NATIONAL OPEN UNIVERSITY OF NIGERIA

FACULTY OF AGRICUTURAL SCIENCES

ANP306 PHYSIOLOGY OF ANIMAL REPRODUCTION AND GROWTH

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MODULE 1

THE DIGESTIVE AND REPRODUCTION SYSTEMS

Introduction

In this module there are two units. The first unit deals with digestion in form animals while the second unit handles the issues of reproductive systems.

The objective of the module include

1. To acquaint you with the process of digestion in farm animals
2. To enable you understand the concept of reproductive system.

UNIT 1: DIGESTIVE SYSTEM

1.0 Introduction

This unit gives you a basic knowledge of what is meant by digestion, the importance of digestion, how food is digested, absorption and transport of nutrients and how the digestive process is controlled. The involvement of hormones and nerve regulators will also be discussed.

1.1 Objectives

By the time you have completed studying this unit, you should be able to:

- Define anatomy and physiology of domestic animals
- Highlight why digestion is important
- Be conversant with how the digestive process is controlled.

1.2 Anatomy

Is the science of the morphology or structure of animals or plants? It involves the dissecting of an animal or plant in order to determine the position, structure alginate etc. of its parts. The structure of an organism or body, or a model of it as dissected is also its anatomy.

1.3 Physiology

Is the branch of biology involved with or dealing with the functions and vital processes of living organisms ot their parts and organs or systems.

1.4 Domestic Animals

This refers to animals that have been tamed, such that they are kept under the care of man.

1.5 Feeding Habits of Farm Animals

The dentition of animals suits their feeding habits.

The dental formula of three typical herbivores is as follows:

Rabbit	1 2/1	C 0/0	PM 3/2	M 3/3	=	28
Horse	1 3/3	C 1/1	PM 3/3	M 3/3	=	40
Sheep	1 0/3	C 0/1	PM 3/3	M 3/3	=	32

In a mammal the teeth or dental formula indicate quite clearly the feeding habits of their owner. For man the teeth of mammals fall into four categories: In the front of the mouth are the chisel – shaped incisors (1) which are followed by a single sharp canine. Behind this are the premolars (PM) which may be modified for grinding but do not usually show the complex CUSP patterns of the back teeth or molars (M).

In herbivores the incisors are large, and are continuously self – sharpening by having a leading edge of enamel working against softer dentine in the opposing tooth. The carnines are usually absent and in their place a large gap, or diastema, exists which allows the food to be freely circulated in the mouth. The premolars tend to become molanform and work in conjunction with the molars, the two types of teeth making up a broad grinding surface. Like the incisors, they show continuous growth and also the most specialized of mammalian CUSP patterns.

In carnivores all the teeth find some use in feeding and, on the whole, there tend to more of them than in the herbivores. In the front of the mouth, the incisors are not particularly well developed though they find some use in grooming and nibbling meat from bones. Behind the incisors are a pair of very large carnines in each jaw and these stabbing teeth are used to catch prey. The premolars and molars are covered in enamel

and rise to sharp edges along the line of the jaw, the joint action of upper and lower teeth providing a powerful shearing action like scissors. These teeth, adapted for cutting and bone crunching, are called the carnassials and are found in the cat family and other families of carnivores.

Animals have varying structures and functions of the stomach depending on the type of farm animal. Cattle, sheep and goats have stomach with compartments, such animals have large pouch known as rumen. This is virtually a storage compartment in which newly eaten but un-chewed food is passed. Some digestion of cellulose and vitamin D synthesis occurdue to bacterial action taking place in the rumen. Some of the products of cellulose digestion are absorbed by the rumen. From the rumen, food passes to a smaller compartment called the reticulum. The food is then regurgitated by anti – peristaltic movement into the mouth where it is masticated. The food in form of pulp is again swallowed and moved to the third (3^{rd}) compartment known as omasum, and from here is then passed into the true stomach which is the fourth (4^{th}) compartment called the abomasums. Animals with this complicated stomach structures (as in fig. 1) are known as ruminants.

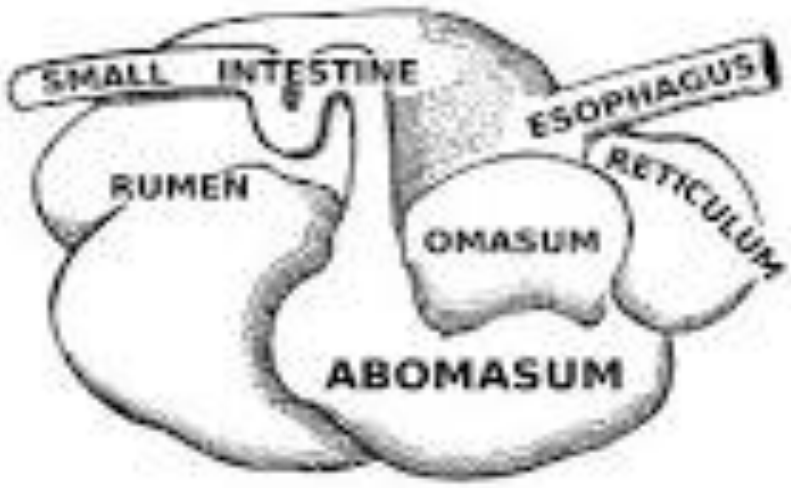

Fig. 1: A Cow's Stomach

A Monogastic Animal has a simple single-chambered stomach, compared to the ruminants. This includes almost all mammals, except for ruminants like Cows and Oxen. There are various species of monogastic animals ranging from humans, cats, dogs, mice, elephants, pigs etc.

Differences is that monogastic- simple stomach ie. Just a bag. Ruminant- stomach has several compartments. Ruminants also regurgitate their food to chew on it further.

A Pseudo ruminant is the classification of an animal based on its digestive tract. These types of animals are still considered forgot – fermenters, but only have three chambers in their stomach, not four like true ruminants do. Pseudo means 'false' so they are 'False' ruminants. The chambers are basically the reticulum, omasum and abomasum. They do not have the characteristic rumen that identifies ruminates ruminants instead they have enlarged cecum. The animals that are often referred to as Pseudo ruminants are all came lids (camels, alpacas, llamas, etc)

1.6 The Digestive System

The digestive system is made up of the digestive tract-a series of hollow organs joined in a long, twisting tube from the mouth to the anus-and other organs that help the body break down and absorb food.

Organs that make up the digestive tract are the mouth, oesophagus, stomach, small intestine, large intestine-also called the colon-retum, and anus. Inside these hollow organs is a lining called the mucosa? In the mouth, stomach, and small intestine, the mucosa, contains tiny glands that produce juice to help digest food. The digestive tract also contains a layer of smooth muscle that helps break down food and move it along the tract.

Two digestive organs, the liver and the pancreas, produce digestive juices that reach the intestine through small tubes called ducts. The gallbladder stores the liver's digestive juices until they are needed in the intestine. Parts of the nervous and circulatory systems also play major roles in the digestive system.

1.8 Importance of Digestion

When you eat foods-such as bread, meat, and vegetables-they are not in a form that the body can use as nourishment. Food and drink must be changed into smaller molecules before they can be absorbed into the blood and carried to cells throughout the body.

Digestion is the process by which food and drink are broken down into their smaller parts so th body can use them to build and nourish cells and to provide energy.

1.9 How food is digested?

Digestion involves mixing food with digestive juices, moving it through the digestive tract, and breaking down large molecules of food into smaller molecules. Digestion begins in the mouth, when you chew and swallow, and is completed in the small intestine.

1.10 Movement of Food through the System

The large, hollow organs of the digestive tract contain a layer of muscle that enables their walls to move. The movement of organ walls can propel and liquid through the system and can also mix the contents within each organ. Food moves from one organ to the next through muscle action called peristalsis. Peristalsis looks like an ocean wave traveling through the muscle. The muscle of the organ contracts to create a narrowing and then provide the narrowed portion slowly down the length of the organ. These waves of narrowing push the food and fluid in front of them through each hollow opening.

The first major muscle movement occurs when food or liquid is swallowed. Although you are able to start swallowing by choice, once the bolus touches the throat it becomes involuntary and proceeds under the control of the nerves.

Swallowed food is pushed into the esophagus, which connects the throat above with the stomach below. At the junction of the esophagus and storage there is a ring like muscle, called the lower esophageal sphincter, closing the passage between the two organs. As food approaches the closed sphincter, the sphincter relaxes and allows the food to pass through to the stomach.

The stomach has three mechanical tasks. First, it stores the swallowed food and liquid. To do this, the muscle of the upper part of the stomach relatively accepts large volumes of swallowed material. The second job is to mix up the food, liquid, and digestive juice produced by the stomach. The lower part of the stomach mixes these materials by its muscle action. The third task of the stomach is to empty its contents slowly into the small intestine.

Several factors affect emptying of the stomach, including the kind of food and the degree of muscle action of the emptying stomach and the small intestine. Carbohydrates, for example, spend the least amount of time in the stomach, while protein stays in the stomach longer, and fats the longest. The food dissolves into the juices from the pancreas, liver, and intestine, the content of the intestine are mixed and pushed forward to allow further digestion.

Finally, the digested nutrients are absorbed through the intestinal walls and transported throughout the body. The waste products of this process in undigested parts of the food, fibre, and older cells that have been shed from the mucosa. These materials are pushed into the colon, where they remain until the faces are expelled by a bowel movement.

Students' Assessment Exercise 1.1

Question: State in a sentence, why digestion is important

1.11 Digestion of Food

The Digestive glands that act first are in the mouth-the salivary glands. Saliva produced by these glands contains an enzyme that begins to digest starch from food into smaller molecules. An enzyme is a substance that speeds up chemical reactions in the body.

The next set of digestive glands is in the stomach lining. They produce stomach acid and an enzyme that digests protein. A thick mucus layer coat mucosa and helps keep the acidic digestive juice from dissolving the tissue of the stomach itself. In most people, the stomach mucosa is able to release the juice, although food and other tissues of the body cannot.

After the stomach empties the food and juice mixture (chyme) into the small intestine, the juices of two other digestive organs mix with the food. One of the main organs, the pancreas, produces a juice that contains a wide array of enzymes to break down the carbohydrate, fat, and protein in food. Other enzymes that are active in the process come from glands in the wall of the intestine.

The second organ, the liver, produces yet another digestive juice-bile. Bile is stored between meals in the gallbladder. At mealtime, it is squeezed out of the gallbladder, through the bile ducts and into the intestine to mix with the fat in food. The bile acids dissolve fat into the watery contents of the intestine, much like detergents that dissolve grease from frying pan. After fat is dissolved, it is digested by enzymes from the pancreas and the intestine.

1.12 Absorption and Transport of Nutrients

Most digested molecules of food, as well as water and minerals, are absorbed through the small intestine. The mucosa of the small intestine containsmany folds that are covered with tiny fingerlike projections called villi. In turn, the villi are covered with microscopic projections called microvilli. The structures create a vast surface area through which nutrients can be absorbed. Specialized cells allow absorbed materials to cross the mucosa into blood, where they are carried off in the bloodstream to other parts of the body for storage or further chemical change. This part of the process varies with different types of nutrients. Absorption of water takes place in the large intestine.

1.13 Carbohydrates.

The Dietary Guidelines for Americans 2005 recommend that 45 to 65 per cent of total daily calories be from carbohydrates. Foods rich in carbohydrates include bread, potatoes, dried peas and beans, rice, pasta, fruits, and vegetables. Many of these foods contain both starch and fiber.

The digestible carbohydrates-starch and sugar and sugar-are broken into simple molecules by enzymes in the saliva, in juice produced by the pancreas, the lining of the small intestine. Starch is digested in two steps. First, an enzyme in the saliva and pancreatic juice breaks the starch into molecules maltose. Then an enzyme in the lining of the small intestine spits the maltose into glucose molecules that can be absorbed into the blood. Glucose is carried through the bloodstream to the liver, where it is stored or used to provide energy for the work of the body.

1.13 Carbonhydrates

An enzyme in the lining of the small intestine digests sucrose, also known as table sugar, into glucose and fructose which are absorbed through the intestine into the blood.

Milk contains another type of sugar, lactose, which is changed into absorbable molecules by another enzyme in the intestinal lining.

1.14 Fibre

Ruminants depend mainly on fibre sources for nutrients whole fibre digestion in Pseudo-ruminants ranges from 40 – 70% depending on the type of fibre.

1.15 Protein.

Foods such as meat, eggs, and beans consist of giant molecules of protein that must be digested by enzymes before they can be used build and repair body tissues. An enzyme in the juice of the stomach starts the digestion of swallowed protein. Then in the small intestine, several enzymes from the pancreatic juice and the lining of the intestine complete the breakdown of huge protein molecules into small molecules called amino acids. These small molecules can be absorbed through the small intestine into the blood and then be carried to all parts of the body to build the wall and other parts of cells.

1.16 Fats.

Fat molecules are a rich source of energy for the body. The first step in digestion of a fat such as butter is to dissolve it into the watery content the intestine. The bile acids produced by the liver dissolve fat into tiny droplets and allow pancreatic and intestinal enzymes to break the large fat molecules into smaller ones. Some of these small molecules are fatty acids and cholesterol. The bile acids combine with the fatty acids and chole and help these molecules move into the cells of the mucosa. In these cells the small molecules are formed back into large ones, most of which pack into vessels called lymphatics near the intestine. These small vessels carry the reformed fat to the veins of the chest, and the blood carries the fat storage depots in different parts of the body.

1.17 Vitamins.

Another vital part of food that is absorbed through the small intestine are vitamins. The two types of vitamins are classified by the fluid in them can be dissolved: water-soluble vitamins (all the B vitamins and vitamin C) and fat-soluble vitamins (vitamins A, D, E, and K). Fat-soluble vitamin stored in the liver and fatty tissue of the body, whereas water-soluble vitamins are not easily stored and excess amounts are flushed out in the urine, water and salt. Most of the material absorbed through the small intestine is

water in which salt is dissolved. The salt and water come from the food liquid you swallow and the juices secreted by the many digestive glands.

1.18 Water and Salt.

Most of the material absorbed through the small intestine is water in which salt is dissolved. The salt and water come from the food and liquid you swallow and the juices secreted by the many digestive glands.

Students Assessment Exercise 1.2

Question: List any 2 digestive organs

1.19 How the digestive system is controlled

The digestive system is controlled by an interplay of both hormonal and nervous regulations

1.19.1 Hormone Regulators: The major hormones that control the functions of the digestive system are produced and released by cells in the mucosa of the stomach and small intestine. These hormones are released into the blood system of the digestive tract, travel back to the heart and through the arteries, and return to the digestive system where they stimulate digestive juices and cause organ movement.

The main hormones that control digestion are gastin, secretin, and cholecystokinin (CCK)

1. Gastin causes the stomach to produce an acid for dissolving and digesting some foods. Gastin is also necessary for normal cell growth in lining of the stomach, small intestine, and colon.
2. Secretin causes the pancreas to send out a digestive juice that is rich in bicarbonate. The bicarbonate helps neutralize the acidic stomach contents as they enter the small intestine. Secretin also stimulates the stomachto produce pepsin, an enzyme that digests protein, and stimulates the liver to produce bile.

3. CCK causes the pancrease to produce the enzymes of pancreatic juice, and causes the gallbladder to empty. It also promotes normal cell growth of the pancreas.
4. Additional hormones in the digestive system regulate appetite:
    a) Ghrelin is produced in the stomach and upper intestine in the absenceof food in the digestive system and stimulates appetite.
    b) Peptide YY is produced in the digestive tract in response to a meal in the system and inhibits appetite.

Both of these hormones work on the brain to help regulate the intake of food for nutrients. Researchers are studying other hormones that may play an inhibiting appetite, including glucagon-like peptide-1 (GPL-1), oxyntomodulin (+), and pancreatic polypeptide.

1.19.2 Nerve Regulators: Two types of nerves help control the action of the digestive system.

Extrinsic, or outside, nerves come to the digestive organs from the brain or the spinal cord. They release two chemicals, acetylcholine and adrenal Acetylcholine which causes the muscle layer of the digestive organs to squeeze with more force and increase the "push" of food and juice through the digestive tract. It also causes the stomach and intestine to squeeze or contract and decreases the flow of blood to these organs, slowing or stopping digestion.

The intrinsic, or inside, nerves make up a very dense network embedded in the walls of the oesophagus, stomach, small intestine, and colon, the inside nerves are triggered to act when the walls of the hollow organs are stretched by food. They release many different substances that speed up or down the movement of food and the production of juices by the digestive organs.

Together, nerves, hormones, the blood, and the organs of the digestive system conduct the complex tasks of digesting and absorbing nutrients from foods and liquids you consume each day.

1.20 CONCLUSION

This unit serves to define digestion, its importance and how it is regulated in domestic animals.

1.21 SUMMARY

You have studied digestion, the nutrients resulting from food digestion, as well as how digestion is regulated in domestic animals.

Answer to students Assessment Exercise 1.1

Digestion is important because food and drink must be changed into smaller molecules before they can be absorbed into the blood and carried to cells throughout the body.

Answer to students Assessment Exercise 1.2

Any two organs of digestion will include liver and pancreas

1.22 TUTOR MARKED ASSIGNMENT

i. Define digestion
ii. List any 4 nutrients
iii. List any 2 regulators of digestion

1.23 REFERENCES AND OTHER RESOURCES

Marshall P.T. and Hughes G.M.1980.Physiology of mammals and other vertebrates 2nd ed. Cambridge University Press, London

National Digestive Diseases Clearing House, Information way, Bethesda, MD20892-3570

UNIT 2: REPRODUCTIVE SYSTEM

2.0 INTRODUCTION

In this unit you will be studying reproduction in domestic livestock. Infact you will learn both the macroscopic and microscopic features of the reproductive tract of a typical farm animal such as a bull.

2.1 OBJECTIVES

At the end of this unit, you should be able to:

- Define reproduction.
- Identify some of the gross reproductive parts of bull or cow
- List some functions of the male and female reproductive parts
- Explain the relationship between reproduction and other disciplines.

2.2 REPRODUCTION

Reproduction is defined as the process sexual or asexual, by which animals and plants produce new individuals. Reproduction in animals normally involves heterosexual mating, conception, pregnancy, parturition and lactation. In this process, conception occurs as a result of the fusion of the male and female gametes, namely spermatozoon and ovum respectively, in a process known as fertilization. For animals to reproduce, they must first attain puberty or reproductive age, from when they become capable of gamete production. Reproduction in animals involves close coordination or synchronization of various physiological events and this is largely achieved through the actions of the reproductive hormones.

2.3 MALE REPRODUCTIVE ANATOMY (GROSS)

These comprise of feature as in fig.1 below.

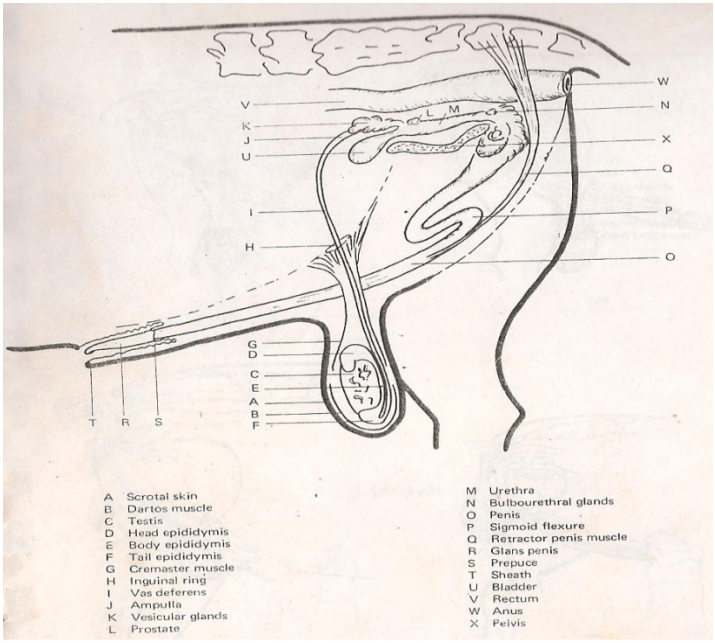

Fig.1: Bull Reproductive System (Gross)

SCROTUM (bag)-the pendulous sac or pouch containing the testes. It consist of

1. Skin-outer covering forprotection
2. Dartos muscle (flayed)-sheet of muscle under the skin of the ventral half of the scrotum.

Function: contract in cold weather to push the testes against the body for warmth or relax in hot weather to allow the testes to be cooled in the pendulous sacs.

TESTES (witness) testes.

Two in number located side by side

Oval or rounded shape

3x3x3 in. (125 x 75 x 75 mm)

Suspended by the spermatic cord

Function: twofold; to produce sperm, the male gamete or germ cell; and the male hormone testosterone.

EPIDIDYMIS (on testis) epididymides

Elongated body consisting of the convoluted tubular ductus epididymidis made up of sections.

1. Head (Caput epididymides) –Flattened portion attached to the anterior third and dorsal surface of each testes. It receives sperm from the testis.

2. Body (Corpus epididymidis) –cord-like tubular portion more loosely attached along the posterior border of the testis.

3. Tail (Caudaepididymidis)- the bulging terminal portion on the ventral surface of the testis.
4. ***Function:*** Transport, maturation, concentration and storage of sperm.

VAS DEFERENS (tube-carry away) vasa deferential- ductus deferens single tube originating at the tail of the epididymis and passing through the inguinal ring into the body cavity over the dorsal surface of the bladder into the anterior urethra

1. Duct-tubular portion
   1/8x20 in. (2 mm x 50 cm)
2. Ampulla (jug) ampullae-the enlarged vas deferens before it enters the urethra.
3. ***Function:*** transport and some storage of sperm, and active muscular contractions during coitus.

SPERMATIC CORD-attachment and support for the external genitalia to the body.

1. Inguinal ring-the opening in the abdominal wall through which the spermatic cord passes.
2. Cremaster muscle (suspend)- muscle attached sheetlike to the head of the testis and to the abdominal musculature.
3. ***Function:*** Support the testes and to raise them in cold weather and lower them in hot weather to maintain a relative constant temperature.

VESICULAR GLANDS (sac-acorn) glandulaevesiculares-paired-lobulated glands located dorsally and anterior to the junction of the bladder and urethra. They attach at this junction and are adjacent and lateral to the ampullae.

Function: Secrete accessory fluid to be added to the sperm to increase volume as they enter the urethra. Source of fructose for energy

Students' Assessment Assignment 2.1
State one main function of the spermatic cord

PROSTATE (before-to stand)- two –lobed body that is continuous and lies across the dorsal urethra adjacent to and posterior to the junction of the vesicular glands and urethra.
Function:Secrete accessory fluid to clean and lubricate the urethra during pre-coital stimulation and add a small amount to the semen.

URETHRA (to water) urethrae-tubular structure in the pelvic area which continues the length of the penis to the exterior
***Function*:** passageway for urine or semen.

