investment in abattoir cooling facilities and retail refrigeration would enable producers to access institutional buyers, hotels, and export markets. Collective marketing through cooperatives gives smallholders greater bargaining power in wholesale markets. The Red Sokoto goat skin, internationally recognised for fine leather quality, represents a high-value export opportunity that is currently under-exploited due to poor tannery capacity and quality control at the slaughter stage.

Answers to Pilot Questions [Series 5]

Part 5.1: Common Diseases of Ruminant Animals

1. PPR causes high fever, nasal and ocular discharge, ulcers in the mouth, severe diarrhoea, and high mortality, especially in young animals. It is controlled by annual vaccination of all sheep and goats with a live attenuated PPR vaccine. There is no specific treatment, but supportive therapy reduces secondary bacterial infections.
2. Haemorrhagic septicaemia is a highly fatal bacterial disease of cattle caused by Pasteurella multocida. It is most common in Nigeria during the wet season, when wet conditions favour bacterial survival and animal stress increases susceptibility.
3. Brucellosis is zoonotic because the causative bacteria (Brucella abortus and Brucella melitensis) can be transmitted to humans through contact with aborted material or consumption of raw milk, causing undulant fever. Two control measures are: vaccination of heifers at 3 to 8 months with Brucella S19 vaccine; and test-and-slaughter of reactor animals to eliminate infected animals from the herd.
4. Four biosecurity measures are: quarantining new animals for at least four weeks; controlling visitor and vehicle access to livestock areas; disposing of dead animals by burial or incineration; and maintaining clean, separate water sources to prevent faecal contamination.
5. Three diseases requiring annual vaccination are: PPR (for sheep and goats), haemorrhagic septicaemia (for cattle), and foot-and-mouth disease (for all cloven-hooved ruminants).

Part 5.2: Parasites of Ruminant Animals

1. Haemonchus contortus is a blood-sucking abomasal nematode that causes anaemia, bottle jaw (submandibular oedema), weight loss, and death in heavily infested young ruminants. The FAMACHA system scores the colour of the lower conjunctiva from 1 (pink, healthy) to 5 (white, severely anaemic) to identify animals requiring anthelmintic treatment, enabling targeted selective treatment of only the most affected individuals.

2. Three tick-borne diseases are: East Coast Fever (Theileria parva, transmitted by Rhipicephalus appendiculatus); Babesiosis (Babesia species, transmitted by Rhipicephalus (Boophilus) species); and Anaplasmosis (Anaplasma marginale, transmitted by several Rhipicephalus species).

3. Trypanosomiasis is transmitted by the bite of tsetse flies (Glossina species), which inject trypanosomes into the bloodstream. Two control strategies are: use of trypanotolerant breeds such as N'dama or WAD cattle in tsetse-endemic areas; and strategic treatment of affected animals with trypanocidal drugs such as diminazene aceturate or isometamidium chloride.

4. Targeted selective treatment (TST) applies anthelmintics only to animals identified as carrying heavy parasite burdens, using diagnostic tools such as FAMACHA or faecal egg counts. It is preferred over blanket treatment because treating all animals at every interval rapidly selects for anthelmintic-resistant worm populations, whereas TST preserves a refugia population of susceptible worms that dilutes the resistant gene pool.

5. Three components are: regular faecal egg count monitoring to assess worm burdens before making treatment decisions; targeted selective treatment to reduce unnecessary drug use and resistance pressure; and strategic timing of treatments at high-risk periods such as the early wet season, periparturient period, and post-weaning.

Part 5.3: Slaughtering of Ruminant Animals

1. Pre-slaughter rest is important because it allows muscle glycogen reserves to be replenished, which is necessary for proper post-mortem acidification (drop in muscle pH) that protects meat quality and extends shelf life. Animals should rest for at least 24 hours at the abattoir, with access to clean water.

2. Ante-mortem inspection examines live animals to identify those unfit for slaughter, protecting public health by preventing diseased animals from entering the food chain. Two conditions leading to condemnation are: clinical signs of FMD (vesicles on feet, mouth, or teats); and suspected anthrax (sudden death, unclotted dark blood from body orifices), which requires immediate quarantine of the entire consignment.