BULBOURETHRAL GLANDS (bulge-water)-embedded paired oval glands in the bulbourethral muscle which is the root of the penis at the posterior extremity of the urethra.
Function: secrete accessory fluids to cleanse and lubricate the urethra in preparation for ejaculation. Small amounts will be added to the semen.

PENIS (tail) penises –male organ of copulation

1. Root-beginning portion in the area of the bulbourethra muscle.
2. Body or shaft-slender round main portion making up most of the length.
3. Sigmoid flexure (S curve)- a curving of the penis between the legs to shorten the length in the relaxed state.
4. Glans (acorn) glandes-the soft terminal portion of the penis.

Function: transport, insertion and deposition of sperm into the female system at copulation

RETRACTOR PENIS MUSCLES-paired muscles attached to the ventral sigmoid flexure and to the sacral area.

Function: To retract and fold the penis in the relaxed state through contraction and to allow extension of the penis during copulation by relaxing.

PREPUCE (foreskin)-this sheath surrounds the glands penis as an invagination of skin that has many folds which cover the penis in the extended state. The opening is covered by coarse hairs. Secretion of glands in the prepuce combined with cellular debris and bacteria form a substance called smegma.

SHEATH-usually used to describe the outer skin covering the preputial segment.

2.4 MALE REPRODUCTIVE ANATOMY (MICROSCOPIC)

The main microscope feature of the Bull Reproductive Anatomy as presented in fig. 2

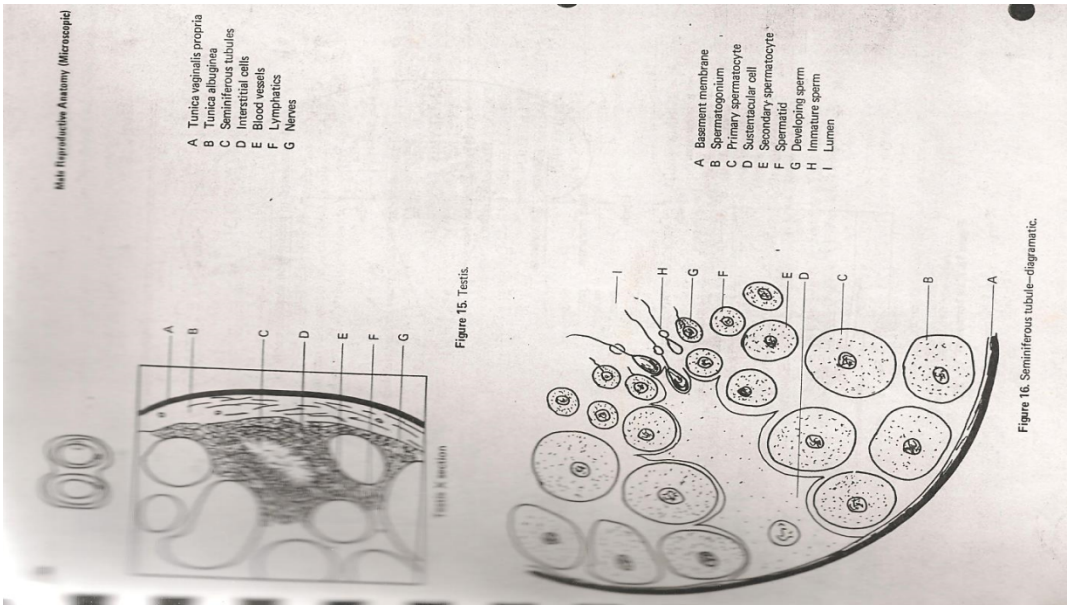

Fig.2: Seminiferous Tubule diagram

TUNICA VAGINALIS PROPRIA-outer connective tissue covering A continuation of the peritoneum

TUNICA ALBUGINEA-white connective tissue layer beneath the tunica vaginalispropria. Strands of the connective tissue penetrate the body of the testes.

Function: support.

SEMINIFEROUS TUBULES (seed-to bear-tubes)-tubular structures coiling through outer testes composed of the following constituents.

1. Basement membrane-a cellular support around the tubules
2. sustentacular cells (to support)-Sertoli's cell-tall irregular cells extending from the basement membrane to the lumen. The nucleus is pale staining and ovoid. The borders of the cell are indistinct and determined by the many spermatogenic cells on either side.

Function: to sustain or nourish the spermatids as they develop into spermatozoa.

SPERMATOGENIC CELLS(seed-to produce)-cells lying in 4 to 8 rows on the basement membrane between the sustentacular cells.

SPERMATOGONIUM (seed-generation) spermatogonia-cuboidal or spherical shaped cells resting on the basement membrane.

Function: to give rise to spermatocytes. They are the primitive cells from which all spermatozoa are derived.

PRIMARY SPERMATOCYTE (first seed cell)-larger rounded cells derived from the spermatogonia and lying adjacent to them on the lumen side, chromatin in the nuleus is readily visible.

Function: give rise to secondary spermatocytes.

SECONDARY SPERMATOCYTES-smaller cells lying inward and adjacent to the primary spermatocytes, fewer are seen because this stage of development is short lived.

Function: give rise to spermatids.

SPERMATIDS (seed-same)-smaller round cells lying inward from the secondary spermatocytes. Meiotic division from the primary spermatocyte has reduced the chromosome content to IN or haploid number. Formation of the spermatid completes spermatocytogenesis (seed cell production).

Spermatogenesis (seed production) - the metamorphosis of the spermatid to change into the spermatozoon. Microscopic forms of the spermatid going through development of

the head, body and tail of the sperm may be seen under high power in the area adjacent to the lumen of the seminiferous tubules. The head imbed themselves in the sustentacular cells until the metamorphosis is complete and then the immature cell with the cytoplasmic droplet on the tail is released into the lumen.

SPERMATOZOON (seed animal) spermatozoa-commonly called sperm (singular or plural)-the mature germ cell with distinct parts and a motile tail.

INTERSTITIAL CELLS (between-to set)-cells of leydig-large ovoid or polygonal cells occurring in groups between the seminiferous tubules. They assume the shape of the space left which is usually triangular.

Function: produce testosterone in response to interstitial Cell Stimulating Hormone from the anterior pituitary.

BLOOD VESSELS, LYMPH VESSELS AND NERVES-found in the interstitial areas

RETE TESTES (straight)-sperm collecting tubes lined with cuboidal epithelium.

EFFERENT DUCTS- 13 to 15 tubes coming from the rete testis.

Epithelium.

a. Secretory cells with large granules.
b. Ciliated columnar cells motile cilia beating away from the testis

Epididymis

SEROSA-shiny connective tissue covering to give shape and support.

Basement membrane.

EPITHELIUM- columnar with stereo cilia (non-motile). The cell height diminishes from head to tail and the cilia are much shorter in the tail.

FUNCTION.

1. Transportation-from testis to vas deferens. Peristaltic motion of the epididymis moves the sperm after the motile cilia of the vas efferens has moved them from the testis.

2. Concentration-moisture is absorbed thereby increasing the number of sperm per unit area.
3. Maturation-the cytoplasmic drop moves down the tail of the sperm as the sperm passes through the epididymis. Sperm in the tail or caudal portion have the droplet near the end of the tail or passed off.
4. Storage-mature sperm are concentrated and remain here for long periods until ejaculated or resorbed.

Vas deferens

FIBROSA- outermost coat of connective tissue containing blood vessels and nerves.

MUSCULAR COAT- very thick and consisting of outer and inner longitudinal muscle layers with a circular layer between.

MUCOSA (mucus coat)

1. Lamina propria-connective tissue supporting layer causing longitudinal folds projecting into the lumen.
2. Epithelium- stereociliated columnar epithelium in the lower vas deferens but changes to pseudostratified columnar epithelium as you move toward the ampulla.

AMPULLA- enlarged portion with thin muscular layer lumen and glands in the wall of the vas.

FUNCTION.

1. Transportation-by peristaltic contractions moving the sperm toward the urethra precoitus and during ejaculation.
2. Storage.

Vesicular glands

FIBROSA – outer connective tissue

MUSCULAR-thin inner circular and outer longitudinal

MUCOSA

1. Lamina propria-made into many deep folds capable of expanding greatly.
2. Epithelium-secretory tall columnar with a basal layer of irregularly distributed small cells.

FUNCTION –secret accessory fluid to act as a vehicle for the ejaculated sperm.

Prostate gland

FIBROSA-thin layer of connective tissue.

MUSCULAR LAYER- thin smooth muscle fibers.

Mucosa

1. Stroma (laid out for lying or sitting upon)-contains many individual glands opening by separate ducts into the urethra. It is composed of a mixture of connective tissue and smooth muscle fibers.

2. Epithelium-glandular tall columnar cells on the lumen with basal smaller rounded or flattened cells irregularly distributed.

FUNCTION-secrete a clear watery fluid that flushes and lubricates the urethra prior to ejaculation.

BULBOURETHRAL GLAND- very similar to the prostate

Urethra-the epithelium changes as the length of the urethra is traversed. Within the pelvic urethra, the epithelium is stratified columnar epithelium with areas of simple columnar cells. They gradually change through cuboidal to stratified squamous as the external opening is reached and continue over the surface of the glans penis and prepuce to the exterior.

2.5 FEMALE REPRODUCTIVE ANATOMY (GROSS)

This comprise of the following structure as in fig 3.

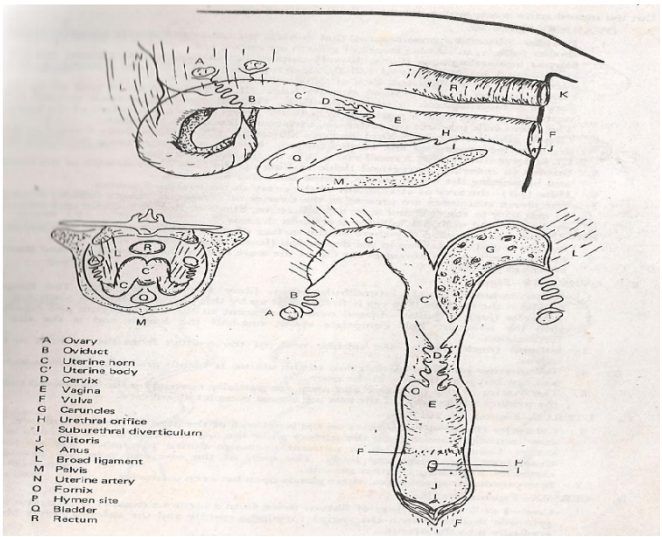

Fig. 3 Reproductive System of a Cow

(A) OVARY (egg) ovaries.

1. Number-two
2. Shape-oval or rounded; usually with rounded eminences.
3. Size-1 ¼ x ¾ x 1 ½ in. (30x20x40mm)
4. Support-broad ligaments in the upper abdominal cavity near the lateral margin of the pelvic opening.
5. Functio-produces the female gamete, the ovum; and produces female sex hormones, estrogens and progestogens.

(B) OVIDUCT (egg-tube) oviducts.

1. Number-two
2. Shape-tortuous tube from area of the ovary to the uterus.
3. Size-4 in. long (100 mm).
4. Suspension-broad ligament.
5. Function-passageway for sperm and the ovum, site of fertilization, and secretory organ.

(C) UTERUS (womb) uteri.

1. Number-2 distinct horns (cornua) and 1 prominent body.
2. Shape-Y.
3. Size-15 in long (37.5 cm) Body is 2 in long (50 mm) although it appears longer on the exterior. Miduterine horns are 1 in .in diameter (25 mm).
4. Suspension-broad ligament in the anterior mid-pelvic region.
5. Function-passageway, aids travel of sperm at breeding, secretary organ, incubator for fertilized ovum, supplies nutrients to embryo.

(D) CERVIX (neck) cervices.

1. Number-single thick-walled extension of the uterus.
2. Shape-round and tubular; firm like gristle.
3. Size-4 in. long (100 mm) and 1 in. in diameter (25 mm) varying considerably with breeds.
4. Support-posterior region of the broad ligament.

5. Function-passageway for sperm following breeding, secretes mucus, seals off the uterus in pregnancy, passageway for fetus at birth.

(E) VAGINA (sheath) vaginas, vaginae.

1. Number-single thin-walled structure
2. Shape-tubular.
3. size-8 in. long (200 mm) and 2 in. in diameter (50)
4. Location-posterior to the cervix extending to the external opening.
5. Function-receives the penis in copulation, secretes small amount of mucus, continuation of the fetus at birth.

(F) VULVA (opening) vulvas, vulvae.

1. Location-outer lips (labia) of the urogenital system.
1. 2. Function-acts as a passageway for urine, receptor for the penis during copulation, for the fetus at birth.

Students' Assessment Exercise 2.2

State any two main functions of the cervix

2.6 FEMALE REPRODUCTIVE ANATOMY (MICROSCOPIC)

As can be seen from fig. 4, the microscopic structures have many features in the Cow.

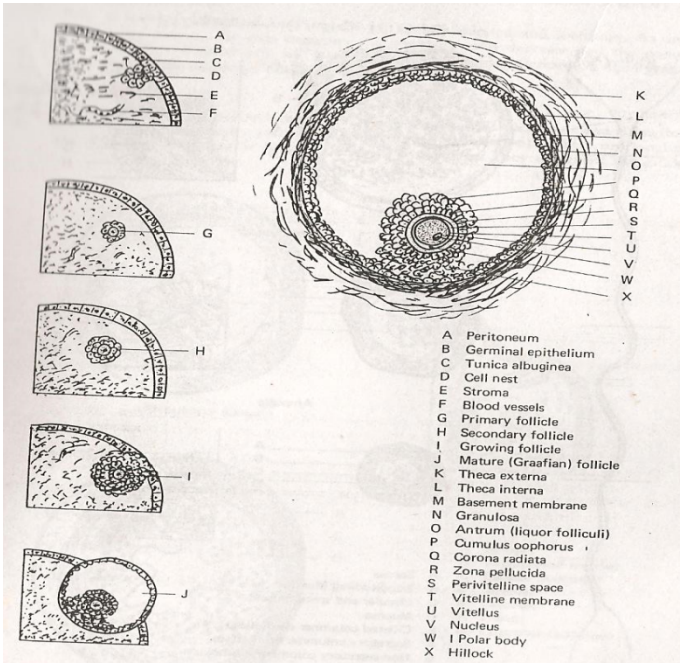

Fig. 4 Follicular development in the Cow

Ovary

(A) **PERITONEUM** (around-to stretch)-thin membrane of connective tissue covering the ovary. Helps maintain shape and structure.

(B) **GERMINAL EPITHELIUM**-single layer of cuboidal cells beneath the peritoneum. Sometimes difficult to distinguish. Gives rise to the female germ cell, the ovum.

(C) **TUNICA ALBUGINEA** (covering-white) –connective tissue membrane beneath the germinal epithelium maintaining structure.

(D) **CELL NEST**-invagination of a cord of germinal epithelial cells from which one will differentiate into an ovum and the others will become supportive cells.

(E) **STROMA-** mass of connective tissue, blood vessels, nerves and other inclusions giving a structural base to the organ.

(F) **PRIMARY FOLLICE**-the differentiated ovum surrounded by a single layer of follicular cells. Usually found near the periphery.

(G) **SECONDARY FOLLICE**-the ovum surrounded by two layers of follicular cells. Found deeper in the stroma.

(H) **GROWING FOLLICE**-the follicular cells surrounding the ovum separate forming an opening (antrum) filed with fluid (liquor folliculi). The ovum in its cell mass becomes periphery inside the follicle. Structural cells (theca eternal and theca interna) organize outside the follicular cells (granulose) and the whole follicle moves to periphery.

(I) **MATURE FOLLICE** (Graafian follicle)-the antrum continues to enlarge as it fills with fluid rich in estrogen and the follicle protrudes on the surface as a blister. From outside to the center of the follicle, the following cells should be observed:

1. Thecaexterna (sheath-outside)-connective tissue support.

2. Thecainterna (sheath-inside)-more dense connective tissue for support and source of estrogen, more vascular.
3. Basement membrane-thin connective tissue.
4. Granulosa (grain) membrane granulose-layered cuboidal cells lining the antrum and source ofestrogen.
5. Antrum (cave)-cavity filled with follicular fluid (liquor folliculi) rich in estrogen.
6. Cumulus oophorus (little mound-egg) discus proligerus-granulosa cells that form the outer layer of the ovum cell mass protruding into the antrum on its hillock.
7. Corona radiate (crown-radiating)-inner cell layer adjacent to the ovum with spindle shaped cells.
8. Zonapellucida (belt-shine through) oolemma-tansparent, non-cellular membrane. beneath the corona radiate.
9. Perivitelline space (around-yolk)-space between the zonapellucida and viteline membrane where the polar body is located.
10. Vitelline membrane-cell membraneof the ovum cytoplasma.
11. Vitellus (yolk)-cytoplasm of the ovum containing nutrients and cellular inclusions.
12. Nucleus-chromosome bearing portion of the ovum. May not be seen in some follicles because of the level of the section through it.
13. 13. Polar body-extruded nucleus containing one-half the chromosomes located in the perivitelline space.
14. Hillock-the stalk of supporting cells for the ovum cell mass consisting of granulosa cells.

(J) **CORPUS HEMORHAGICUM**-the ruptured follicle filled with blood and with a collapsedappearance of folded tissues,granulosa cells are starting todifferentiate into lutein cells which are larger and more rounded. This is an intermediate stage of change that lasts only a short time. Few will be found in histological sections.

(K) **CORPUS LUTEUM**- a mass of rounded cells of varying sizes. Shapes and sizes differ with stage of activity. Cells stain faintly. The theca lavers are less distinct than in the follicular stage. Luteal cells produce progesterone.

(L) **CORPUS ALBICANS**-mixture of connective tissue and degenerating lutein cells. This is the old corpus luteum being resorbed into the stroma. In the final stage, this will appear as a small dense mass of connective tissue.

(M) **ATRETIC FOLLICLE**-a dead follicle being invaded by connective tissue to be resorbed by the ovary. There are numerous atretic follicles in varying stages of disintegration and resorption as compared to those that reach the mature stage and rupture. The ovum may sometimes be found entrapped in connective tissue cells.

(N) **CYSTIC FOLLICLE-**An intact follicle that has not ruptured. Low LH or mechanical causes may be responsible. The walls are thickened and well organized. Theca and granulosa continue to secrete estrogen and the female is in continuous or intermittent estrus,

(O) **PERSISTENT CORPUS LUTEUM**-a corpus luteum that does not regress. Gross and microscopic structure may be the same as a mature corpus luteum. Cause is unknown but probably associated with the progresterone-FSH relationship. The female is in a pseudopregnant oranestrous state.

Oviduct

A. **SEROSA**- outer connective tissue cover. Shiny and tough. Gives shape and strength.
B. **MUSCULARS**-muscular layer beneath the serosa. Smooth muscle fibers run longitudinally in the outer layers and are circular or spiral in the inner layers. The thickness of the muscularis is very thin at the infundibulum but thickens markedly as it approaches the tubo-uterine junction. Peristaltic contractions move the sperm and ovum to the point of union.
C. **MUCOSA**-the lining made up of many longitudinal folds. These folds are more abundant in the ovarian end and decrease as they approach the uterine area. The mucosa is covered with three types of cells.

1. Ciliated columnar epithelium-columnar cells with hair-like motile projections capable of moving the ovum the surface by rhythmic beating.
2. Secretory cells (goblet cells) –columnar cells with basal nuclei and distended bodies filled with secretion. The secretions act as a medium for ova and sperm transport.
3. Nonsecretory cells-columnar cells which may be depleted secretory cells or supporting cells.

Cells in the infundibulum and ampulla are mostly ciliated and secretory. As one moves toward the uterus, the cilia decrease, the secretory cells decrease and the nonsecretory increase. The columnar cells will be pseudostratified during periods of rapid growth as at estrus and simple columnar during periods of rest.

Uterus

A. **SEROSA**-outer connective tissue cover. shiny and tough. gives shape and strength.
B. **MYOMETRIUM** (muscle-uterus) muscular layer-outer smooth fibers run longitudinally and the inner fibers circle or spiral around the mucosa. they act under the influence of estrogen to contract and relax (peristaltic motion) to move the sperm up the reproductive tract.
C. **ENDOMETRIUM** (mucosa)-consists of several parts.
    1. Stroma-structural connective tissue and supporting structures.
    2. Glands-organized tortuous spiraled glands embedded in the stroma with ducts opening on the intercaruncular areas of the cow and ewe and diffused over the uterine surface of the sow and mare. These secrete fluids for bathing the sperm and ovum and furnish nutrients in early pregnancy (sometimes called uterine milk).
    3. Epithelium-columnar cells varying from simple to pseudostratified depending upon activity. Occasionally ciliated cells may be found but they are scarce. These are seated on a basement membrane. These cells will slough during pregnancy in the cow and ewe

There is little change in the endometrium through the cornua and body of the uterus.

Cervix

A. **SEROSA**-outer connective tissue cover. Shiny and tough. Gives shape and strength.
B. **MUSCULARIS**-dense muscle and connective tissue with some smooth muscle fibers. Feels firm. Stretches to open during estrus to allow sperm to pass and during parturition to allow fetus to pass. Both are responses to estrogen. At other times, progesterone causes a closing of the opening.
A. **MUCOSA**-composed of many folds giving a fern-like appearance in cross section. Manysecretory cells line the crypts of the folds and the outer folds are covered with columnar epithelium. There are no organized glands in the cervix. Secretion is copious and thin under estrogen for sperm transport and tenacious and scarce under progesterone to seal the uterus during pregnancy.

Vagina

B. **SEROSA**-outer connective tissue cover. Shiny and tough. Gives shape and strength.
C. **MUSCULARIS**-not as well developed as the uterus. Inner layer is thick and circular and the outer layer is thin and longitudinal. Not very active.
D. **MUCOSA**-stratified squamous epithelium. The thickness and activity depend on hormones. Estrogen causes rapid growth and death of the outer layers. The epithelium extends deep papillae into the muscularis in the posterior vagina while few are present in the anterior portion. The columnar epithelium of the cervix gradually changes to the stratified squamous where the cervix joins the vagina. Some secretory cells may be found in the fornix area of the cow. The hardened surface of the stratified squamous cells protects the vagina against abrasion of the penis during copulation.

Vulva

A. **STROMA**-structural tissue of connective tissue, fat cells and the vestibular glands (glands of Bartholin).
B. **MUCOSA**-thick stratified squamous with distinct deep penetrating papillae.

2.7 REPRODUCTION AND OTHER DISCIPLINES

A proper understanding of animal reproduction would involve some knowledge of reproductive physiology, endocrinology, environmental physiology, cell biology, immunology, genetics, biochemistry, sociology, reproductive diseases, psychology, embryology, obstetrics and a few others. In agriculture, animal production revolves around reproduction. Livestock products such as eggs and milk are direct outputs from reproductive processes. Meat production depends primarily on production of offsprings which are subsequently grown out or fattened for slaughter.

2.8 CONCLUSION

This unit attempts to give a brief description of the reproductive tracts of male and female farm animals using cattle as a model. Both gross and microscopic features were described as well as the need to understand some other disciplines that are related to reproduction.

Answers to Students' Assessment Exercise 2.1

The main function of the spermatic cord is attachment and support for the external genitalia to the body.

Answers to Students' Assessment Exercise 2.2

Two main functions of the cervix are 1. Serves as passage way for the spermatozoa during breeding 2.Seals off the uterus in pregnancy.

2.9 SUMMARY

The process of reproduction in livestock involves both the male and female animals in healthy and good condition. The science of reproduction however needs an understanding of other related disciplines.

2.10 TUTOR- MARKED ASSIGNMENT

Describe the gross reproductive anatomy of a named male farm animal.

2.11 REFERENCES AND OTHER RESOURCES

Osinowo O.A.2006. Introduction to Animal Reproduction. Sophie Academic Services Ltd. P.O. Box 47,UNAAB Post Office, Abeokuta, Nigeria.

Sorensen Jr. A.M. Repro Lab.A Laboratory Manual for Animal Reproduction. 3rd Edition. Kendall/Hunt Publishing Company, U.S.A.

MODULE 2

Introduction

In this module, you will be studying 2 units. The first unit deals with the topic lactation, while the second unit in this module handles the nervous system.

The objectives of this module include

1. To acquaint you with process of lactation in livestock
2. To enable you understand the nervous system in livestock

UNIT 3: LACTATION

3.0 Introduction

In this unit you will be studying about lactation, the milk ejection reflex and species differences. Also, factors affecting milk ejection reflex will be studied.

3.1 Objectives

By the end of your studying this unit, you should be able to:

- Explain Lactation
- List any example of neuroendocrine reflex
- State any species differences in lactation

3.2 **Lactation.**

Lactation is the secretion of milk by a mammary gland (fig. 1). The period during which milk is secreted or the suckling of young.

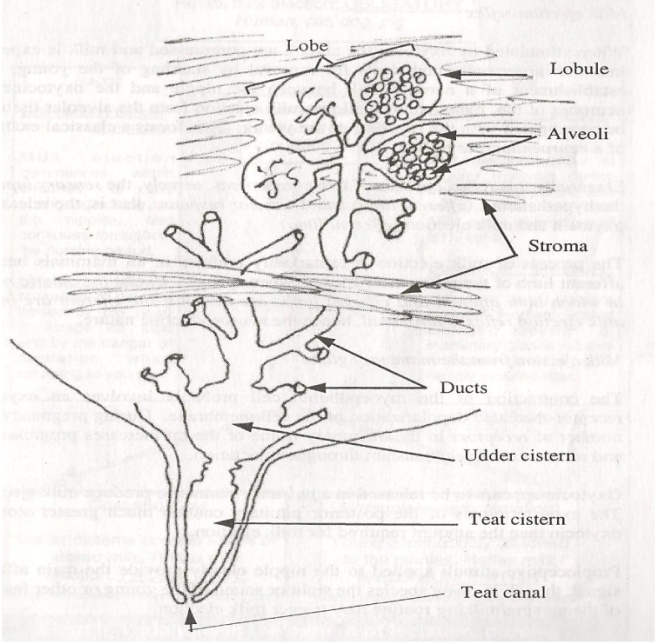

Fig. 1 Anatomy of the Mammary Gland

Mammary glands are identical in fine structure and consist of alveolar tissue within which milk is continuously secreted during lactation. An alveolar structure increases by about 10,000 – fold the surface area for secretion relative to the external size of the mammary gland but this also complicates the problem of milk removal.

Small ducts generate substantial surface tension forces that oppose the movement of fluids; suction is therefore a relatively ineffective method for the removal of alveolar milk. The problem has been solved by covering the alveolar with a basket – like network of myoepithelium which contracts in response to oxytocin released from the posterior pituitary.

3.3 Milk Ejection Reflex

When stimulated by oxytocin the alveoli are compressed and milk is expelled into the larger collecting ducts for removal by suckling of the young. The establishment of a nervous link between the nipple and the oxytocinergic neurons of the hypothalamus allows milk ejection from the alveolar tissue to be coordinated with the suckling of the young. This forms a classical example of a neuroendocrine reflex.

Essentially the milk ejection reflex consist of two component, namely, the sensory input to the hypothalamus (afferent limb) and the motor response, that is the release of oxytocin and milk ejection (efferent limb)

3.4 Species Differences

In humans, cats, dogs and pigs, more than 80% of the milk produced by the mammary glands are stored in the alveoli. In these species, reflex milk ejection is obligatory. In the goat, and to a lesser extent in other ruminants, most of the milk is stored in voluminous cisterns from where it can be withdrawn by suction applied to the nipple. Substantial milk yields have been obtained in the goat after denervation. In these species therefore, a milk ejection reflex is not essential for the feeding of the young, though it could facilitate the process.

In the cow, the remaining portion of the milk (20-50%) stored in the alveoli can only be removed by milk ejection. Stimulation of the teat triggers the nerve receptors in the skin and nerve impulse to be transmitted up the spinal cord to reach the hypothalamus where they cause oxytocin release from the posterior pituitary into the circulation. oxytocin is carried in the blood to the mammary gland where it causes the my epithelial cells to contract , thereby expelling the milk from the alveoli into the cisterns.

Student's Exercise 3.1

Is milk ejection reflex a typical example of neuroendocrine reflex?

3.5 Factors Affecting the Milk Ejection Reflex

The milk ejection reflex like other reflexes can become conditioned so that the reflex occurs in responses to visual or a coustic stimulus (define) ie. Esther seeing or hearing a particle thing or sound which the cow has come to associate with milking.

Reflex milk ejection is inhibited by adrenalin at the level of the mammary gland, by opioid peptides influencing secretion from the terminals of oxytocin-producing neurons in the posterior pituitary, and by noradrenaline acting on betadrenoceptors within the central nervous system.

Student's Exercise 3.2

List one hormone that inhibits milk ejection reflex

3.6 Conclusion

You have studied lactation and the fact that there are species differences in lactation. The fact that the milk ejection reflex is one of the neuroendocrine reflexes was also studied.

Answer to Student's Assessment Exercise 3.1

Two examples of neuroendocrine reflex are:

a) Milk ejection reflex

b) Ovulation in rabbits

Answer to Student's Assessment Exercise 3.2

Adrenalin

3.7 Summary

Lactation is the secretion of milk by the mammary gland. Milk ejection reflex is a typical neuroendocrine reflex, but there are species differences and certain factors affect the milk ejection reflex. All these have been shown in this unit.

3.8 Tutor-Marked Assignment

Describe the process of milk ejection

3.9 References/Further Readings

Osinowo O.A.2006. Introduction to Animal Reproduction. Sophie Academic Services Ltd. P.O. Box 47, UNAAB Post Office, Abeokuta, Nigeria.

Marshall P.T. and Hughes G.M.1980.Physiology of mammals and other vertebrates 2nd ed. Cambridge University Press, London

UNIT 4: NERVOUS SYSTEM

4.0 Introduction

In this unit, you will be studying about the nervous system, the structure of the nervous system and the anatomy in vertebrates. You will also learn about the function of the nervous system.

The nervous system derives its name from nerves, which are cylindrical bundles of fibers that emanate from the brain and central cord, and branch repeatedly to innervate every part of the body.

4.1 Objectives

At the end of this unit, you should be able to:

- Define the nervous system
- Explain the function of the nervous system
- Understand intrinsic pattern generation

4.2 Nervous system

Definition:-The **Nervous System** is the part of an animal's body that coordinates the voluntary and involuntary actions of the animal and transmits signals between different parts of its body. In most types of animals it consists of two main parts, the central nervous system (CNS) and the peripheral nervous system (PNS). The CNS contains the brain and spinal cord. The PNS consists mainly of nerves, which are long fibers that connect the CNS to every other part of the body. The PNS includes motor neurons, mediating voluntary movement, the autonomic nervous system, (comprising the sympathetic nervous system and the parasympathetic nervous system and regulating involuntary functions) and the enteric nervous system, a semi-independent part of the nervous system whose function is to control the gastrointestinal system.

Nervous systems are found in most multicellular animals, but vary greatly in complexity. The only multicellular animals that have no nervous system at all are sponges, placozoans and mesozoans, which have very simple body plans. The nervous systems of ctenophores (comb jellies) and cnidarians (e.g., anemones, hydras, corals

and jellyfishes) consist of a diffuse nerve net. All other types of animals, with the exception of a few types of worms, have a nervous system containing a brain, a central cord (or two cords running in parallel), and nerves radiating from the brain and central cord. The size of the nervous system ranges from a few hundred cells in the simplest worms, to 100 billion cells in humans.

At the most basic level, the function of the nervous system is to send signals from one cell to others or from one part of the body to others. The nervous system is susceptible to malfunction in a wide variety of ways, as a result of genetic defects, physical damage due to trauma or poison, infection, or simply aging. The medical specialty of neurology studies the causes of nervous system malfunction, and looks for interventions that can prevent it or treat it. In the peripheral nervous system, the most commonly occurring type of problem is failure of nerve conduction, which can have a variety of causes including diabetic neuropathy and demyelinating disorders such as multiple sclerosis and amyotrophic lateral sclerosis.

Neuroscience is the field of science that focuses on the study of the nervous system.

4.3. Structure of the nerve cell

Nerves are large enough to have been recognized by the ancient Egyptians, Greeks, and Romans, but their internal structure was not understood until it became possible to examine them using a microscope. A microscopic examination shows that nerves consist primarily of the axons of neurons, along with a variety of membranes that wrap around them and segregate them into fascicles. The neurons that give rise to nerves do not lie entirely within the nerves themselves—their cell bodies reside within the brain, central cord, or peripheral ganglia.

All animals more advanced than sponges have nervous systems. However, even sponges, unicellular animals, and non-animals such as slime molds have cell-to-cell signalling mechanisms that are precursors to those of neurons. In radially symmetric animals such as the jellyfish and hydra, the nervous system consists of a diffuse network of isolated cells. In bilaterian animals, which make up the great majority of existing species, the nervous system has a common structure that originated early in the Cambrian period, over 500 million years ago.

At the cellular level, the nervous system is defined by the presence of a special type of cell, called the neuron, also known as a "nerve cell". Neurons have special structures that allow them to send signals rapidly and precisely to other cells. They send these signals in the form of electrochemical waves traveling along thin fibers called axons, which cause chemicals called neurotransmitters to be released at junctions called synapses. A cell that receives a synaptic signal from a neuron may be excited, inhibited, or otherwise modulated. The connections between neurons form neural circuits that generate an organism's perception of the world and determine its behavior. Along with neurons, the nervous system contains other specialized cells called glial cells (or simply glia), which provide structural and metabolic support.

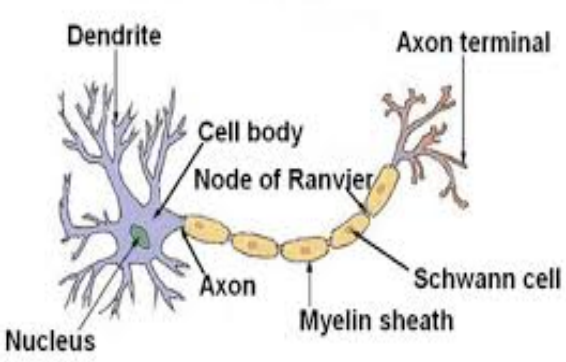

Fig. 1 Structure of a typical neurone

Dendrite
Soma
Axon
Nucleus
Node
Ranvier
Axon terminal
Schwann cell
Myelin sheath

The nervous system is defined by the presence of a special type of cell—the neuron (sometimes called "neurone" or "nerve cell") as in fig. 1. Neurons can be distinguished from other cells in a number of ways, but their most fundamental property is that they

communicate with other cells via synapses, which are membrane-to-membrane junctions containing molecular machinery that allows rapid transmission of signals, either electrical or chemical. Many types of neuron possess an axon, a protoplasmic protrusion that can extend to distant parts of the body and make thousands of synaptic contacts. Axons frequently travel through the body in bundles called nerves.

Even in the nervous system of a single species such as humans, hundreds of different types of neurons exist, with a wide variety of morphologies and functions. These include sensory neurons that transmute physical stimuli such as light and sound into neural signals, and motor neurons that transmute neural signals into activation of muscles or glands; however in many species the great majority of neurons receive all of their input from other neurons and send their output to other neurons.

4.6 Glial Cells

Glial cells (named from the Greek for "glue") are non-neuronal cells that provide support and nutrition, maintain homeostasis, form myelin, and participate in signal transmission in the nervous system.[9] In the human brain, it is estimated that the total number of glia roughly equals the number of neurons, although the proportions vary in different brain areas. Among the most important functions of glial cells are to support neurons and hold them in place; to supply nutrients to neurons; to insulate neurons electrically; to destroy pathogens and remove dead neurons; and to provide guidance cues directing the axons of neurons to their targets. A very important type of glial cell (oligodendrocytes in the central nervous system, and Schwann cells in the peripheral nervous system) generates layers of a fatty substance called myelin that wraps around axons and provides electrical insulation which allows them to transmit action potentials much more rapidly and efficiently.

Students 'Assessment Exercise 4.1

List 2 types of nervous system cells

2. **Structure of the nerve cell**

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3. Function of the Nervous System

At the most basic level, the function of the nervous system is to send signals from one cell to others or from one part of the body to others. There are multiple ways that a cell can send signals to other cells. One is by releasing chemicals called hormones into the internal circulation, so that they can diffuse to distant sites. In contrast to this "broadcast" mode of signaling, the nervous system provides "point-to-point" signals—neurons project their axons to specific target areas and make synaptic connections with

specific target cells. Thus, neural signaling is capable of a much higher level of specificity than hormonal signaling. It is also much faster: the fastest nerve signals travel at speeds that exceed 100 meters per second.

At a more integrative level, the primary function of the nervous system is to control the body. It does this by extracting information from the environment using sensory receptors, sending signals that encode this information into the central nervous system, processing the information to determine an appropriate response, and sending output signals to muscles or glands to activate the response. The evolution of a complex nervous system has made it possible for various animal species to have advanced perception abilities such as vision, complex social interactions, rapid coordination of organ systems, and integrated processing of concurrent signals. In humans, the sophistication of the nervous system makes it possible to have language, abstract representation of concepts, transmission of culture, and many other features of human society that would not exist without the human brain.

Students' Assessment Exercise 4.2

State the main function of the nervous system

4.7 Anatomy in Vertebrates (4 Impulse transmission)

The nervous system of vertebrate animals (including humans) is divided into the central nervous system (CNS) and peripheral nervous system (PNS).

The central nervous system (CNS) is the largest part, and includes the brain and spinal cord.[11] The spinal cavity contains the spinal cord, while the head contains the brain. The CNS is enclosed and protected by meninges, a three-layered system of membranes, including a tough, leathery outer layer called the dura mater. The brain is also protected by the skull and the spinal cord by the vertebrae.

The peripheral nervous system (PNS) is a collective term for the nervous system structures that do not lie within the CNS. The large majority of the axon bundles called nerves are considered to belong to the PNS, even when the cell bodies of the neurons to which they belong reside within the brain or spinal cord. The PNS is divided into

somatic and visceral parts. The somatic part consists of the nerves that innervate the skin, joints, and muscles. The cell bodies of somatic sensory neurons lie in dorsal root ganglia of the spinal cord. The visceral part, also known as the autonomic nervous system, contains neurons that innervate the internal organs, blood vessels, and glands. The autonomic nervous system itself consists of two parts: the sympathetic nervous system and the parasympathetic nervous system. Some authors also include sensory neurons whose cell bodies lie in the periphery (for senses such as hearing) as part of the PNS; others, however, omit them.

Horizontal section of the head of an adult female, showing skin, skull, and brain with grey matter (brown in this image) and underlying white matter

The vertebrate nervous system can also be divided into areas called grey matter ("gray matter" in American spelling) and white matter. Grey matter (which is only grey in preserved tissue, and is better described as pink or light brown in living tissue) contains a high proportion of cell bodies of neurons. White matter is composed mainly of myelinated axons, and takes its color from the myelin. White matter includes all of the nerves, and much of the interior of the brain and spinal cord. Grey matter is found in clusters of neurons in the brain and spinal cord, and in cortical layers that line their surfaces. There is an anatomical convention that a cluster of neurons in the brain or spinal cord is called a nucleus, whereas a cluster of neurons in the periphery is called a ganglion. There are, however, a few exceptions to this rule, notably including the part of the forebrain called the basal ganglia.

4.9 Neurons and Synapses 4 reflex arch

Major elements in synaptic transmission. An electrochemical wave called an action potential travels along the axon of a neuron. When the wave reaches a synapse, it provokes release of a small amount of neurotransmitter molecules, which bind to chemical receptor molecules located in the membrane of the target cell.

Most neurons send signals via their axons, although some types are capable of dendrite-to-dendrite communication. (In fact, the types of neurons called amacrine cells have no axons, and communicate only via their dendrites.) Neural signals propagate along an

axon in the form of electrochemical waves called action potentials, which produce cell-to-cell signals at points where axon terminals make synaptic contact with other cells.

Synapses may be electrical or chemical. Electrical synapses make direct electrical connections between neurons, but chemical synapses are much more common, and much more diverse in function. At a chemical synapse, the cell that sends signals is called presynaptic, and the cell that receives signals is called postsynaptic. Both the presynaptic and postsynaptic areas are full of molecular machinery that carries out the signaling process. The presynaptic area contains large numbers of tiny spherical vessels called synaptic vesicles, packed with neurotransmitter chemicals. When the presynaptic terminal is electrically stimulated, an array of molecules embedded in the membrane are activated, and cause the contents of the vesicles to be released into the narrow space between the presynaptic and postsynaptic membranes, called the synaptic cleft. The neurotransmitter then binds to receptors embedded in the postsynaptic membrane, causing them to enter an activated state. Depending on the type of receptor, the resulting effect on the postsynaptic cell may be excitatory, inhibitory, or modulatory in more complex ways. For example, release of the neurotransmitter acetylcholine at a synaptic contact between a motor neuron and a muscle cell induces rapid contraction of the muscle cell. The entire synaptic transmission process takes only a fraction of a millisecond, although the effects on the postsynaptic cell may last much longer (even indefinitely, in cases where the synaptic signal leads to the formation of a memory trace).

There are literally hundreds of different types of synapses. In fact, there are over a hundred known neurotransmitters, and many of them have multiple types of receptors. Many synapses use more than one neurotransmitter—a common arrangement is for a synapse to use one fast-acting small-molecule neurotransmitter such as glutamate or GABA, along with one or more peptide neurotransmitters that play slower-acting modulatory roles. Molecular neuroscientists generally divide receptors into two broad groups: chemically gated ion channels and second messenger systems. When a chemically gated ion channel is activated, it forms a passage that allow specific types of ion to flow across the membrane. Depending on the type of ion, the effect on the target cell may be excitatory or inhibitory. When a second messenger system is activated, it starts a cascade of molecular interactions inside the target cell, which may ultimately

produce a wide variety of complex effects, such as increasing or decreasing the sensitivity of the cell to stimuli, or even altering gene transcription.

According to a rule called Dale's principle, which has only a few known exceptions, a neuron releases the same neurotransmitters at all of its synapses. This does not mean, though, that a neuron exerts the same effect on all of its targets, because the effect of a synapse depends not on the neurotransmitter, but on the receptors that it activates. Because different targets can (and frequently do) use different types of receptors, it is possible for a neuron to have excitatory effects on one set of target cells, inhibitory effects on others, and complex modulatory effects on others still. Nevertheless, it happens that the two most widely used neurotransmitters,glutamate and GABA, each have largely consistent effects. Glutamate has several widely occurring types of receptors, but all of them are excitatory or modulatory. Similarly, GABA has several widely occurring receptor types, but all of them are inhibitory. Because of this consistency, glutamatergic cells are frequently referred to as "excitatory neurons", and GABAergic cells as "inhibitory neurons". Strictly speaking this is an abuse of terminology—it is the receptors that are excitatory and inhibitory, not the neurons—but it is commonly seen even in scholarly publications.

One very important subset of synapses are capable of forming memory traces by means of long-lasting activity-dependent changes in synaptic strength. The best-known form of neural memory is a process called long-term potentiation (abbreviated LTP), which operates at synapses that use the neurotransmitter glutamate acting on a special type of receptor known as the NMDA receptor. The NMDA receptor has an "associative" property: if the two cells involved in the synapse are both activated at approximately the same time, a channel opens that permits calcium to flow into the target cell. The calcium entry initiates a second messenger cascade that ultimately leads to an increase in the number of glutamate receptors in the target cell, thereby increasing the effective strength of the synapse. This change in strength can last for weeks or longer. Since the discovery of LTP in 1973, many other types of synaptic memory traces have been found, involving increases or decreases in synaptic strength that are induced by varying conditions, and last for variable periods of time.Reward learning, for example, depends on a variant form of LTP that is conditioned on an extra input coming from a reward-signaling pathway that uses dopamine as neurotransmitter. All these forms of synaptic

modifiability, taken collectively, give rise to neural plasticity, that is, to a capability for the nervous system to adapt itself to variations in the environment.

Simplified schema of basic nervous system function: signals are picked up by sensory receptors and sent to the spinal cord and brain, where processing occurs that results in signals sent back to the spinal cord and then out to motor neurons

The simplest type of neural circuit is a reflex arc, which begins with a sensory input and ends with a motor output, passing through a sequence of neurons in between. For example, consider the "withdrawal reflex" causing the hand to jerk back after a hot stove is touched. The circuit begins with sensory receptors in the skin that are activated by harmful levels of heat: a special type of molecular structure embedded in the membrane causes heat to change the electrical field across the membrane. If the change in electrical potential is large enough, it evokes an action potential, which is transmitted along the axon of the receptor cell, into the spinal cord. There the axon makes excitatory synaptic contacts with other cells, some of which project (send axonal output) to the same region of the spinal cord, others projecting into the brain. One target is a set of spinal interneurons that project to motor neurons controlling the arm muscles. The interneurons excite the motor neurons, and if the excitation is strong enough, some of the motor neurons generate action potentials, which travel down their axons to the point where they make excitatory synaptic contacts with muscle cells. The excitatory signals induce contraction of the muscle cells, which causes the joint angles in the arm to change, pulling the arm away.

In reality, this straightforward schema is subject to numerous complications. Although for the simplest reflexes there are short neural paths from sensory neuron to motor neuron, there are also other nearby neurons that participate in the circuit and modulate the response. Furthermore, there are projections from the brain to the spinal cord that are capable of enhancing or inhibiting the reflex.

Although the simplest reflexes may be mediated by circuits lying entirely within the spinal cord, more complex responses rely on signal processing in the brain. Consider, for example, what happens when an object in the periphery of the visual field moves, and a person looks toward it. The initial sensory response, in the retina of the eye, and the final motor response, in the coulometer nuclei of the brain stem, are not all that

different from those in a simple reflex, but the intermediate stages are completely different. Instead of a one or two step chain of processing, the visual signals pass through perhaps a dozen stages of integration, involving the thalamus, cerebral cortex, basal ganglia, superior colliculus, cerebellum, and several brainstem nuclei. These areas perform signal-processing functions that include feature detection, perceptual analysis, memory recall, decision-making, and motor planning.