3. In conventional stunning, a captive bolt or electrical device renders the animal insensible before bleeding. In halal slaughter, the animal is conscious but restrained, and a swift, single cut severs the jugular vein, carotid artery, and trachea. The requirement common to both is immediate and complete exsanguination (bleeding out) to ensure meat hygiene and quality.

4. Dressing percentage is the carcass weight expressed as a percentage of live body weight before slaughter. For Nigerian indigenous cattle such as White Fulani, the typical dressing percentage ranges from 45 to 52 percent.

5. Four edible by-products are: liver, kidney, tripe (rumen and reticulum), and tongue. Two non-edible by-products are: hides and skins (processed into leather); and bones (processed into bone meal or gelatin).

Part 5.4: Marketing of Ruminant Animals and Products

1. The traditional chain involves the producer selling to an assembler or broker, who transports animals to a wholesale livestock market, where butchers purchase and slaughter for retail to consumers. The main weakness is that the long chain absorbs a large proportion of the final consumer price, leaving producers with a low share of total value generated.

2. Four factors are: season and festival demand (prices peak at Eid-el-Kabir and Christmas); animal sex and condition (intact males and well-finished animals command higher prices); breed (improved or crossbred animals are valued more highly by commercial buyers); and supply disruptions from disease outbreaks or drought that reduce market availability.

3. Nono is fresh fermented milk produced by allowing whole milk to stand until it sours naturally, producing a thin, tangy yoghurt-like product. Kindirmo is a thicker fermented milk product made by further concentrating nono through slow stirring or straining, producing a product with higher solids content. Both are sold locally by Fulani milk traders.

4. Value addition is the processing or transformation of raw ruminant products to increase their economic value and shelf life. Three examples are: kilishi (spiced, dried beef); yoghurt and cheese (from processed raw milk); and tanned leather (from processed hides and skins).

5. Three measures are: collective marketing through farmer cooperatives to increase bargaining power and reduce transaction costs; investment in feeder roads and transport infrastructure to reduce movement costs; and grading and certification systems that reward producers for quality, creating incentives for improved management practices.

References and Attributions [Series 5]

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- Usman, A., & Ibrahim, H. (2014). Analysis of beef marketing in selected markets in Sokoto State, Nigeria. International Journal of Agricultural Economics and Extension, 2(1), 45-52.

Figures, Plates, Tables, and Boxes

- Table 5.1: Common viral diseases of ruminants in Nigeria Attribution: AI generated. Suggested OER search string: "viral diseases ruminants Nigeria PPR FMD CBPP lumpy skin disease table OER".
- Box 5.1: Recommended vaccination calendar for a ruminant farm in Nigeria Attribution: AI generated. Suggested OER search string: "ruminant vaccination calendar Nigeria PPR FMD HS blackleg brucellosis CBPP schedule OER box".
- Table 5.2: Common internal parasites of ruminants in Nigeria Attribution: AI generated. Suggested OER search string: "internal parasites ruminants Nigeria Haemonchus Fasciola Trichostrongylus Moniezia anthelmintic table OER".
- Figure 5.1: Strategic parasite control calendar for a Nigerian ruminant farm Attribution: AI generated. Suggested OER search string: "strategic parasite control calendar ruminant Nigeria anthelmintic acaricide faecal egg count OER diagram".
- Figure 5.2: Sequential steps of ruminant slaughter and carcass dressing Attribution: AI generated. Suggested OER search string: "ruminant slaughter carcass dressing steps abattoir stunning bleeding evisceration inspection OER diagram".
- Figure 5.3: The traditional live ruminant marketing chain in Nigeria Attribution: AI generated. Suggested OER search string: "ruminant live animal marketing chain Nigeria producer assembler market butcher consumer flow OER diagram".
- Box 5.2: Value addition opportunities for Nigerian ruminant producers Attribution: AI generated. Suggested OER search string: "value addition ruminant products Nigeria kilishi yoghurt leather bone meal suya OER box".