Feature detection is the ability to extract biologically relevant information from combinations of sensory signals. In the visual system, for example, sensory receptors in the retina of the eye are only individually capable of detecting "points of light" in the outside world. Second-level visual neurons receive input from groups of primary receptors, higher-level neurons receive input from groups of second-level neurons, and so on, forming a hierarchy of processing stages. At each stage, important information is extracted from the signal ensemble and unimportant information is discarded. By the end of the process, input signals representing "points of light" have been transformed into a neural representation of objects in the surrounding world and their properties. The most sophisticated sensory processing occurs inside the brain, but complex feature extraction also takes place in the spinal cord and in peripheral sensory organs such as the retina.

4.10 Intrinsic Pattern Generation

Although stimulus-response mechanisms are the easiest to understand, the nervous system is also capable of controlling the body in ways that do not require an external stimulus, by means of internally generated rhythms of activity. Because of the variety of voltage-sensitive ion channels that can be embedded in the membrane of a neuron, many types of neurons are capable, even in isolation, of generating rhythmic sequences of action potentials, or rhythmic alternations between high-rate bursting and quiescence. When neurons that are intrinsically rhythmic are connected to each other by excitatory or inhibitory synapses, the resulting networks are capable of a wide variety of dynamical behaviors, including attractor dynamics, periodicity, and even chaos. A network of neurons that uses its internal structure to generate temporally structured output, without requiring a corresponding temporally structured stimulus, is called a central pattern generator.

Internal pattern generation operates on a wide range of time scales, from milliseconds to hours or longer. One of the most important types of temporal pattern is circadian rhythmicity—that is, rhythmicity with a period of approximately 24 hours. All animals that have been studied show circadian fluctuations in neural activity, which control circadian alternations in behavior such as the sleep-wake cycle. Experimental studies dating from the 1990s have shown that circadian rhythms are generated by a "genetic clock" consisting of a special set of genes whose expression level rises and falls over the course of the day. Animals as diverse as insects and vertebrates share a similar genetic clock system. The circadian clock is influenced by light but continues to operate even when light levels are held constant and no other external time-of-day cues are available. The clock genes are expressed in many parts of the nervous system as well as many peripheral organs, but in mammals all of these "tissue clocks" are kept in synchrony by signals that emanate from a master timekeeper in a tiny part of the brain called the suprachiasmatic nucleus.

Physically, the brain and spinal cord are surrounded by tough meningealment

4.11 Conclusion

This unit attempts to give a brief overview of the nervous system. The anatomy in vertebrates and function were also outlined.

Answer to students' assessment exercise 4.1

The nervous system's 2 types of cells are 1.neurons 2.glial cells

Answer To Students' Assessment Exercise 4.2

The function of the nervous system is to send signals from one cell to others or from one part of the body to others.

4.12 Summary

The nervous system is part of the animal's body that coordinates the voluntary and involuntary action of the animal and transmits signals between parts of its body. Two main parts are involved; the central nervous system and the peripheral nervous system.

4.13 Tutor-Marked Assignment

Discuss exhaustively, the two main parts involved in the central nervous system in most farm animals.

4.14 References and Other Resources

Nervous System".*Columbia Encyclopedia*.Columbia University Press.

1. Kandel ER, Schwartz JH, Jessel TM, ed. (2000). "Chapter. 2: Nerve cells and behavior". *Principles of Neural Science*. McGraw-Hill Professional. ISBN 978-0-8385-7701-1.
2. Finger S (2001). "Ch. 1: The brain in antiquity". *Origins of neuroscience: a history of explorations into brain function*. Oxford Univ. Press. ISBN 978-0-19-514694-3.

MODULE 3

Introduction

In this module there are 2 units, the first unit addresses the muscular system, while the second unit deals with the issues of the skeletal system.

The objectives of the module includes:

1. To enable you understand the muscular system
2. To enable you grasp the concept of the skeletal system.

UNIT 5: MUSCULAR SYSTEM

5.0 Introduction

This unit will treat in general, the muscular system, the different types of muscle and the control of muscle contraction in animals.

5.1 Objectives

By the time you have studied this unit, you should be able to;

- Differentiate aerobic and anaerobic muscle activity
- List different types of muscle
- Explain control of muscle contraction

5.2 Muscular System

Latin: Sytemamusculare

The **Muscular System**is an organ system consisting of skeletal, smooth and cardiacmuscles. It permits movement of the body, maintains posture, and circulates blood throughout the body. The muscular system in vertebrates is controlled through the nervous system, although some muscles (such as the cardiac muscle) can be completely autonomous.

5.3 Muscles (1. Types of muscle cells)

There are three distinct types of muscles: skeletal muscles, cardiac or heart muscles, and smooth (non-striated) muscles. Muscles provide strength, balance, posture, movement and heat for the body to keep warm.

Upon stimulation by an action potential, skeletal muscles perform a coordinated contraction by shortening each sarcomere. The best proposed model for understanding contraction is the sliding filament model of muscle contraction. Actin and myosin fibers overlap in a contractile motion towards each other. Myosin filaments have club-shaped heads that project toward the actin filaments.

Larger structures along the myosin filament called myosin heads are used to provide attachment points on binding sites for the actin filaments. The myosin heads move in a coordinated style, they swivel toward the center of the sarcomere, detach and then reattach to the nearest active site of the actin filament. This is called a rachet type drive system. This process consumes large amounts of adenosine triphosphate (ATP).

Energy for this comes from **ATP**, the energy source of the cell. ATP binds to the cross bridges between myosin heads and actin filaments. The release of energy powers the swiveling of the myosin head. Muscles store little ATP and so must continuously recycle the discharged adenosine diphosphate molecule (ADP) into ATP rapidly. Muscle tissue also contains a stored supply of a fast acting recharge chemical, creatine phosphate which can assist initially producing the rapid regeneration of ADP into ATP.

Calcium ions are required for each cycle of the sarcomere. Calcium is released from the sarcoplasmic reticulum into the sarcomere when a muscle is stimulated to contract. This calcium uncovers the actin binding sites. When the muscle no longer needs to contract, the calcium ions are pumped from the sarcomere and back into storage in the sarcoplasmic reticulum.

5.5 Cardiac Muscle (2. Structure of muscle cells)

Heart muscles are distinct from skeletal muscles because the muscle fibers are laterally connected to each other. Furthermore, just as with smooth muscles, they are not controlling themselves. Heart muscles are controlled by the sinus node influenced by the autonomic nervous system.

5.6 Smooth Muscle

Smooth muscles are controlled directly by the autonomic nervous system and are involuntary, meaning that they are incapable of being moved by conscious thought. Functions such as heart beat and lungs (which are capable of being willingly controlled, be it to a limited extent) are involuntary muscles but are not smooth muscles.

Students' Assessment Exercise 5.2

List any 2 types of Muscles

5.4 Aerobic and Anaerobic Muscle Activity (3. Function of Muscles)

At rest, the body produces the majority of its ATP aerobically in the mitochondria without producing lactic acid or other fatiguing byproducts.[3] During exercise, the method of ATP production varies depending on the fitness of the individual as well as the duration, and intensity of exercise. At lower activity levels, when exercise continues for a long duration (several minutes or longer), energy is produced aerobically by combining oxygen with carbohydrates and fats stored in the body. Activity that is higher in intensity, with possible duration decreasing as intensity increases, ATP production can switch to anaerobic pathways, such as the use of the creatine phosphate and the phosphagen system or anaerobic glycolysis. Aerobic ATP production is biochemically much slower and can only be used for long-duration, low intensity exercise, but produces no fatiguing waste products that can not be removed immediately from sarcomere and body and results in a much greater number of ATP molecules per fat or carbohydrate molecule. Aerobic training allows the oxygen delivery system to be more efficient, allowing aerobic metabolism to begin quicker Anaerobic ATP production produces ATP much faster and allows near-maximal intensity exercise, but also produces significant amounts of lactic acid which render high intensity exercise unsustainable for greater than several minutes. The phosphagen system is also anaerobic, allows for the highest levels of exercise intensity, but intramuscular stores of phosphocreatine are very limited and can only provide energy for exercises lasting up to ten seconds. Recovery is very quick, with full creatine stores regenerated within five minutes

Students' Assessment Exercise 5.1

At what time does the body produce maximum ATP?

5.7 Control of muscle contraction (4. Muscle contraction and relxation)

Neuromuscular junctions are the focal point where a motor neuron attaches to a muscle. Acetylcholine, (a neurotransmitter used in skeletal muscle contraction) is released from the axon terminal of the nerve cell when an action potential reaches the microscopic junction, called a synapse. A group of chemical messengers cross the synapse and stimulate the formation of electrical changes, which are produced in the muscle cell when the acetylcholine binds to receptors on its surface. Calcium is released from its storage area in the cell's sarcoplasmic reticulum. An impulse from a nerve cell causes calcium release and brings about a single, short muscle contraction called a muscle twitch. If there is a problem at the neuromuscular junction, a very prolonged contraction may occur in the disease, tetanus. Also, a loss of function at the junction can produce paralysis.

Skeletal muscles are organized into hundreds of motor units, each of which involves a motor neuron, attached by a series of thin finger-like structures called axon terminals. These attach to and control discrete bundles of muscle fibers. A coordinated and fine tuned response to a specific circumstance will involve controlling the precise number of motor units used. While individual muscle units contract as a unit, the entire muscle can contract on a predetermined basis due to the structure of the motor unit. Motor unit coordination, balance, and control frequently come under the direction of the cerebellum of the brain. This allows for complex muscular coordination with little conscious effort, such as when one drives a car without thinking about the process.

5.8 Conclusion

You have studied the muscular system and the various types of muscle in the animal's body, Aerobic and anaerobic muscle activity as well as the control of muscle contraction.

Answer to Students' Assessment Exercise 5.1

At rest the body produces majority of its ATP aerobically in the mitochondria

Answer to students' Assessment Exercise 5.2

Two types of muscles are 1. Cardiac muscle 2. Smooth muscle

5.9 Summary

There are different types of muscles in the animals' body, and both aerobic and anaerobic muscle activity occur. The control of muscle contraction was also elaborated.

5.10 Tutor – Marked Assignment

Elaborate on the types of muscle

5.11 Reference and further Reading

- Online Muscle Tutorial

Medical and Health Encyclopedia, chapter 1

UNIT 6: THE SKELETAL SYSTEM

6.0 Introduction

In this unit you will be studying the skeletal system in farm animals. The skeletal system serves a lot of purposes in the animals' body including man, right from babyhood to manhood, but there are some differences as will be seen.

6.1 Objectives

By the end of your studying this unit, you should be able to:

- List what the skeletal system does to the animal
- State who has more bones, a baby or an adult
- Elaborate on how to keep bones healthy

6.2 The Skeletal System (1. Types of bones)

Your skeletal system is all of the bones in the body and the tissues such as tendons, ligaments and cartilage that connect them.

Your teeth are also considered part of your skeletal system but they are not counted as bones. Your teeth are made of enamel and dentin. Enamel is the strongest substance in your body.

6.6 What is a bone made of? (2. Structure of bones and bone cells)

A typical bone has an outer layer of hard or compact bone, which is very strong, dense and tough. Inside this is a layer of spongy bone, which is like honeycomb, lighter and slightly flexible. In the middle of some bones is jelly-like bone marrow, where new cells are constantly being produced for the blood. Calcium is an important mineral that bone cells need to stay strong so keep drinking that low-fat milk!

6.3 How the Skeletal System helps us? (3. Function of bone/skeletal system)

6.3.1 Support

The main job of the skeleton is to provide support for our body. Without your skeleton your body would collapse into a heap. Your skeleton is strong but light. Without bones you'd be just a puddle of skin and guts on the floor.

5.3.2 Protection

Your skeleton also helps protect your internal organs and fragile body tissues. The brain, eyes, heart, lungs and spinal cord are all protected by your skeleton. Your cranium (skull) protects your brain and eyes, the ribs protect your heart and lungs and your vertebrae (spine, backbones) protect your spinal cord.

6.3.3 Movement

Bones provide the structure for muscles to attach so that our bodies are able to move. Tendons are tough inelastic bands that hold or attaches muscle to bone.

Students Assessment Exercise 6.1

- List any 3 functions of the skeletal system

6.4 Who has more bones a baby or an adult?

Babies have more than adults! At birth, you have about 300 bones. As you grow older, small bones join together to make big ones. Adults end up with about 206 bones.

6.5 Are bones alive?

Absolutely old bones are dead, dry and brittle. But in the body, bones are very much alive. They have their own nerves and blood vessels, and they do various jobs, such as storing body minerals like calcium. Bones are made of a mix of hard stuff that gives them strength and tons of living cells which help them grow and repair themselves.

6.7 How do bones break and heal? (4. Bone healing)

Bones are tough and usually don't break even when we have some pretty bad falls. I'm sure you have broken a big stick at one time. When you first try to break the stick it bends a bit but with enough force the stick finally snaps. It is the same with your bones. Bones will bend a little, but if you fall the wrong way from some playground equipment

or maybe your bike or skateboard you can break a bone. Doctors call a broken bone a fracture. There are many different types of fractures.

Luckily, bones are made of living cells. When a bone is broken your bone will produce lots of new cells to rebuild the bone. These cells cover both ends of the broken part of the bone and close up the break.

Student Assessment Exercise 6.2

Who has more bones a baby or an adult?

6.8 How to keep bones healthy

Bones need regular exercise to stay as strong as possible. Walking, jogging, running and other physical activities are important in keeping your bones strong and healthy. Riding your bike, basketball, soccer, gymnastics, baseball, dancing, skateboarding and other activities are all good for your bones. Make sure you wear or use the proper equipment like a helmet, kneepads, shin guards, mats, knee pads, etc... to keep those bones safe. All vertebrate animals need exercise to keep there bones healthy.

6.9 Conclusion

The skeletal system has been studied. This should help in guiding the farm manager's expectation as the animal's age. It is also important that the farm manager knows how to keep bones healthy.

Answers to students' assessment Exercise 6.1

- Support
-Protection
-Movement

Answers to students' Assessments' Exercise 6.2

- A baby has more bones than an adult

6.10 Summary

In this unit, the importance of the skeletal system has been shown. What the bones are made of have been described as well as how to keep the bones healthy.Good farm managers should be able to note that as the animals age, their bones decrease.

6.11 Tutor –Marked Assignment

Elaborate on how to keep bones healthy

6.12 Reference and other Resources

Hillendale Health Main Index@Main Index@ Welcome page/health Index/Main Site Index

Marshall P.T. and Hughes G.M.1980.Physiology of mammals and other vertebrates 2nd ed. Cambridge University Press, London

MODULE 4

In this module, you will be studying 2 units. The first unit under the module is on circulatory system, while the second unit deals with the endocrine system and relationship with other systems of the body.

The objectives of the module:

1. To enable you understand the circulatory system
2. To enable you understand the endocrine system and relationship with other system of the body.

UNIT 7: CIRCULATORY SYSTEM

7.0 Introduction

In this unit you will be studying the circulatory system, using the human cardio vascular system and other vertebrates, as well as a few other living things with absence of circulatory system, as cases under study.

7.1 Objectives

At the end of the study in this unit, you should be able to:

- List the types of circulations
- Elaborate on open circulatory system
- List some examples of living things with absence of circulatory system.

7.2 Circulatory System

Latin Systema cardiovasculare

The circulatory system is an organ system that permits blood and lymph circulation to transport nutrients (such as amino acids and electrolytes), oxygen, carbon dioxide, hormones, blood cells, etc. to and from cells in the body to nourish it and help to fight diseases, stabilize body temperature and pH, and to maintain homeostasis.

This system may be seen strictly as a blood distribution network, but some consider the circulatory system as composed of the cardiovascular system, which distributes blood, and the lymphatic system, which returns excess filtered blood plasma from the interstitial fluid (between cells) as lymph. While humans, as well as other vertebrates, have a closed cardiovascular system (meaning that the blood never leaves the network of arteries, veins and capillaries), some invertebrate animals have an open cardiovascular system. The more primitive, diploblastic animal phyla lack circulatory system. The lymphatic system, on the other hand, is an open system providing an accessory route for excess interstitial fluid to get returned to the blood.

Two types of fluids move through the circulatory system: blood and lymph. Lymph is essentially recycled blood plasma after it has been filtered from the blood cells and returned to the lymphatic system. The blood, heart, and blood vessels form the cardiovascular (from Latin words meaning 'heart'-'vessel') system. The lymph, lymph nodes, and lymph vessels form the lymphatic system. The cardiovascular system and the lymphatic system collectively make up the circulatory system.

The development of the circulatory system initially occurs by the process of vasculogenesis. The human arterial and venous systems develop from different embryonic areas. While the arterial system develops mainly from the aortic arches, the venous system arises from three bilateral veins during weeks 4 - 8 of human development.

7.3 The Cardiovascular System

The essential components of the human and other vertebrate cardiovascular system are the heart, blood, and blood vessels. It includes: the pulmonary circulation, a "loop" through the lungs where blood is oxygenated; and the systemic circulation, a "loop" through the rest of the body to provide oxygenated blood. An average adult contains five to six quarts (roughly 4.7 to 5.7 liters) of blood, accounting for approximately 7% of their total body weight. Blood consists of plasma, red blood cells, white blood cells, and platelets. Also, the digestive system works with the circulatory system to provide the nutrients the system needs to keep the heart pumping.

7.3.1 Pulmonary circulation

The pulmonary circulatory system is the portion of the cardiovascular system in which oxygen-depleted blood is pumped away from the heart, via the pulmonary artery, to the lungs and returned, oxygenated, to the heart via the pulmonary vein.

Oxygen deprived blood from the superior and inferior vena cava, enters the right atrium of the heart and flows through the tricuspid valve (right atrioventricular valve) into the right ventricle, from which it is then pumped through the pulmonary semilunar valve into the pulmonary artery to the lungs. Gas exchange occurs in the lungs, whereby CO2 is released from the blood, and oxygen is absorbed. The pulmonary vein returns the now oxygen-rich blood to the left atrium.

7.3.2 Systemic Circulation

Systemic circulation is the circulation of the blood to all parts of the body except the lungs. Systemic circulation is the portion of the cardiovascular system which transports oxygenated blood away from the heart through the aorta from the left ventricle where the blood has been previously deposited from pulmonary circulation, to the rest of the body, and returns oxygen-depleted blood back to the heart. Systemic circulation is, distance-wise, much longer than pulmonary circulation, transporting blood to every part of the body.

7.3.3 Coronary circulation

The coronary circulatory system provides a blood supply to the myocardium (the heart muscle). It arises from the aorta by two coronary arteries, the left and the right, and after nourishing the myocardium blood returns through the coronary veins into the coronary sinus and from this one into the right atrium. Back flow of blood through its opening during atrial systole is prevented by the Thebesian valve. The smallest cardiac veins drain directly into the heart chambers.

7.4 Heart

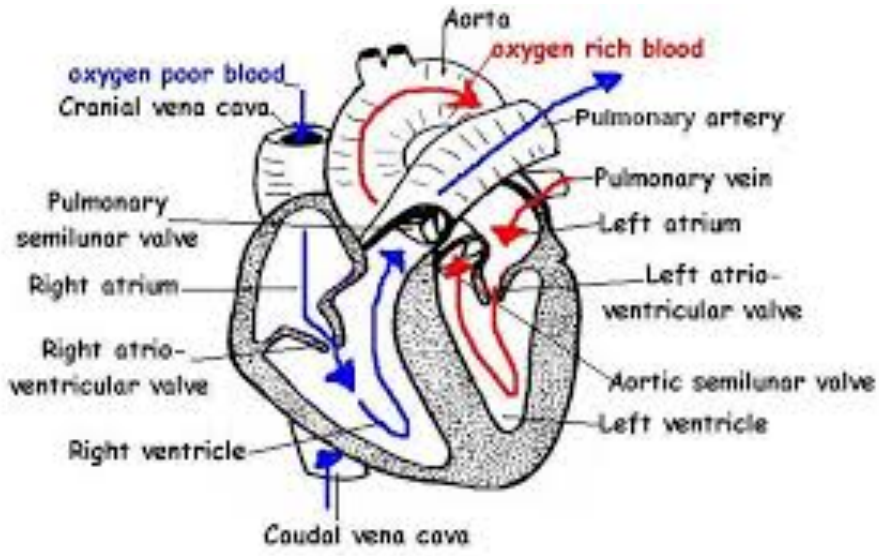

Fig. 1 Diagram of the heart of a typical mammal

The heart pumps oxygenated blood to the body and deoxygenated blood to the lungs. In the Mammalian heart there is one atrium and one ventricle for each circulation, and with both a systemic and a pulmonary circulation there are four chambers in total: left atrium, left ventricle, right atrium and right ventricle (fig. 1). The right atrium is the upper chamber of the right side of the heart. The blood that is returned to the right atrium is deoxygenated (poor in oxygen) and passed into the right ventricle to be pumped through the pulmonary artery to the lungs for re-oxygenation and removal of carbon dioxide. The left atrium receives newly oxygenated blood from the lungs as well as the pulmonary vein which is passed into the strong left ventricle to be pumped through the aorta to the different organs of the body.

7.5 Closed cardiovascular system

The cardiovascular systems of humans are closed, meaning that the blood never leaves the network of blood vessels. In contrast, oxygen and nutrients diffuse across the blood vessel layers and enters interstitial fluid, which carries oxygen and nutrients to the target cells, and carbon dioxide and wastes move out of the cells into the blood. The other component of the circulatory system, the lymphatic system, is not closed.

7.6 Oxygen transportation

About 98.5% of the oxygen in a sample of arterial blood in a healthy human is chemically combined with hemoglobin molecules. About 1.5% is physically dissolved in the other blood liquids and not connected to hemoglobin. The hemoglobin molecule is the primary transporter of oxygen in mammals and many other species.

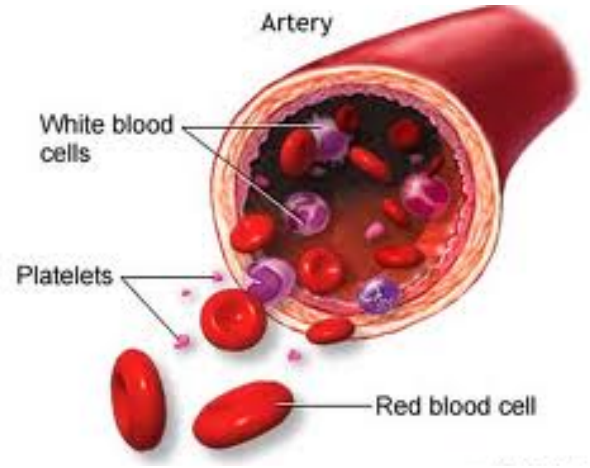

Fig. 1 Types of Blood Cells

An animation of a typical human red blood cell cycle in the circulatory system (fig. 1). This animation occurs at real time (20 seconds of cycle) and shows the red blood cell deform as it enters capillaries, as well as changing color as it alternates in states of oxygenation along the circulatory system.

Magnetic resonance angiography of aberrant subclavian artery development

7.7 Measurement techniques

Electrocardiogram—for cardiac electrophysiology

Sphygmomanometer and stethoscope—for blood pressure

Pulse meter—for cardiac function (heart rate, rhythm, dropped beats)

Pulse—commonly used to determine the heart rate in absence of certain cardiac pathologies

Heart rate variability—used to measure variations of time intervals between heart beats

Nail bed blanching test—test for perfusion

Vessel cannula or catheter pressure measurement—pulmonary wedge pressure or in older animal experiments.

Students' Assessment Exercise 7.1

Give the name of the instrument for measuring cardiac electro physiology.

7.8 Other vertebrates

Two-chambered heart of a fish

The circulatory systems of all vertebrates, as well as of annelids (for example, earthworms) and cephalopods (squids, octopuses and relatives) are closed, just as in humans. Still, the systems of fish, amphibians, reptiles, and birds show various stages of the evolution of the circulatory system.

In fish, the system has only one circuit, with the blood being pumped through the capillaries of the gills and on to the capillaries of the body tissues. This is known as single cycle circulation. The heart of fish is, therefore, only a single pump (consisting of two chambers).

In amphibians and most reptiles, a double circulatory system is used, but the heart is not always completely separated into two pumps. Amphibians have a three-chambered heart.

In reptiles, the ventricular septum of the heart is incomplete and the pulmonary artery is equipped with a sphincter muscle. This allows a second possible route of blood flow. Instead of blood flowing through the pulmonary artery to the lungs, the sphincter may be contracted to divert this blood flow through the incomplete ventricular septum into the left ventricle and out through the aorta. This means the blood flows from the capillaries to the heart and back to the capillaries instead of to the lungs. This process is useful to ectothermic (cold-blooded) animals in the regulation of their body temperature.

Birds and mammals show complete separation of the heart into two pumps, for a total of four heart chambers; it is thought that the four-chambered heart of birds evolved independently from that of mammals.

7.9 Open circulatory system

The open circulatory system is a system in which a fluid in a cavity called the hemocoel bathes the organs directly with oxygen and nutrients and there is no distinction between blood and interstitial fluid; this combined fluid is called hemolymph or haemolymph. Muscular movements by the animal during locomotion can facilitate hemolymph movement, but diverting flow from one area to another is limited. When the heart relaxes, blood is drawn back toward the heart through open-ended pores (ostia).

Hemolymph fills all of the interior hemocoel of the body and surrounds all cells. Hemolymph is composed of water, inorganic salts (mostly Na+, Cl-, K+, Mg2+, and Ca2+), and organic compounds (mostly carbohydrates, proteins, and lipids). The primary oxygen transporter molecule is hemocyanin.

There are free-floating cells, the hemocytes, within the hemolymph. They play a role in the arthropod immune system.

7.10 Absence of circulatory system

Flatworms, such as this Helicometra sp., lack specialized circulatory organs

Circulatory systems are absent in some animals, including flatworms (phylum Platyhelminthes). Their body cavity has no lining or enclosed fluid. Instead a muscular pharynx leads to an extensively branched digestive system that facilitates direct diffusion of nutrients to all cells. The flatworm's dorso-ventrally flattened body shape also restricts the distance of any cell from the digestive system or the exterior of the organism. Oxygen can diffuse from the surrounding water into the cells, and carbon dioxide can diffuse out. Consequently every cell is able to obtain nutrients, water and oxygen without the need of a transport system.

Some animals, such as jellyfish, have more extensive branching from their gastrovascular cavity (which functions as both a place of digestion and a form of circulation), this branching allows for bodily fluids to reach the outer layers, since the digestion begins in the inner layers.

Students 'Assessment Exercise 7.2

List any animals without circulatory system.

7.11 Conclusion

You have studied the circulatory system in man, other vertebrates and even some other living things with absence of circulatory system.

Answers to students' Assessment Exercise 7.1

Electro cardiogram

Answers to students Assessment Exercise 7.2

Flat worms

7.12 Summary

You have learnt the circulatory system in living things. The measure of the circulatory system is also the measure of an animal's health. There are different types of circulation that should be noted when discussing the circulatory system.

7.13 Tutor – Marked Assignment

Elaborate on the concept of closed cardio vascular system

7.14 References and Further Readings.

Cardiovascular system" at Dorland's Medical Dictionary
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UNIT 8 ENDOCRINE SYSTEM AND ITS RELATIONSHIP WITH OTHER SYSTEMS OF THE BODY

8.0 Introduction

In this unit, you will study the endocrine system, its relationship with other systems and its effects on growth and reproduction in farm and other animals. You will also learn about the basis for categorization of the various hormones.

8.1 Objectives

By the end of this unit, you should be able to:

- List some endocrine organs
- Relate the endocrine system to reproduction in farm animals
- Classify or categorize reproductive hormones

8.2 Endocrine System and Its Relationship with Other Systems of the Body

The endocrine system is the system of glands, each of which secretes different types of hormones directly into the bloodstream (some of which are transported along nerve tracts to maintain homeostasis. The endocrine system is in contrast to the exocrine system, which secretes its chemicals using ducts. The word endocrine derives from the Greek words "endo" meaning inside, within, and "crinis" for secrete. The endocrine system is an information signal system like the nervous system, yet its effects and mechanism are different. The endocrine system's effects are slow to initiate, and prolonged in their response, lasting from a few hours up to weeks. The nervous system sends information very quickly, and responses are generally short lived. Hormones are substances (chemical mediators) released from endocrine tissue into the bloodstream where they travel to target tissue and generate a response. Hormones regulate various human functions, including metabolism, growth and development, tissue function,

sleep, and mood. The field of study dealing with the endocrine system and its disorders is endocrinology, a branch of internal medicine.

Features of endocrine glands are, in general, their ductless nature, their vascularity, and usually the presence of intracellular vacuoles or granules storing their hormones. In contrast, exocrine glands, such as salivary glands, sweat glands, and glands within the gastrointestinal tract, tend to be much less vascular and have ducts or a hollow lumen.

In addition to the specialised endocrine organs mentioned above, many other organs that are part of other body systems, such as the kidney, liver, heart and gonads, have secondary endocrine functions. For example the kidney secretes endocrine hormones such as erythropoietin and renin.

The endocrine system is made of a series of glands that produce chemicals called hormones. A number of glands that signal each other in sequence are usually referred to as an axis, for example, the hypothalamic-pituitary-adrenal axis.

As opposed to endocrine factors that travel considerably longer distances via the circulatory system, other signalling molecules, such as paracrine factors involved in paracrine signalling diffuse over a relatively short distance.

Paracrine Signalling – A form of cell signalling in which the target cell is near the signal – releasing cell, altering the behaviour or differentiation of those competent cells.

8.3 Major Endocrine Systems

The human endocrine system consists of several systems that operate via feedback loops. Several important feedback systems are mediated via the hypothalamus and pituitary.

TRH - TSH - T3/T4

GnRH - LH/FSH - sex hormones

CRH - ACTH - cortisol

Renin - angiotensin - aldosterone

leptin vs. insulin

8.4 Interaction with Immune System

Extensive bidirectional interactions exist between the endocrine system and the immune system. Cortisol has major immunosuppressive effects, and dopamine has immunomodulatory functions. On the other hand, cytokines produced during inflammation activate the HPA axis define or explain and include illustration too at all three levels, sensible to negative feedback. Moreover cytokines stimulate hepcidin release from the liver, which is eventually responsible for the anemia of chronic disease.

8.5In Other Species

A neuroendocrine system has been observed in all animals with a nervous system and all vertebrates have an hypothalamus-pituitary axis. All vertebrates have a thyroid, which in amphibians is also crucial for transformation of larvae into adult form. All vertebrates have adrenal gland tissue, with mammals unique in having it organized into layers. All vertebrates have some form of renin-angiotensin axis, and all tetrapods have aldosterone as primary mineralocorticoid.

Diseases of the endocrine system are common, including conditions such as diabetes mellitus, thyroid disease, and obesity. Endocrine disease is characterized by disregulated hormone release (a productive pituitary adenoma), inappropriate response to signaling (hypothyroidism), lack of a gland (diabetes mellitus type 1, diminished erythropoiesis in chronic renal failure), or structural enlargement in a critical site such as the thyroid (toxic multinodular goitre). Hypofunction of endocrine glands can occur as a result of loss of reserve, hyposecretion, agenesis, atrophy, or active destruction. Hyperfunction can occur as a result of hypersecretion, loss of suppression, hyperplastic or neoplastic change, or hyperstimulation.

Endocrinopathies are classified as primary, secondary, or tertiary. Primary endocrine disease inhibits the action of downstream glands. Secondary endocrine disease is

indicative of a problem with the pituitary gland. Tertiary endocrine disease is associated with dysfunction of the hypothalamus and its releasing hormones.

As the thyroid, and hormones have been implicated in signaling distant tissues to proliferate, for example, the estrogen receptor has been shown to be involved in certain breast cancers. Endocrine, paracrine, and autocrinesignaling have all been implicated in proliferation, one of the required steps of oncogenesis.

8.6Other Types of Signalling

The typical mode of cell signaling in the endocrine system is endocrine signaling. However, there are also other modes, i.e., paracrine, autocrine, and neuroendocrine signaling. Purely neurocrinesignaling between neurons, on the other hand, belongs completely to the nervous system.

Autocrine

Autocrinesignaling is a form of signaling in which a cell secretes a hormone or chemical messenger (called the autocrine agent) that binds to autocrine receptors on the same cell, leading to changes in the cells.

Paracrine

Paracrine signaling is a form of cell signaling in which the target cell is near the signal-releasing cell, altering the behavior or differentiation of those competent cells.

Juxtacrine

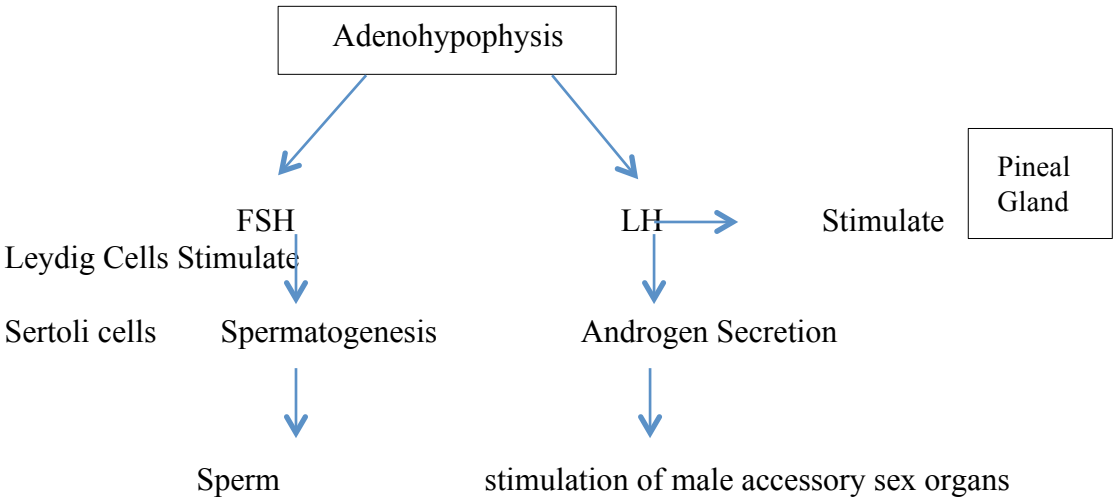
Juxtacrinesignaling is a type of intercellular communication that is transmitted via oligosaccharide, lipid, or protein components of a cell membrane, and may affect either the emitting cell or the immediately adjacent cells.

It occurs between adjacent cells that possess broad patches of closely opposed plasma membrane linked by transmembrane channels known as connexons. The gap between the cells can usually be between only 2 and 4 nm.

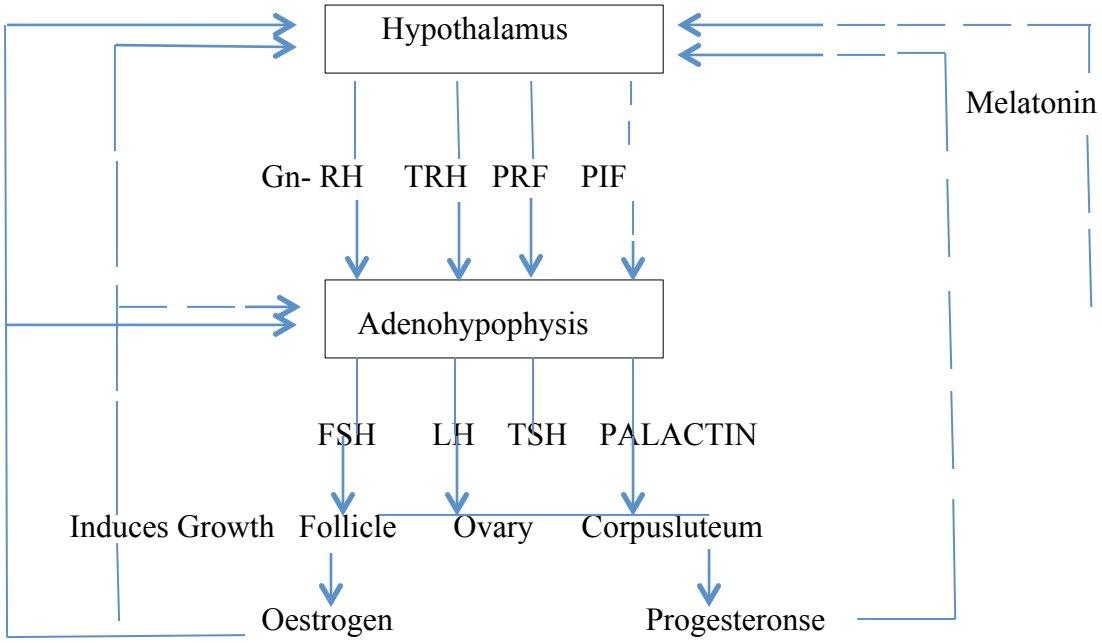
Unlike other types of cell signaling (such as paracrine and endocrine), juxtacrinesignaling requires physical contact between the two cells involved.

Juxtacrinesignaling has been observed for some growth factors, cytokine and chemokine cellular signals.

8.7 Endocrine Control of Reproduction in the Male



8.8Endocrine Control of Reproduction in the Female



Melatonic hormone is produced in the dark. The more the melatonic production, the more negative effect on the production of other hormones

Classification of Reproductive hormones

Hormones can be classified into types based on their effects on reproduction (whether direct), site of origin, chemical properties or the types of responses evoked in target organs.

8.9 Primary and Secondary Hormones of Reproduction

a. Primary hormones of reproduction – These are directly involved in various aspects of reproduction such as spermatogenesis, follicular development, ovulation sexual behaviours, implantation, maintenance of pregnancy, parturition and lactation. Hormones in this category include follicle stimulating hormone (FSH), luteinizing hormone (LH), Prolactin, oxytocin, testosterone, oestradiol, progesterone and relaxin. Hypothalamic releasing hormones also belong in this group.
b. Secondary hormones of reproduction – These are necessary for the general well-being of the animal through their effects on growth, development and metabolism, without which successful of efficient reproduction cannot take place. Hormone (STH), thyroid stimulating hormone (TSH), adrenocorticotropic hormone (ACTH), antidiuretic hormone (ADH), thyroxine, insulin, etc.

8.10 Chemical Categories of Reproductive Hormones

a. Peptides and protein hormones – MW 1000- 50,000. Includes hypothalamic releasing andgonadatropic hormones.

b. Steriod hormones- MW 300-400. The steroid structure is characterized by the presence of a cyclopentanoperhydrophenanthrene nucleus. Includes the gonadal hormones.

8.11 Functional Categories of Reproductive Hormones

1. Hypothalamic releasing hormones- These are produced in the hypothalamus and control thesynthesis andor release of hormones from the adenohypophysis (anterior pituitary).
2. Hypophysial hormones- produced in the hypophysis (pituitary) and involved in maturation and release of gametes. They stimulate secretion of the sex steroid hormones from the gonads.
3. Sex steroid hormones –produced in the gonads and play important roles in behavioural aspects of reproduction, development of secondary sex characters, maintenance of reproductive organs and regulation of the reproductive cycle and .pregnancy

Student's Assessment Exercise 8.1
Question: List any 2 primary hormones of reproduction

Student's Assessment Exercise 8.2
Question: Give any 2 basis for categorization of reproductive hormones

8.12 Conclusion

You have studied the endocrine system and its relationship with other systems of the body especially, reproduction. The hormones of reproduction can also be categorized based on certain criteria as has been studied.

Answer to Students' Assessment Exercise 8.1

- Follicle stimulating hormones
- Estrogen

Answer to Students' Assessment Exercise 8.2

Reproductive hormones can be categorized based on:

- Chemical nature
- Function

8.13 Summary

This unit gave an overview of the endocrine system, the various endocrine organs, the hormones as they are related to reproduction and other organs, as well as basis for the

categorization of the reproductive hormones. The interaction with the immune system was also explained.

8.14 Tutor-Marked Assignment

Attempt classifying hormones of reproduction based on their functions

8.15 References and Further Reading

Colorado State University - Biomedical Hypertextbooks - Somatostatin

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Physiology at MCG 5/5ch4/s5ch4_17

MODULE 5

BIOSYNTHESIS AND REGULATION OF HORMONAL SECRETION AND THE EFFECT OF ABNORMAL SECRETIONS AS WELL AS ARTIFICIAL INSEMINATION

Introduction

In this module there are 2 units, the first unit deals with the concept of Biosynthesis and regulation of hormonal secretions and the effects if abnormal hormonal secretions. The second unit handles the issue of artificial insemination.

The objectives include

1. To acquaint you with the Biosynthesis and regulation of hormonal secretions and the effects of abnormal secretions.
2. To enable you learn more about artificial insemination (AI).

UNIT 9 BIOSYNTHESIS AND REGULATION OF HORMONAL SECRETIONS AND THE EFFECTS OF ABNORMAL HORMONAL SECRETIONS

9.0 Introduction

This unit provides you with the basic biosynthesis and regulation of hormonal secretion and the effects of abnormal hormonal secretions, your knowledge of the symptoms of abnormal hormonal secretions will help in your tentative diagnosis when such are observed in any farm animals.

9.0 Objectives

By the end of your study in this unit, you should be able to;

- Explain the mechanism of steroid hormone action
- List the types of hormone molecules
- State types of hormone molecule secretions.

9.2 Biosynthesis and Regulation of Hormonal Secretions and the Effects of Abnormal Hormonal Secretions

You have learnt that,the endocrine system consists of the ductless glands. These glands produce chemical messengers called hormones which pass into the bloodstream for circulation throughout the body. Hormones will excite or inhibit the activity of target organs or tissues. Whether or not a target tissue will be affected by a hormone depends upon the presence of specific receptor molecules on the membranes or in the cytoplasm of the target cells.

When a hormone is present in excess the number of receptor molecules on the target cells will decrease. This "down regulation" will reduce the responsiveness of the target cells to the hormone. However, when a hormone is at a very low level in the blood, the number of receptor molecules on the target cells may increase. This is known as "up regulation". As a result, the target tissue becomes more sensitive to the lower levels of that hormone.

Steroid hormones are small so in exerting their effects they have to enter the cells. The protein hormones are generally larger molecules; therefore they exert their effect on the surface of the cells. Target cells contain receptors that can recognise particular steroid or signals from hormones (The lock and key concept).

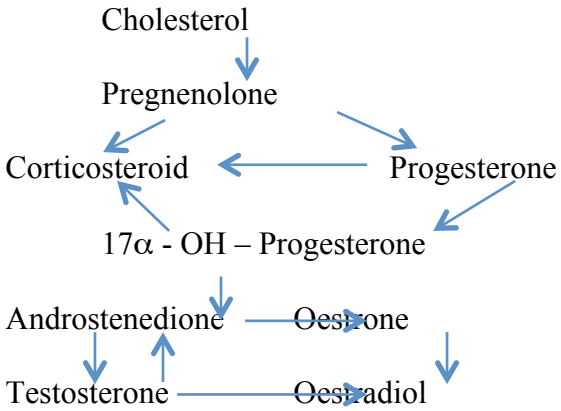
9.3 Biochemistry of Steroid Hormones

The basic molecules from which steroids are formed is the cholesterol. There are 5 main groups of steroid hormones.

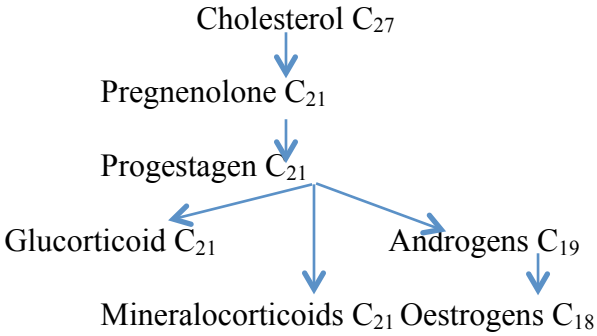
1. Oestrogen — Graafian follicle
2. Progesterone — Ovary, Corpus luteum
3. Androgen - Principally synthesized in the testis.
4. Glucorticoid — Andrenals
5. Mineralocorticoids — Andrenals

9.4 Biosynthesis of Steroid Hormones

Acetate



If one starts from cholesterol the following is the chain of events



Cholesterol-formed from Acetyl – COA in the smooth endoplasmic reticulum (s.e.r). Hydroxylation by mixed function oxidases utilizing NADPH and O_2.

Pregnenolone – formed by scission of cholesterol side chain, in mitochondria.

Progesterone – formed from pregnenolone in s.e.r.

Androgen – formed from scission of side chain of progesterone.

Oestrogen – results from loss of angular methyl group and of aromatization of the A – rings.

Students' Assessment Exercise 9.1

What are the basic molecules from which steroid hormones are formed?

9.5 Mechanism of Steroid Hormone Action.

To effect action, the steroid molecule which is small will enter the cell. The receptors are dispersed throughout the cytoplasm. The receptor molecule recognises the steroid

molecules and forms the hormone-receptor complex. The hormone receptor molecule acquires another sub-unit. The hormone-receptor subunit migrates into the nucleus and bind to a specific part of the DNA. This leads to secretion of RNA which is released into cytosol. This helps to induce the secretion of protein synthesis.

The one degree effect of steroid hormones is on gene expression. The target tissues contains steroid receptors which are protein molecules.

We find oestrogen and progesterone receptors in reproductive tract, mammary gland, hypothalamus, adenohypophysis.

In testosterone, receptors are found in accessory organs, hypothalamus and adenohypophysis.

The major site of steroid hormone action is the cell nucleus.

Effects – takes hours rather than minutes because the biologic effects depend often on protein synthesis.

1. Oestradiol – Steroid hormone – 1st it must enter the cell and then binds to the receptor molecule in the cytosol.
2. The receptor hormone complex acquires 2nd subunit.
3. The hormone-receptor complex enters the cell nucleus and bind on specific site on DNA.
4. As a result of the binding, synthesis of specific RNA molecules facilitated by the enzyme (DNA – dependent RNA polymerase).
5. The RNA formed is transported or exported to the cytosol, resulting ultimately in specific protein synthesis.

9.6 Types of Hormone Molecules

Basically there are three types of hormone molecules:

a. Protein hormones are large, complex molecules made up of many amino acids joined together. These molecules range in size from those hormones composed

of 8 to 10 amino acids, e.g., oxytocin and vasopressin (ADH) to the very large molecules of insulin and growth hormone.

b. Amine hormones are derived from a single modified amino acid, e.g., the catecholamines (epinephrine and dopamine) are produced from tyrosine.
c. Steroid hormones are manufactured from cholesterol, a fat soluble substance.

The glands of internal secretion (endocrine) are concerned with the control and coordination of processes which are widespread in the body, such as, Metabolism, Growth, Homeostasis, Adaptation to Stress and Sexual Reproduction. Although each endocrine gland has specific functions, all are interdependent. The activity or lack of activity of one gland usually influences the rest of the system.

9.7 Control of Hormone Secretions

Hormone secretion is stimulated and inhibited by three types of signals:

i. Neuronal signals are basically nerve impulses which control hormone secretion. For example, sympathetic nerve stimulation of the adrenal medulla causes the release of epinephrine into the blood.
ii. Hormonal signals - Hormones can stimulate other endocrine tissues to release their hormones. ACTH from the anterior pituitary stimulates the release of steroids from the adrenal cortex.
iii. Humoral signals - The presence or absence of a particular chemical substance in the blood can bring on the release of a given hormone from an endocrine gland. An example of this type of mechanism can be seen in the effect of high blood calcium producing the release of calcitonin from the thyroid.

9.8 Negative and Positive Feedback

The most common method of controlling endocrine secretions is through negative feedback. When a stress, such as low blood sugar, triggers the release of a hormone (glucagon in this case) a response is produced in the body, i.e., an increase in blood sugar (positive feedback). If the response reduces the stress, then the secretion of hormone will also be reduced - negative feedback. Less often, the effect of a hormone will enhance or intensify the original stress. In this positive feedback condition, the

mechanism is usually shut off by an outside event. For example, the release of the hormone oxytocin increases during labor due to the increased pressure on the uterine wall. The birth of the baby shuts down the mechanism.

9.9 PITUITARY GLAND

9.9.0. The Anterior Lobe

The pituitary gland is attached to the median eminence of the hypothalamus by a stalk-like infundibulum. The anterior lobe of this gland accounts for about 75% of the weight of the pituitary and is derived from a pocket in the roof of the embryonic mouth (Rathke's pouch). In addition to a direct arterial supply, the anterior lobe of the pituitary receives blood through the hypothalamic-hypophyseal portal system from the hypothalamus. Secretion of the hormones produced by the anterior pituitary is controlled by Releasing and Inhibiting factors released from the hypothalamus into the hypothalamic portal vessels.

9.9.1. The principal hormones produced by the anterior lobe of the pituitary are:

1. Corticotropin; Adreno-corticotrophic Hormone (ACTH) - is released in response to all forms of stress, i.e., pain, trauma, cold, hypoglycemia, fear and anger. It targets the cells of the adrenal cortex. Under the influence of ACTH, the adrenal cortex (zonareticularis) releases cortisol along with some aldosterone. Over-production of ACTH leads to Cushing's disease.
2. Somatotropin (Growth hormone) - is released during the active growth years and throughout life. A powerful stimulant for its release is the condition of hypoglycemia. Growth hormone has a wide variety of metabolic effects. In general, it operates through two pathways. First, it has a direct effect on the metabolism of proteins, fats and carbohydrates. These activities lead to an increase in blood sugar, cellular uptake of amino acids and lipolysis. Indirectly, growth hormone stimulates the liver to release a class of growth stimulating substances called Somatomedins. The somatomedins target the growing tissues of the body, especially the skeletal system.

   Hyposecretion of growth hormone during childhood leads to dwarfism. Oversecretion during childhood produces unchecked body growth - giantism.

Oversecretion during adulthood produces the condition called acromegaly in which the victim exhibits overgrowth of the mandible ("lantern jaw") and brow ridges.

3. Thyrotropin (Thyroid Stimulating Hormone) - acts on the thyroid gland to stimulate the synthesis and secretion of thyroxine. A major factor leading to the release of TSH would be a hypothermic condition in the body. An autoimmune condition which prevents the thyrotropic cells of the anterior pituitary from recognizing the level of TSH in the blood leads to oversecretion of TSH. This is Grave's disease, a condition marked by overproduction of thyroxine, exophthalmia and goiter.
4. Prolactin or lactogenic hormone initiates and maintains milk secretion. It also seems to be responsible for the stability of the ovarian corpus luteum. Prolactin release is triggered by a releasing factor from the hypothalamus. The inhibiting factor for prolactin appears to be dopamine. During the late secretory phase of the menstrual cycle, a drop in the blood level of estrogens and progesterone leads to an increased release of prolactin. The resulting increase in lactogenic activity may be responsible for the breast tenderness many women experience at this time.
5. Gonadotropic hormones - The anterior pituitary releases two hormones which target the gonads:
    a. Follicle Stimulating Hormone (FSH) - facilitates the development of ovarian follicles and sperm production. Its release is controlled partly by blood levels of gonadal steroids.
    b. Luteinizing hormone (LH) - controls ovulation, the development of the corpus luteum and estrogen secretion in the female. In the male, this hormone is called Interstitial Cell Stimulating hormone and stimulates the testis to produce testosterone from the cells located between the semeniferous tubules (interstitial cells).

9.9.2 Pituitary Gland - The Posterior Lobe

The posterior pituitary or neurohypophysis derives from the hypothalamus of the embryonic brain. The activity of the posterior lobe is controlled directly by nerve cells whose cell bodies are located in the supraoptic and paraventricular nuclei of the

hypothalamus. The posterior pituitary secretes the hormones vasopressin (ADH) and oxytocin. Vasopressin is released under the conditions of low blood volume (hypovolemia) and increased osmotic pressure of the blood. The latter condition may be due to:

i. loss of body water from sweat, expired air, feces (especially during diarrhea), excessive urine production (diabetes).
ii. Lack of fluid intake.
iii. Increased intake of salt.

Vasopressin is produced in cells of hypothalamic nuclei and travels within the axons of these cells through the infundibular stalk. It is stored and released from the posterior lobe and causes an increased reabsorption of water by the kidney tubule cells into the blood.

Oxytocin is also produced by the hypothalamic nuclei and released from the posterior pituitary. The stimuli for this release include sensory nerve impulses from the uterus during the last stages of pregnancy. This will result in a reflexive contraction of uterine muscle leading to the birth of the child. Another source of stimuli for the release of this hormone originates from the teats of a doe or female animal nursing the young. Oxytocin will cause a contraction of the myoepithelial tissue in a lactating mammary gland forcing milk into the young animal's mouth (milk letdown)

9.10 Thyroid Gland

The thyroid gland consists of a right and left lobe joined by a middle region called the isthmus. The thyroid is located on the anterior surface of the trachea just below the larynx.

Histologically, the interior of the gland consists of hollow balls of cuboidal cells called follicles. Inside the follicles there is a space within which is stored a product of the follicular cells called thyroglobin. Thyroglobin is an incomplete form of thyroid hormone. Thyroid hormone can be stored temporarily in follicles. This represents the only example of extracellular storage of a hormone in endocrine tissue.

The production of thyroid hormone is regulated by the release of hormones from the hypothalamus and anterior pituitary. The chief stress leading to the increased release of thyroid hormone is a low basal metabolic rate usually accompanied by lower than normal body temperature.

Hyposecretion of thyroid hormone during the growth years can lead to cretinism (dwarfism with retardation). Hyposecretion during adulthood leads to myxedema, which is characterized by a low Basal Metabolic Rate (BMR), low body temperature and muscular weakness. If the hyposecretion is due to a lack of iodine in the diet, the individual may also develop an enlargement of the thyroid gland called simple goiter. Overactivity of the thyroid in an adult is often associated with an enlarged thyroid and eyes that appearto bulge from their orbits (exophthalmia). This condition is called Grave's disease.

9.11 Parathyroid Glands

The parathyroids consist of four, small masses of tissue located on the posterior aspect of the lobes of the thyroid gland. The principal product of the parathyroid gland is parathyroid hormone (PTH). It acts to increase the blood level of calcium by:

a. Increasing the activity of the bone reabsorbing osteoclasts.
b. Increasing the absorption of calcium from the food by the gut wall.
c. Decreasing the excretion of calcium by the kidney.

PTH release is stimulated by hypocalcemia i.e lower state of calcium in the blood and inhibited by hypercalcemia i.e higher than normal state of calcium in the blood. Overproduction of PTH is usually caused by a tumor of the parathyroid gland and produces a severe depletion of calcium salts from the bones called Osteitis Fibrosa Cystica. As a result, cavities form in the bone making them more susceptible to fracture. In postmenopausal women, osteoclasts become more sensitive to PTH. This leads to the bone-weakening disorder called osteoporosis, a bone disease characterized

by a reduction in bone density, accompanied by increasing porosity and brittleness, associated with loss of calcium from the bones.

9.13 The Pancreas

The Pancreas - is a mixed or compound gland consisting of acinar (exocrine) tissue specialized to manufacture digestive secretions. This tissue makes up most of the gland. In addition, about 2,000.000 islets of endocrine tissue (Islets of Langerhans) produce and secrete a variety of hormones.

The beta cells of the pancreatic islets are stimulated to release insulin due to hyperglycemia, high plasma levels of amino acids and fatty acids. Hypersecretion of glucagon, epinephrine, growth hormone, thyroxine and cortisol will also stimulate insulin release. After release from the beta cell, insulin is carried to the liver by the blood where about 50% is removed and inactivated. The remainder of the hormone passes into the general circulation, where it remains active for about 15 to 35 minutes. Insulin increases the uptake of glucose by body cells. It stimulates glycogen synthesis in liver and skeletal muscle cells. In adipose tissue, insulin favorslipogenesis. The primary effect of insulin is to reduce blood glucose levels. Another effect of insulin release would be the increased uptake of amino acids by body cells. This leads to increased protein synthesis and growth.

The alpha cells of the pancreatic islet release the hormone glucagon. The chief factors triggering this release are hypoglycemia and high levels of amino acids in the blood. Glucagon causes increased glycogenolysis in liver and skeletal muscle cells. This leads to the release of glucose into the circulation. Glucagon also produces an increased formation of glucose from amino acids and fatty acids by liver cells. Glucagon is the chief antagonist to the action of insulin.

9.13.1 Disorders of Pancreatic Hormones

Diabetes mellitus - is due to a hyposecretion of insulin or a hypoactivity of insulin. They are three primary effects of this disorder:

i. Hyperglycemia - The lack of insulin leads to an accumulation of glucose in the blood. Most of the cells of the body require insulin to take up glucose. The result is that in

these tissues alternate sources of energy are utilized, e.g., fatty acids and amino acids undergo gluconeogenesis under the influence of cortisol and glucagon. At the same time, glucagon and epinephrine increase the breakdown of glycogen in the liver (glycogenolysis). Both of these activities only exacerbate the problem of hyperglycemia.

ii. Ketosis - Another complication results from the accumulation of ketone bodies in the blood. These compounds result from the increased reliance on fat for energy. Ketones are organic acids. Their accumulation lowers the pH of the blood and reduces the oxygen-carrying capacity of the blood. Unchecked, this will eventually lead to coma and death.

iii. Dehydration - The presence of high levels of glucose in the glomerular filtrate interferes with the reabsorption of water by the kidney tubules.

Hypoglycemia - This symptom may be produced by several conditions not all of them related to islet function. Established causes of hypoglycemia include:

a. Beta cell tumor - "hyperinsulinism" i.e excessive secretion of insulin from the pancreas, resulting in hypoglycaemia.
b. Poor glucagon production and release
c. Defective glucose release by the liver
d. Addison's disease i.e. A disease caused by failure of the adrenal glands. It is characterized by weakness, low blood pressure, and brownish discoloration of the skin.
e. Hyposecretion of growth hormone

Students' Assessment Exercise9.2

What is the consequence of hyposecretion of insulin?

9.14 The Adrenal Glands

Adrenal glands are located retroperitoneal i.e behind the peritoneal on the superior surface of the kidney. Each gland structure is composed of an outer, steroid-producing cortex of mesodermal origin and an inner catecholamine-synthesizing medulla derived

from the neural crest. The medulla is very similar, histologically, to the sympathetic ganglia. Its cells contain dark-staining granules (chromaffin cells).

Adrenal Cortex - The outer region of the gland is divided into three fairly distinct region:

i. Zonaglomerulosa - is a thin, outer area responsible for the manufacture of the mineralocorticoids. The most important of these is aldosterone (95% of this group). These steroids regulate the levels of certain electrolytes in the body fluids, i.e., Na+ and K^+. Specifically, they cause the reabsorption of Na+ by the kidney tubules and the elimination of K^+.
ii. Zonafasciculata - is a fairly thick middle zone which synthesizes the glucocorticoids, a group of steroids which help to regulate glucose metabolism. Cortisol is the most important of these steroids. This group of hormones is essential for life as they permit adaptation to various stresses - psychological, as well as, physiological.
iii. Zonareticularis - is the most innermost layer of the cortex. These cells manufacture glucocorticoids and small amounts of adrenal sex steroids (gonadocorticoids). The latter are androgens, for the most part.
iv. Adrenal Medulla - The major products of this gland are epinephrine (most abundant product) and norepinephrine. Small amounts of the precursor dopamine are also produced. We refer to these hormones as "sympathomimetic" meaning that they mimic the effects of the sympathetic nervous system, i.e., increased heart rate, construction of blood vessels in the skin and viscera, inhibition of smooth muscle in viscera, dilation of bronchioles, increased respiratory rate and hyperglycemia.

Disorders of Cortical Hormones

Cushing's Syndrome - is the result of a hypersecretion of Cortisol. There are number of causes of this hypersecretion:

A. Excessive secretion of ACTH - is usually due to a tumor of the anterior pituitary (60 to 70% of the cases). This condition is referred to as Cushing's disease.

B. Adrenal Cushing's syndrome - is the result of an adrenal adenoma, a tumor of the adrenal cortex. In this condition, there are low levels of ACTH. About 20% of the cases are due to this cause.
C. Paraneoplastic Cushing's syndrome - results from the production of ACTH by a non-endocrine tumor, e.g., Bronchogenic carcinoma.
D. Iatrogenic Cushing's syndrome - due to the long term use of glucocorticoids to suppress inflammation or immune response.

Symptoms of Cushing's disease or syndrome:

a. Hyperglycemia and hypertension
b. Catabolysis of protein and fat
c. Immunosuppression
d. Fat accumulation in the face and upper back

Addison's Disease - is an uncommon disorder that requires the destruction of about 90% of both adrenal cortexes before becoming clinically apparent. The chief causes are believed to be:

1. Tuberculosis - responsible for about 25% of the cases.
2. Autoimmune disease - is suggested by the infiltration of cortical tissue with lymphocytes and the presence of antibodies in the victim's plasma to his own adrenal glands.
3. Insufficiency of ACTH - due to a lesion of the hypothalamus or pituitary.

Symptoms of Addison's disease:

1. Hypoglycemia and hypotension
2. Dehydration and hypovolemia
3. Atrophy of the heart
4. Anorexia, nausea and diarrhea

9.15 The Ovary

The ovaries are a pair of bean-shaped structures located in the lower pelvic portion of the abdominopelvic cavity. Each ovary is associated with the funnel-shaped opening of

an oviduct (Fallopian tube) and held in place by supporting ligaments. The ovary contains a large number of immature sex cells. During the ovarian cycle, a group of these immature oocytes continues through the process of oogenesis.

In the first half of the ovarian cycle, the oocytes become surrounded by an increasing number of follicle or nurse cells. The growth and storage of food by the oocyte are due to the activities of these cells. The follicle cells also produce increasing amounts of estrogens during this growth or proliferative stage. The most important of these hormones is estradiol. The estrogens induce ovulation and cause growth of the uterus, uterine tubes and mammary tissue. They also bring on the expression of female traits, such as, fat deposition in the breasts, thighs and buttocks. Progesterone is secreted by the corpus luteum. This structure develops from the remnants of the follicle wall remaining in the ovary after ovulation. Luteinizing hormone is chiefly responsible for the development of the corpus luteum. The most important function of progesterone is to prepare the lining of the uterus for the implantation of the embryo following fertilization. It also stimulates milk formation during pregnancy, as well as, the inhibition of ovulation during gestation.

9.16 The Testis

The testes lie in the scrotal sac which is suspended outside the male's abdominopelvic cavity. During most of fetal development, the testes are found in the abdominopelvic cavity. Towards the end of the fetal period, the testes migrate through the inguinal canal into the scrotum. If this migration does not occur (cryptochidism) then at the time of puberty the slightly higher temperature of the body cavity will lead to a destruction of the testicular tissue and sterility.

The principal secretory product of the testis is the steroid testosterone. This hormone is secreted by the interstitial cells under the influence of luteinizing hormone from the anterior pituitary. The chief actions of testosterone lead to the virilization of the male, i.e., facial hair, deepening of the voice, increase in the strength of muscles and bone growth. Later on, this hormone produces the closure of the epiphyseal growth plates in long bones and the cesession of growth in height. Red blood cell production and hemoglobin synthesis are also enhanced.

9.17 Conclusion

In this unit, an overview of the biosynthesis and regulation of hormonal secretions and the effects of abnormal hormonal secretions has been done. The mechanism of steroid hormonal action has also shown as well as the disorders of these should help the serious farm manager in tentative diagnosis.

Answers to students' Assessment Exercise 9.1

The basic molecules from which steroids are formed are the Cholesterols.

Answers to Students' Assessment Exercise 9.2

Diabetes mellitus

9.18 Summary

The biosynthesis and regulation of hormonal secretions and the effects of abnormal secretions as studied in this unit show that some of the not well understood abnormal behaviour in some farm animals might be actually due to abnormal hormone secretions. Careful study and observance of farm animals will help in proffering solutions to these disorders.

9.19 Tutor-Marked Assignment

Describe the mechanism of steroid hormone action

9.20 References and Other Resources

Pentikäinen V, Erkkilä K, Suomalainen L, Parvinen M, Dunkel L (May 2000). "Estradiol acts as a germinal cell survival factor in the human testis in vitro". J ClinEndocrinolMetab. 85 (5): 2057–67. doi:10.1210/jc.85.5.2057. PMID 10843196.

UNIT 10: ARTIFICIAL INSEMINATION

10.0 Introduction

This unit gives you a basic knowledge of what is meant by artificial insemination (AI) and its advantages and disadvantages. Some methods of semen collection from male animals for insemination into the female animals will also be discussed.

10.1 Objectives

By the time you have completed studying this unit, you should be able to:

- Define clearly what artificial insemination (AI) is;
- Highlight some advantages and disadvantages of AI;
- Be conversant with some common methods of semen collection.

10.2 Artificial Insemination (AI):

Is the possible impregnation of a female by artificial introduction of semen taken from a male. It is also defined as the process whereby semen collected from the male is artificially introduced into the female reproductive tract for the purposes of conception.

10.3 Advantages

- Eliminates time and space constraints.
- It is a very powerful tool for genetic development i.e. sex limitation on the part of the male is removed i.e. the best species of male is used for artificial insemination.
- It helps to control venereal disease spread in the animals, e.g. brucellosis, etc. In artificial insemination, there is no physical contact between the male and female.
- It is more economical with artificial insemination than in natural mating. The storage and preservation is cheaper than keeping a bull alive. Greater economic value from a high quality bull by selling the semen.
- It helps in keeping accurate record of the female oestrus, thus breeding time can be determined. In artificial insemination, the bull to be used, the period of heat, time of breeding and time of parturition are all well recorded.
- It increases safety on the farm. The danger of keeping a bull is eliminated.

10.4 Disadvantages

- Conception rates are lower in artificial insemination than for natural mating.
- There is the need for accurate determination of oestrous and involves costs because it requires refrigeration facilities, with either liquid N_2 or solid CO_2 (dry ice).

  Liquid N_2 - at −196°C
  Dry Ice - at −78°C

  Liquid N_2 evaporates, so one has to keep topping up. Where Liquid N_2 is not readily available, forget about deep freezing.
- It requires good communication facilities to facilitate ease of contacting artificial insemination centres to inseminate animals.
- Artificial insemination comes into serious conflicts with social norms and the production system does not permit easily, the introduction of exotic breeds.

Students' Assessment Exercise 1.1

Question: Apart from the advantages of AI given above, which other do you know?

10.5 PROCESSES INVOLVED IN ARTIFICIAL INSEMINATION

- Conduct breeding program to determine the best males
- Have a lot of artificial insemination centres nationally

10.5.1 Semen Collection

Five methods can be used to collect semen in most farm animals.

a. The Artificial Vagina (AV) method.
b. The Dummy method
c. The electro ejaculator method
d. The Rectal massage method
e. The recovery method

a. The Artificial Vagina (AV) Method: The artificial vagina collection results in the best quality semen, therefore, of the five methods of collection, AV is the best. The AV

is a special device that mimics the natural vagina. It consists of a hose opened at both ends.

It has an inner lining held to both ends by rubber band. Water is introduced through the valve, and blown hot air. The valve is later closed or tightened and petroleum jelly rubbed to facilitate easy penetration of the male sex organ (mimic secretion of the natural vagina)

To collect semen, a teaser female or animal is tied to the collecting crate and the male whose semen is to be collected introduced. The male is allowed at least two false mounting before collection of the semen, by diverting his penis into the AV. The males have to be trained for collection of their semen through AV.

b. The Dummy Method: This involves the design of a figure made in form of the animal, usually in pigs and a collecting tube inserted. The male whose semen is to be collected is trained to mount the dummy, ejaculate and the semen drained and collected in the collection tube. Semen collection using this method in the boar is by the gloved-hand technique.

The technician wears a rubber glove on one hand with which the screw like end of the boar penis is held firmly after mounting the dummy, to mimic the locking-in in the cervix. The boar semen is released in distinct fractions sequentially as per-sperm, sperm rich and post sperm portions, which can be collected in 3 different collection flasks. Ejaculation in the boar lasts from 10 to 30 minutes.

c. Electro-ejaculation (EE): This method involves electrical probe. The electrical probe is inserted in the male's rectum after evacuating any feaces. The probe is used to deliver intermittent voltage surges from a battery pack for electrical stimulation of the nerves around the accessory sex glands, leading to involuntary ejaculation. The semen from EE is usually more dilute and poorer in quality than those from AV and dummy.

The male animal has to be well restrained during EE to contain any violent reaction arising from the electric shocks. Also, EE is said to shorten the life span of the males on which they are used.

d. The Rectal Massage Method: This involves insertion of hand by a person through the rectum, usually of a bull, when feaces have been evacuated. The region of the accessory sex glands is massaged to stimulate ejaculation, and the semen flows out through the sheath of the penis.

The quality of semen under this method is lower than the previous 3 earlier discussed, because of debris that normally follows the passing of semen though the sheath.

e. The Recovery Method: This involves insertion of vaginal peccaries into the vagina of the female animal on heat. The male is allowed to mount and ejaculate. The pessary inserted is withdrawn and semen squeezed out.
This method results in lower quality semen than the earlier 4 discussed.

Student's Assessment Exercise 1.2

Question: Which is the best method of semen collection?

10.5.2 Semen Evaluation

- **Appearance –** Normal appearance is creamy white. Blood stain includes injury or veneral disease.
- **Volume –** Should fall within range for the species.
- **Motility –** Good enough motility (70%) for storage is required. At X400mag, using a phase contrast microscope.
- **Concentration –** Should be within range for the species, determined using;

- Haemocytometer
- Electronic counting e.g. coulter counter
- Photo electric method

10.5.3 To Determine the Quality

- Live/dead counts – By use of eosin/nigrosin stain. They are supravital stains. Dead cells pick up eosin where as live ones don't pick eosin.
- Morphology of the spermatozoa – can be determined using slide smears and immersion oil.

- pH – can also be determined using a pH meter.

Ejaculate Characteristics of Some Farm Animals

	Farm Animals		
Trait	**Bull**	**Ram**	**Boar**
Volume (ml)	3-8	0.5-1.2	150-300
Sperm Conc. $\times 10^9$/ml	0.6-2	2-5	0.2-0.3
Motility %	60-85	60-90	60-80
Morphological Normal SPZ	65-95	80-95	70-90
pH	6.9	6.9	7.5

10.5.4 Storage/Preservation

There are several methods available, but common ones include:

1. Liquid Storage – This is storage above 0°c
2. Deep Frozen Storage – This is storage in about 196°c. Under this condition, they can live indefinitely.
3. Ambient Temperature Storage – From about 20-35°c. They survive for within 2 weeks.
4. Chilled Storage – Usually between 4-15°c. Under chilled condition, spermatozoa can survive for 6-7 days.

   Regardless of the storage method, the basic thing is to preserve the live of the cell where the spermatozoa will stay longer or to slow their metabolic rate.

   Under ambient temperature storage, provide a buffer and dilute the semen so that the waste product does not accumulate fast.
5. Flows Dialysis Method – Fresh solution enters and the medium around the cells changes frequently. Under this method, cells survive for 8 days. When cocked in a container or McCartney bottles (semen + diluents) they survive for 4 days.
6. Freeze Drying – Here, the water level of the spermatozoa are reduced to make it into a powdered form, but success for fertilization is elusive under this method.
7. Other methods include formaldehyde preservation and other fruit juice, milk, etc.

10.5.5 Principles of Semen Preservation

1. Slow down the metabolic rate – can be by reduction of temperature or use of chemical metabolic inhibitors e.g. CO_2, HCHO.
2. Eliminate or control or remove injurious metabolic waste or by-products e.g. by dialysis, dilution, filtration or buffering.
3. Supply of energy source – e.g. fructose or glucose.
4. Maintenance of cell integrity to prevent cold shock especially in the case of deep freezing.

   This can be by use of egg yolk (protection against cold shock)

   - Albumin (prevent dilution shock)
   - Citrate (maintains membrane integrity and also a metabolite)
   - Cryoprotective agents (to prevent freezing injury) e.g. Glycerol, ethylene, glycol, erythritol.

10.5.6 Factors Affecting Fertility During AI

1. Method of semen collection or initial semen quality.
2. Species, breed and individual differences.

   Success rate for cattle is higher than for sheep and goats, and boars.

   Cattle > Sheep and Goats > Pigs
3. Semen preservation method.

   Fresh or natural is better than chilled and chilled is better than frozen in terms of fertility. In terms of storage, frozen is better.
4. Processing method.

   - Holding time before process
   - Choice of diluents
   - Dilution temperature – should be at about 30°c.
   - Dilution ratio, 1:4 (semen: diluents) best.
   - Method of dilution (mix gradually)
   - Diluents composition – should be such that pH is around 7; osmolarity should be about 300 milliosmol.
   - Cooling time to 5°c (should take 0.5-2hrs.)
   - Freezing method e.g.
     - Pellet freezing on dry ice

- Straw freezing in liquid nitrogen vapour

- Storage temperature – the lower the better
- Length of storage (chilled or ambient temperature storage), the smaller the better.
- Thawing temperature (should be 37°c)
- Post thawing incubation period – the longer the poorer. Use immediately.

5. Timing of insemination.

   Generally, insemination should precede ovulation by a few hours. With single insemination, inseminate 12-24 hours after oestrus detection.

   For double insemination;

   - Ewes detected in the morning, inseminate in the evening on same day and again on the following morning.
   - Ewes detected in the evening, inseminate morning and evening of the following day.

6. Insemination dose – This varies between 5m-500m, but in poultry, after evaluating sperm characteristics for quality, volume (in ml) is used for AI e.g. 0.05m, 0.1m or 0.2m, etc.
7. Skill of the technician

10.6 Diluents Composition

Ingredients	Tris-Yolk	Cornell University Extender	Yolk Citrate	Homogenized Milk
Tris* (g)	30.28	-	-	-
Citric acid (g)	16.75	0.87	-	-
Fructose (g)	12.50	-	-	-
$NaHCO_3$ (g)	-	2.10	-	-
KCL (g)	-	0.40	-	-
Tri-Na citrate (g)	-	14.50	29.0	-
Glucose (g)	-	3.0	-	-
Glysine (g)	-	9.37	-	-
Sulphanilamide (g)	-	3.0	-	-
Homogenized milk	-	-	-	1000

(cc)*[1]				
Distilled water (cc)	-	To 1000	-	1000
Buffer (cc)	-	800	-	-
Egg yolk	200	200	-	-
Na penicillin (cu/ml)	1000	1000	1000	1000
Streptomycin Sulphate (mg/ml)	1	1	1	1
Distilled water	1000		1000	-

Types of Diluents

- Tris-yolk
- Cornell University Extender
- Homogenized Milk

*[1] Cow or goat milk, heated to 92°c for 10 minutes and cooled to 37°c.

* Tris -2 Amino – 2- (hydroxyl methyl) propane – 1, 3 – diol.

10.7 Conclusion

This unit serves to define artificial insemination (AI), how to collect semen and evaluate, the advantages and disadvantages of AI.

Answer to Students' Assessment Exercise 1.1

Other advantages of AI are:

- Additional sources of employment
- Additional source of income for farmers

Answer to Students' Assessment Exercise 1.2

The best method of semen collection in terms of quality is the AV.

10.8 Summary

You have studied what artificial insemination is, its advantages and disadvantages as well as methods of evaluating semen for AI.

10.9 Tutor-Marked Assignment

I. Define AI.

II. List any five advantages of AI

III. List any three semen characteristics related to semen evaluation.

10.10 References and Other Resources

- Osinowo O.A.2006. Introduction to Animal Reproduction. Sophie Academic Services Ltd. P.O Box 47, UNAAB Post Office, Abeokuta, Nigeria.
- Sorensen Jr. A.M. Repro Lab. A Laboratory Manual for Animal Reproduction. 3rd Edition. Kendall/Hunt Publishing Company, U.S.A.

MODULE 6

GAMETOGENESIS, FERTILIZATION AND PREGNANCY

Introduction

In this module there are 2 units, the first unit deals with the topic, Gametogenesis; while the second unit deals with the issue of fertilization and pregnancy.

The objectives of the module include;

1. To enable you understand the concept of gametogenesis
2. To enable you understand the issue of fertilization and pregnancy

UNIT 11 GAMETOGENESIS: THE DEVELOPMENT OF THE SEX CELLS, SPERMATOZOON AND OVUM AS WELL AS OESTROUS CYCLE

11.0 Introduction

This unit gives you the development of both spermatozoa and ova and an overview of the oestrous cycle in farm animals, comparing same with the menstrual cycle in primates. Abnormal oestrus and deranged cycles are also discussed.

11.1 Objectives

At the end of your study in this unit you will be able to:

- Differentiate between oestrous cycle, oestrus period and menstrual cycle
- Define post-partum oestrus
- List some deranged cycles

11.2 Gametogenesis:

The development of the sex cells, spermatozoon and ovum-delete

Gametogenesis is the entire process of consecutive cell divisors and differentiation by which mature eggs or sperm are developed. In the gonads of the mature mammal the process of gametogenesis occurs whereby diploid cells produce by meiosis haploid

daughter cells-the spermatozoa of the male and the ova of the female. In the male the process is termed spermatogenesis and in the female oogenesis.

11.3 Spermatogenesis

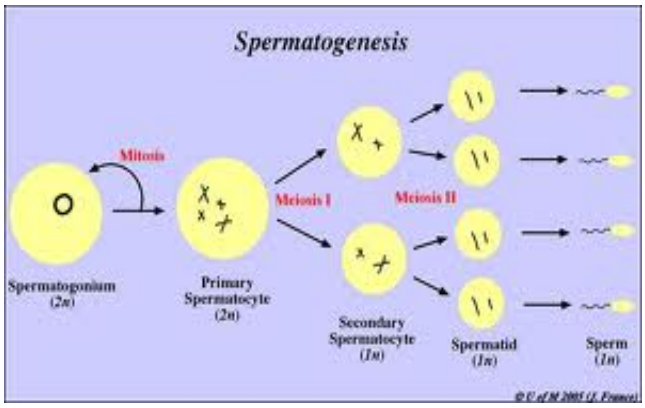


Fig. 1: Spermatogenesis

The mammalian testis consists of many coiled seminiferous tubules whose length in man may exceed 200 metres. The cells that line the tubules are termed spermatogonia and these proliferate by mitosis to make large numbers of similar diploid cells (fig. 1). At some stage the spermatogonia are changed, by hormonal stimuli, into primary spermatocytes with large central nuclei. These then start to undergo meiosis.

The first meiotic division produces two haploid secondary spermatocytes which have smaller and more compact nuclei. These in turn complete the meiotic process to produce four haploid spermatids, which are partially embedded in the large Sertoli cells that are between the banks of developing spermatogonia. Finally, while still attached to the Sertoli cells, the spermatids develop into mature spermatozoa.

The whole process is under control of the hormone FSH and in the case of man continues steadily from the time of puberty until old age. In other mammals, such as insectivores and the orders of herbivorous and carnivorous mammals, the testes are only active seasonally, at a time that coincides with the oestrous cycles of the females.

It is generally supposed that in many mammals viable sperm are stored at somewhat below the normal body temperature and for this reason the testis, and the epididymis

where the sperm are stored, descend outside the body cavity. Such is the case in man, cattle, sheep, goats, and boar.

11.4 Oogenesis

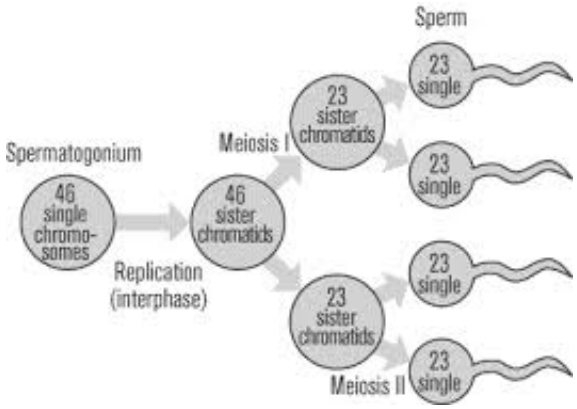


Fig. 2 Oogenesis

11.5 Oestrous cycle

The activity of the ovary is cyclic, unlike that of the testis, and the pattern of activity and ovulation, the oestrous cycle, varies from one species to another, but similar in divisions (fig. 2) as in that of Spermatogenesis. Most female mammals show no reproductive behavior during their anoestrous period when the ovary is quiescent.

All female mammals with the exception of human females have a breeding season, and if they show a single cycle of ovulation during that period they are termed monoestrous. Such is the case for many carnivores, including dogs and cats. If, on the other hand, the female has many cycles of ovulation during the breeding season then the species is polyoestrous. This is the case in horses and other herd animals. In fact females of domesticated mammals tend to change their rhythms from monoestrous to polyoestrous, showing that environmental factors can produce phenotypic change. While the significance of the various cycles is not very clear it is certain that the overall result of the breeding pattern is to allow the female to produce her offspring at a time when they are most likely to survive.

In the case of the human female there is a more-or-less regular 28-day cycle of ovulation which starts with the ripening of a single (or very exceptionally two or more)

Graafian follicles. Although the human female may possess a couple of million immature follicles in her ovaries at birth the number is very substantially reduced by the time of puberty, and most of these surviving follicles will never develop but will degenerate in time.

Within each follicle the process of meiosis has started but becomes suspended at the stage of the first prophase. Maturation of the ovum only occurs at ovulation, when the primary oocyte first completes meiosis II to produce a mature (haploid) ovum, or egg, and a second polar body. In some species, such as the rabbit, the maturation division is only completed after fertilization.

Cells within the ripening Graafian follicle break down to provide some of the follicle liquor and some cells become granular (granulosa cells) and form the basis of the cumulus oophorus that surrounds the egg. Meanwhile the egg itself produces the zonapellucida, homologous to the vitelline membrane in lower vertebrates. Within this zonapellucida is the true egg cell, with its protoplasmic membrane rich in microvilli and a space, the perivitelline space, between this membrane and the zonapellucida.

Meanwhile in the ruptured follicle granulosa cells, under the influence of luteinizing hormone, enlarge and become secretory, producing the hormone progesterone. If fertilization has not taken place the corpus luteum (which is the name given to the modified follicle) degenerates and the oestrous cycle starts again with the ripening of another primary follicle.

Oestrus- period of sexual receptivity in female animal (heat).

Oestrous cycle- period between one oestrus and the next.

Menstrual cycle- interval from one menstrual period to another in primates.

Ovulation – rupture of follicle and shedding of ovum. It is the culminating event of the oestrous cycle.

Student's Assessment Exercise 11.1

Is an ovum a haploid or diploid cell?

Following the attainment of puberty in the female, the sequence of reproductive event is cyclic in nature.

11.5.1 Definitions

Oestrous and ovarian cycles

The oestrous cycle last for 16 – 25 days in domestic mammals and varies between species as well as between individuals. Events associated with the oestrous cycle can be hastened, modified or delayed by exteroceptivefactors such as sound, odour and change of environment. Pheromones can cause profound shifts in the neuroendocrine control mechanisms.

The ovarian cycle refers to the cyclic physiological and morphological changes occurring in the ovary. The oestrous cycle is a concomitant of the ovarian cycle. Changes in the ovary include follicular development, ovulation , corpus luteum formation and luteal regression, which bring about changes in the lower tract, such as the uterus, cervix and vagina.

The oestrous cycle may be divided into the following stages, taking oestrus on set as the first day of the cycle lasting 21 days:

Stages of the oestrous cycle	Associated Behavior	Duration (days of cycle)
Proestrus Oestrus Metoestrus Dioestrus	Excitement Standing for male Decreasing interest in male Sexual rest	19-21 1-3 4-6 7-18

The above stages of the oestrous cycle are based on behavioural changes. A different classification may be made, based on the ovarian cycle:

OestrousCycle	**Luteal Phase**-extends from luteum formation after ovulation to corpus luteum regression at end of cycles. Lasts 14-15 days in the ewes, 16 –days in the cow and sow
	Follicular Phase– period of rapid follicular development, beginning from corpus luteum regression and ending with oestrus and ovulation. Lasts 2-3 days in the ewe and goat, 3-5 days in cow

	and sow.

11.7 Comparison of Oestrous and Menstrual Cycles

The menstrual cycle occurs mainly in primates (Monkey, woman) whileoestrous cycles occurs in non-primates (cow, sheep, sow). Bothinvolve identical physiological and morphological changes in the ovaries, vagina and uterus but non-primates show periodic peaks of sexual receptivity (oestrus) whereas primates do not.

Also, the sloughing off of the uterine endometrium is accompanied by bleeding in primates while does not in non-primates. The oestrous cycle also differs from the menstrual cycle in the length of the follicular phase which is short in non-primates (2-5 days) but which lasts up to 2 weeks in primates. The luteal phase in both groups is of similar duration.

11.8 Oestrus (Heat) and Ovulation

Oestrus coincides with the greatest development of ovarian follicles. The psychological manifestation is brought about by oestrogen. Administration of exogenous oestrogen cause heat almost at any time during the oestrous cycle. However, it should be noted that oestrus can occur without ovulation. In many species, the full manifestation of oestrus seems to require progesterone priming.

Duration of oestrus varies between individuals as well as between species. The same is true of ovulation time. In ewes, the interval between oestrus and ovulation lengthens with increasing number of ovulations. Sexual stimulation reduces length of oestrus in the cow, and decreases variability of ovulation time in the ewe. Season may also affect duration of oestrus.

Prior to ovulation, in the follicular phase of the oestrous cycle, follicular growth is regulated by basal levels of FSH and LH. When the oestrogen secreted by the follicles reaches a sufficiently high level it facilitates the pre-ovulatory surge of gonadotropins.

The rate of increase and the level of increase of progesterone secretion following ovulation is dependent on the number of corpora lutea. Corpus luteum regression is

caused by a uterine luteolytic factor prostalglandin PGF2α, in the ewe, sow and cow. However, in primates, CL regression is not under the control of a uterine luteolytic factor. The secretion of PGF2αis under the influence of oestrogen.

11.9 Behavioural and Biophysical Changes Associated with Oestrus

The increased activity shown by many animals around the time of oestrus is caused by oestrogen. Pigs on heat show significant changes in bioelectric potentials measured externally over the ovarian region of the body (23 .2mV in pigs on heat vs 6.6 mV in non- oestrous pigs).

Similar changes in electric potential occur in women at the time of ovulation. In women, ovulation is preceded by a slight drop in basal body temperature. Such temperature changes are more difficult to show in farm animals due to difficulty in obtaining basal temperature. Vaginal pH varies between individuals and with stage of the oestrous cycle. It is more alkaline in dioestrus and more acidic during heat.

Student's Assessment Exercise 11.2

List two animals in which quite or silent oestrus is common

11.10 Genital tract changes during the oestrous cycle

The vagina, cervix, uterus and oviduct are all steroid target organs and their activities vary synchronously with the ovarian cycle. The volume of genital secretion increases at oestrus under the influence of oestrogen. The physiochemical changes which occur during oestrus facilitate transport, survival and capacitation of spermatozoa and facilitate fertilization, cleavage and implantation. Vaginal changes occur under the influence of oestrogen and progesterone. The vaginal epithelium changes with the stage of the oestrous cycle, fluctuating between stratified squamous and low cuboidal types. These changes can be followed by vaginal smear technique.

Changes in vagina histology most accurately reflect ovarian events in species with short cycles (mice, rats). They are less reliable in species with longer cycle due to one to several days inthe reflection of ovarian changes in the vaginal histology. The rapid increase and cornification of the vagina epithelium during early and late oestrus is caused by oestrogen. When oestrogen level drops after ovulation, the cornified vaginal epitehelium starts breaking down.

In the uterus, the most striking changes occur in the endometrium. During the follicular phase, the uterus is under progesterone influence. The uterine endometrium increases in thickness while the uterine glands grow in length and diameter, becoming extremely branched and convoluted.

11.11 Abnormal oestrus

Quiet or silent oestrus – ovulation without behavioural oestrus. More Common in cows and mares, LH level is normal but FSH level is low.

May be due also to low oestrogen levels. Occurs also in the post- parturition - period.

Anovulatory oestrus- oestrus with out ovulation. FSH level is normal but

LH is insufficient. May be caused by climatic or nutritional stress.

May also occur in the post-partum period immediately after parturition.

Split oestrus- interruption of heat period by period of non-receptivity lasting few hours to2 days.

11.12 Post- partum oestrus

Females of several species show heat shortly after parturition. In rats, post-partum heat is accompanied by ovulation within 48 hours after parturition. No further heats occur in suckled rats till after weaning. Mating at first post-partum heat in rats result in pregnancy.

In women, breastfeeding creates an anovulatory condition but individuals vary, in sows, post-partum heat occurs within a few days. No ovulation occurs and therefore no pregnancy occurs if mated. Removal of litter results in heat and ovulation few days later in sows.

In cows, first heat occurs between 30 – 60 days post-partum but fertility is low at first heat. In sheep, post-partumheat occurs 0-2 days after parturition. However, no pregnancyoccurs till 30days post-partum.

11.13 Deranged cycles

- Whitten effect – shift in proportions of females showing heat daily caused by odour of male or ingestion of male faeces. The original experimentswere conducted with mice.
- Bruce effect – female mice mated by one strain conceive to mating by male of different strain. Introduction of male of new strain probably caused CL degeneration and ovulationof new crop follicles.

- Sudden introduction of rams in ewe flock may have synchronizing effect on oestrus in ewes.
- Transportation of mature pigs from one location to another tend to synchronize their sexual activity (heat and ovulation) in relation to the moving day.
- Transportation also advances onset of puberty in gilts.
- Psychosomatic modification of menstrual cycle is common in women i.e. women are sometimes sexually attracted to the males from the small of some scents on the males.

11.14 Conclusion

In this unit, you have learnt that in the female animal, reproduction is cyclic while in the male, it is not. Also, there are some behavioural and biophysical changes associated with oestrus, which the farm manager can take advantage of to ensure conception following artificial insemination.

Answer to Student's Assessment Exercise 11.1

An ovum is a haploid cell

Answer to Student's Assessment Exercise 11.2

Quite or silent oestrus is common in cows and mares

11.15 Summary

In the gonads of mature mammals the process of gametogenesis occur whereby diploid cells produce by meiosis haploid daughter cells called spermatozoa in the male and ova in the female. In the female, oestrous is cyclic and affects behaviour and some physiological structures of the animals, unlike the male counterpart that is fairly stable or isotonic. Understanding these features will help in good management for optimal reproduction.

11.16 Tutor-Marked Assignment

Elaborate on the differences between oestrous and menstrual cycles

11.17 Reference and Further Reading

Osinowo O.A.2006. Introduction to Animal Reproduction.Sophie Academic Services Ltd. P.O Box 47, UNAAB Post Office, Abeokuta, Nigeria.

UNIT 12 FERTILIZATION AND PREGNANCY

12.0 Introduction

In this unit you will study the concept of fertilization and pregnancy in farm animals. You will also learn about the maintenance of pregnancy and parturition mechanism as well as uterine involution.

After mating, semen is deposited in the vagina of the ewe andthe cow or in the relaxed cervix in the mare or the body of the uterus in the sow. Mechanism of sperm transport is mainly passive and is due to uterine contractions which are made stronger by the effect of organism. Sperm are transported to the oviduct within five minutes of ejaculation in the cow.

Although hundreds of millions of spermatozoa are ejaculated, less than 1,000 or 0.01 % reach the ampulla. Spermatozoa undergo some necessary changes called capacitation in the female genital tract before they are capable of fertilization.

12.1 Objectives

By the end of your studies in this unit, you should be able to:

- Define fertilization
- List the types of placentation in animals
- Elaborate on maternal requirements for normal birth

12.2 Fertilization and Pregnancy

Ova are flushed in follicular fluid into the infundibulum during ovulation. Transport of ova within the oviduct is by muscular contraction of the myometrium and beating of kinocilia.

12.3 Fertilization

This is the fusion of two cells, male and female gametes, to form a single cell, called the zygote. Two aspects are involved:

A, Embryologic aspect: Activation of the ovum by sperm. Cleavage and embryonic development do not begin until after fertilization.

B, Genetic aspect: Introduction of genes from sire into ovum. The fusion of the male and female nuclei, known as syngamy, is the central process of fertilization.

In most mammals, fertilization takes place in the lower half of the ampulla (oviduct). Fertilization begins after the extrusion of the first polar body in most mammals, with sperm penetrating the ovum while the second reduction division is in progress. Fertilization occurs earlier in the dog and horse.

The zonapellucida undergoes some changes after the passage of the first sperm which renders it less easy to penetrate by other sperm. The change is referred to as the zona reaction. Extra sperm which succeed in passing through the zonapellucida into the peri-vitelline space are called supplementary sperm.

The other defense mechanism against the entry of more than a single sperm is exhibited by the vitellus, the vitelline surface thereafter becomes unresponsive to contract and no further sperm is engulfed.

Extra sperm which succeed in entering the vitellus despite both the zona reaction and the vitelline block are called supernumerary sperm and the ovum is said to show polyspermy. The incidence of polyspermy in mammals is low and leads to triploidy which is a lethal condition.

12.4 Cleavage

After syngamy the embryo leads a free-living existence in the oviduct and uterus of the mother, nourished by uterine secretions. The process of cleavage, cellular division without growth, commences soon after syngamy and continues until implantation from one cell stage to all **ingwmtric** progression. The embryonic cells are known as blastomeres during the early cleavage stages, before blastocoele formation.

By the 16 – 32 cell stage the cells are crowded together in a compact group within the zonapellucida and the embryo is now known as a morula. It is only after the morula stage that total embryonic mass increases. Fluid starts collecting in interstitial spaces which expand, forming an inner cavity or blastocoele. The embryo is now called a blastocyst.

Cell differentiation already takes place in the morula stage, the three cells nearer the one pole becoming the embryo and the others the trophoblast. The embryo pole forms the generative pole while the trophoblast becomes the vegetative pole.

12.5 Blastocyst

The inner cell mass gives rise eventually to the adult organism while the cells of the trophoblast form the placenta and embryonic membranes.

12.6 Implantation

The embryo spends some days in the oviduct before reaching the uterus where implantation occurs. It is said to be implanted or attached when it becomes fixed in position and physical contact with the maternal organism is established. In ungulates and carnivores, the blastocyst elongates and enlarges until it fills a good part of the uterine cavity. This is known as central implantation.

In rodents the blastocyst remains small and becomes lodged in a fold of the uterine lumen where it implants itself. This is known as eccentric implantation. In the guinea pig, insectivores and man, the blastocyst implants itself interstitially by passing through the uterine epithelium, becoming completely cut off from the uterine lumen. Implantation begins in sheep between days 10 and 22 of pregnancy, days 11 and 40 in the cow and in man, days 6 and 8.

12.7 Placentation

Table 1: Classification of types of placentation

Type	Gross shape	Examples of species
Epitheliochorial	Diffuse	Pig, horse, donkey
Syndesmochorial	Cotyledonary	Sheep, cow, goat
Endotheliochorial	Zonary or discoid	Cat, dog
Hemochorial	Discoid or zonary	Primates
Hemoendothelial	Discoid or spheroidal	Rat rabbit, guinea pig

Source: Osinowo (2006)

As the blastocyst increases in size, it can no longer absorb enough nutrients by diffusion as in the early stages. A transition from embryotrophic to hermotrophic nutrition occurs

soon after implantation. The placenta may be defined as a union of foetal and maternal tissues for physiologic exchange. Different types of placentation are classified.

Shortly after implantation begins, the organization of placental membranes starts, and the chorion, amnion and allantois are formed. The chorion, the outermost membrane, is in contact with the endometrium. The allantois, located between the amnion and the chorion, is continuous with the anterior extremity of the bladder by way of the urachus, which passes through the umbilical cord. The inner layer of the allantois is fused to the amnion; the outer layer is fused to the chorion, forming the chorioallantois. By this fusion, the foetal vessels in the allantois come in close apposition to the umbilical arteries and veins located in the connective tissue between the allantois and chorion. These vessels are important for exchange between the foetus and placenta.

The placenta functions as a multi-organ performing many functions and substituting for the foetal gastrointestinal tract, lung, kidney, liver and endocrine glands. In addition, the placenta separates the maternal and foetal organisms, thus ensuring separate development of the foetus.

Embryology

During early differentiation, cells at one pole of the blastocyst, the germ-disc, give rise to three separate layers of cells, the endoderm which is the innermost layer, the ectoderm (outermost layer) and the mesoderm (between the ectoderm and the endoderm).

Formation of most organs and body parts takes place between the second and sixth week of gestation in cattle. Heartbeat and blood circulation commence on day 21 of pregnancy in cattle, day 16 in the sow.

The absolute growth of the foetus is exponential up to parturition but relative growth declines around mid-gestation. In cattle, more that 50% of the increase in foetal weight occurs during the last two months of gestation.

12.8 Maintenance of pregnancy

Following fertilization and normal embryonic development up to implantation, conceptus – maternal interactions occur which result in:

1) Maintenance of the corpus luteum and thus continued secretion of progesterone
2) Continued development of the uterine endometrium
3) Implantation

The maintenance of pregnancy requires continuous production of progesterone.

Maintenance of the CL and hence progesterone production is accomplished by the action of the conceptus on the endometrium:

1. To cause continuing release of LH
2. To prevent the release or production of PGF2αfrom the uterus thus preventing luteolysis.

Maintenance of the CL is necessary throughout pregnancy in the goat and cow, while it is necessary only for 40-60 days in sheep, after which pregnancy is maintained by placental progesterone. Placental progesterone takes over pregnancy maintenance in the mare from 150 – 180 days onwards.

12.9 Parturition

This is the physiologic process by which the pregnant uterus delivers the foetus and placenta from the maternal organism. Initiation of parturition is entirely under hormonal control. The regulation (control) of parturition is by a complex interaction of endocrine, neural and mechanical factors.

The mechanisms involved in parturition are the following:

12.10 Parturition Mechanisms

1. The signal for the initiation of parturition begins in the foetus and evokes a response from the maternal endocrine system.
2. It involves maturation of the foetal hypothalamic – hypophysical – adrenal axis.
3. The foetal hypothalamus stimulates the foetal hypophysis to produce ACTH.
4. ACTH stimulates production of cortisol by the adrenals.

5. Cortisol stimulates increase of oestrogens and less progesterone by the placenta.

6. Oestrogens stimulate release of PGF2αfrom the endometrium and enhances oxytocin effect on the myometrium.

7. PGF2αcauses luteolysis, leading to a fall in progesterone secretion.

8. These lead to release of oxytocin from the neurohypophysis, uterine contraction and relaxation of the cervix

9. Oxytocin release following distension of vagina and cervix plays important part in the second stage of labour.

10. Relaxin causes expansion of the birth canal.

Parturition is completed in three stages of unequal duration and is followed by uterine involution.

Students Assessment Exercise 12.2

Who initiates parturition, is it the foetus or dam?

Students Assessment Exercise 12.1

Where is semennormally deposited during mating in the cow?

12.11 Stages of Parturition

1. ***Preparatory phase:*** Dilatation and relaxation of the cervix brought about by relaxin. There is an active rhythmic contraction of the cervix. Symptoms of this phase are the onset of milk secretion in most species and relaxation of the pelvic ligament in the cow.
2. ***Expulsive phase:*** Characterized by increase in the intensity and frequency of uterine contractions. The amnion breaks due to the pressure and the amniotic fluid lubricates the cervix and vagina through which the foetus is delivered.
3. ***Purgatory phase:*** Follows the expulsion stage. The uterus is cleaned out of the remaining foetal membranes and cellular debris.

Requirements for normal birth

Maternal requirements for normal birth include the following:

12.12 Maternal Requirements for Normal Birth

A. Normal physical condition. Good health and full physical maturity favour normal birth.
B. Normal size of the soft and bony birth canal
C. Normal relaxation of the soft and bony birth canal.
D. Normal lubrication of the birth canal.
E. Adequate expulsive forces:
    i. Uterine contraction and
    ii. Abdominal press.

12.13 Uterine involution

The uterus undergoes regression after parturition. The uterine mass undergoes reduction and the endometrium returns from the pregnant to the non-pregnant state. In most species there is some amount of vulva discharge called lochia, a greyish red fluid containing blood cells and endometrial debris. Its amount decreases gradually and ceases in most animals by the end of the second week postpartum.

12.14 Conclusion

You have studied fertilization, pregnancy and parturition in farm animals. There are quite or silent oestrus, and pregnancy ought to be maintained. Also, you learnt that for parturition to take place, as expected, there are both foetal and maternal requirements.

Answer to Students' Assessment Exercise 12.1

During mating in the cow, semen is deposited either in the vagina or relaxed cervix

Answer to Students' Assessment Exercise 12.2

The foetus initiates parturition in cattle

12.15 Summary

In this unit you have studied how pregnancy is maintained, following fertilization. The stages of parturition were also discussed and on successful parturition, uterine involution is expected to follow.

12.16 Tutor-Marked Assignment

Elaborate on the various stages of parturition.

12.17 Reference and Further Reading

Osinowo O.A.2006. Introduction to Animal Reproduction.Sophie Academic Services Ltd. P.O Box 47, UNAAB Post Office, Abeokuta, Nigeria.

MODULE 7

REPRODUCTIVE EFFICIENCY, INFERTILITY AND STERILITY IN FARM ANIMALS

Introduction

In this module, there are two units. The first unit deals with the issue of reproductive efficiency an problems .the second unit deals with the issue of infertility and sterility in farm animals.

The objectives of the module include;

1. To enable you understand the issue of reproductive efficiency and problems
2. To acquaint you with the issues of infertility and sterility in farm animals.

UNIT 13 REPRODUCTIVE EFFICIENCY AND PROBLEMS

13.0 Introduction

This unit will treat and elaborate on the significance of reproduction for any profit to be made in any farm animal venture. The problems that need to be addressed for efficient reproduction to be achieved are also stated.

13.1 Objectives

- At the end of your study in this unit, you should be able to :
- -Elaborate on the significance of efficient reproduction to profitable animal production
- -Write on any key issues in maintaining high reproductive efficiency.

13.2 Reproductive Efficiency and Problems

Profitable animal production is greatly dependent on the maintenance of high reproductive efficiency. Increase in number of stock, milk and egg production depends directly on reproduction. In general, the higher the reproductive rate the lower the cost of production and the higher the profit margin. For example in sheep production, the weight of lambs marketed/ewe is largely dependent on the reproductive rate. Also increasing the reproductive rate through accelerated lambing virtually doubles the

annual lamb crop from the same number of ewes. It pays at the farm level to maintain a high reproductive efficiency for any type of flock.

13.3 Problems

The problems in maintaining high reproductive efficiency hangs on 3 issues.

1. The female animal being in a normal state i.e. cycling normal in a healthy body with the right body condition score.
2. The male animal counterpart, being in an optimal condition and ratio to mate female animals on heat or release healthy spermatozoa of adequate quantity and quality for artificial insemination.
3. The human factor, which has to do with good husbandry practices by the farm manager.

Students Assessment Exercise 13.1.

Which of the problems of efficient reproduction do you consider as the most important?

13.4 Conclusion

You have studied the significance of efficient reproduction for profitability in animal agriculture and the challenges you should watch out for i.e., both animal and human factors

Answers to students' Assessment Exercise 13.1

The most important problem is the human factor.

13.5 Summary

Profitable animal production is greatly dependent on the maintenance of high reproductive efficiency; this is the case whether you are looking for meat, milk, eggs, or their bye-products. It is therefore extremely important that you ensure efficient reproduction if you are aiming for profit in your animal husbandry.

13.6 Tutor-Marked Assignment

Discuss exhaustively the imperative of efficient reproduction to profitable animal husbandry

13.7 Reference and Further Readings

Reproduction in farm animals.5th edition.Edited by E.S.E. Hafez,Lea and Febiger, Philadelphia.

UNIT 14: INFERTILITY AND STERILITY IN FARM ANIMALS

14.0 Introduction

In this unit, you will be studying what is meant by infertility and sterility in farm animals. You will get to know the difference between infertility and sterility as well as the causes of these reproductive failure and possible prevention and treatment issues

4.2 Objectives

By the time you have completed studying this unit you should be able to :

- State clearly the difference between infertility and sterility
- List the causes if infertility and sterility
- State how to prevent case of infertility

14.3 Infertility /Sterility in Farm Animal

Livestock are deemed infertile when they are neither normally fertile nor completely sterile. Infertility is the dimished capacity to produce viable offspring.

Sterility is the inability of an animal or an organism to produce offspring or fruit, because of some disorder of the reproductive system; it is also referred to as bareness or unfruitfulness.

Sterility is more orless a permanent condition while infertility can be corrected and therefore a non- permanent condition.

14.4 Causes of Infertility / Sterility

The causes of infertility are many and can be complex (Arthur, 1982). They relate to Graafian follicle development and maturation, oestrus onset, successful coitus, ovulation, fertilization, implantation and the development and delivery of the foetus and its membranes. Anything interfering with these routines, such as disease, poor nutrition, inadequate herd management, hereditary and congenital factors, hormonal disturbances or environmental changes, makes the animal infertile (Osmanu, 1979) and on prolonged basis, makes the animals sterile.

The to 30% of lactations may be affected by infertility and reproductive disorder (ErbMatin, 1980), and 3-6% of the herd is culled annually in developed countries for these reasons. The extent of the problem is likely to be similar in the tropics like Nigeria, although extensive data are not available.

Some of the common causes of infertility are given below.

14.4.1 Congenital Morphological Causes,

Congenital causes of infertility are often inherited. They include developmental abnormalities of the ovaries oviducts, uterus, cervix, vagina and vulva. Some are lethal, a few have morphological significant and others a functional significance.

Common morphological conditions include ovarian (Gonodal) hypoplasite and aplasia, anomalies of the tubular genitalia , hermaphroditism, freematisim, arrested development of the mulleins ducts (White heifer disease) and double cervix (Lagenlof , 1963).

Bovine gonadal hypoplasia is not easy to diagnose and in case of bilateral ovarian hypoplasia heifers do not develop secondary sexual characteristics. They are anoestrous and infertile, where the condition in unilateral normal sexual organs and oestrous activity way be observed, such animals are fertile, although less so than normal. The condition is potentiated by an autosomal excessive gene with incomplete penetrance, and therefore the incidence of gonadal hypoplasia can be reduced by using only animals (both male and female) with normally developed sexual organs as breeding stock.

14.4.2 Functional Causes of Infertility and Repeat Breeding.

The causes of functional infertility include cystic and inactive ovaries with an oestrus, early embryonic mortality with repeat breeding, and prolonged gestation.

14.4.2.1 Cystic ovaries and retained (persistent) corpora luteal cystic ovaries contain one or more persistent fluid- filled cavities larger than a ripe follicle. This is sometimes referred to as cystic ovarian disease. Ovarian cysts can be classified as follicular and

luteal. They may vary in size from that of a ripe follicle to that of an orduge in cattle. Their effects also vary according to their number and degree of luteinisation. Many unleinised follicles tend to lead to symphonic with frequent, irregular heat, where as a cow either a few extensively luteinized cysts may become anoestrus. Cows with long-term cysts may show virilise. In addition to the pathologic follicular and luteal cysts, there are the non-pathologic cystic corpora luteal. These are normal structures that follow a normal ovulation but have a fluid-filled central cavity 7-10 mm in diameter in cow. On rectal palpation, they feel like normal corpora luteal but more fluctuant and both. They do not alter the oestrous cycle duration and when conceptions occur, it can be maintained to term (Roberts, 1971). The term ‘’cystic ovaries’’ is therefore usually applied to pathological follicular and luteal cysts.

Estimates of the incidence of cystic ovaries in Zebu cattle range from 1 to 13% (Hussain and Muniraju, 1984).

Cystic ovaries are conventionally diagnosed by rectal palpation in the large ruminants, but it may be difficult to differentiate between follicular and luteal cysts. Although, both tend to be smooth and convex, follicular cysts are tenser and thinner- walled.

Follicular cysts are follicles like structures more than 2.5 cm (in cows) in diameter that persist on the surface of the ovary for more than 10days. They grow in a disorderly manner, fail to regress or undergo atresia and instead accumulate fluid. Since there is no ovulation, such cows are infertile until normal cycles resume.

Retained or persistent corpora luteal (CL) are those that persist beyond the moral luteal phase. These continue to produce enough progesterone to prevent further follicular development, ovulation and oestrus. Severe endometritis may be associated with a persist ant CL due to toxic damage to the endometrium, which prevents proper secretion of luteolyticprostaglandins. This foetal ummification and maceration.i.e. Conditions that stimulate pregnancy.

Diagnosis of persistent CL is based on the presence of large, persistent CL on the ovary, anoestrus and persistently high levels of progesterone. Frequent visits and rectal palpations of affected cows, with accurate records of the rectal findings at each visit are required before a diagnose of persistent CL can be confirmed, the persistent CL can be enucleated or lysed by prostaglandins,

14.4.3 Other Causes of Anoestrus

Anoestrus

An oestrous cows have swell, flaccid uteri and swell, inactive ovaries with no palpable corpus luteum or follicle, in contrast, cycling cows are identified by the size and tone of the uterus and the presence of the corpus luteum or follicle or both on either of the

ovaries. Nevertheless, cows may show anoestrus despite having normal ovarian structures

Anoestrous is a major problem in the topics and subtropics, where inadequate nutrition, high ambient temperature, high parasite burdens and disease exacerbate the problem. Low body weight and poor body condition, compounded with lactation stress, can further extend the postpartum anoestrous period. The most common cause of infertility in beef herds is poor cow nutrition. Over conditioning can also be detrimental especially in heifers, nut far less common, a problem, body condition before calving, after calving, and at breeding can all contribute to infertility. Cows that calve tin but are gaining at breeding will have better conception rates than cows that remain thin. However, cows that maintain good body condition throughout pregnancy will have the best chance of breeding back. Most commonly protein and energy are deficient in cattle diets, but vitamin and mineral deficiencies can also cause infertility.

Stress can cause pregnancy wastage at any stage of gestation. Low stress handling when processing cattle will minimize this problem. That stress is also a major cause of infertility, especially early in pregnancy. High humidity exacerbates heat stress and would be expected to impact conception rates even more.

Genetics and other environmental factors play a role in infertility. Selection for other production traits can sometimes lead to selection against reproductive ability. There are breed difference in reproductive efficiency, especially when comparing Bos Taurus to Bosindicus breeds. In general, Bosinducus breeds are superior in subtropical climates, but have later puberty and longer inter calving interval than Bos Taurus breeds. There are wide variations between individuals, so selecting for early maternity and shorter intercalving interval will increase efficiency over time.

Bulls should have a breeding soundness exam prior to each season. Bull infertility due to heat stress and poor nutrition is a major problem in the topics. Although there are general rules for how many bulls are needed for a group of cows, this varies highly between herds. The age of the bulls, single virus multisite breeding groups, terrain and climate can all affect how many bulls are needed. Young bulls, particularly in breeding groups with older bulls, will not service, if bulls are not used to the heat, they may spend more time in the shade than servicing cows due to lack libido. A breeding soundness test does not test libido so nulls should be watched to make sure they are breeding cows once they are turned out,

14.4.4 Repeat Breeders

Repeat breeders are those that require three or more services to conceive. Nuraand Denise (1976) found that the incidence of repeat breeding ranged from 16.6 to 58.8% in Fulani herds surveyed in six states if northern Nigeria in 1972-73.

Repeat breeding can be caused by a number of factors, including sub fertile bulls, endocrine problems, nutrition, reproductive tract infections and poor management.

Proper diagnosis of the causes of repeat breeding is very important and requires a careful assessment of production and breeding records, before treatment.

14.4.5 Infectious Causes of Infertility

Infectious agents that have detectable effect on the animal may interferes, if only slightly with its reproduction. These include several bacterial, protozoan, viral and mycoplasma infections. Details of the most common and economically important once are given below.

Several are important zoonoses. Some write ups on endometutismetritis, pyrometer and retained after birth are also given.

14.4.5.1 Bacteria and Protozoan

Infections

Pathological conditions do not necessary render cows permanently sterile. Their seriousness depends on the location of the infection. The bacterial infections include.

Brucellosis

Importance and incidence

Brucellosis is found world-wide. It affects human, domestic animals and wildlife. It is caused by Brucellaabortus B. Meliteusis, B. suis, B.ours and B. canis .

Brucelllosis has been extensively studied, partly because it causes widespread economic losses due to abortion and extended calving intervals and because it affect humans.

Transmission

Brucellosis is normally acquired by cattle by ingesting the bacterial. Infection may also occur through the mucosa of the eye, nose and teat and through the endometrium if the cow is artificially inseminated with infected semen. The multi-layered mucosa of the vagina seems to protect against infection following natural service,

The disease is more serious in cow infected during pregnancy .the bacteria show a preference for the pregnant uterus, foetus and the lymph glands of the udder. Both the membranes foetus respond to Brucella infection by increasing their production of erythuritol, a simple carbohydrate, which increase the growth rate of the bacteria. This usually results in abortion at about 6 to 8 months of gestation in cows. The organism may also produce toxins and allergens, uterine motility. In some cases the dead foetus is

not aborted but is retained in a mummified or macerated form. If a calf is born alive it is likely to be weak and to contract calf scours easily, many die soon after delivery.

Aborted maternal and vaginal discharges form infected females are heavily infected with brucella, and these contaminate pastures, penis and buildings. Organisms are also present in the milk of infected cows. Brucellosos is a professional hazard for cattle keepers veterinarians.

Foetal membranes are commonly retained because of uterine inertial, placentitis or both. Retained membrane must be handled with great care. Puerperal metritis may develop and cows may remain infertile for some time. After abortion, uterine infection normally declines within months. The animal may not abort on the next conception, but she will continue to discharge the Brucella.

Some calves are born infected. Many lose the infection quickly but a few do not .the latter do not show any signs of the disease and represent ‘’latent infection’’ the organism remains dormant until the animal becomes pregnant. Calves born to serologically positive dams are, therefore at risk of developing the disease in the future and ought to be carefully screened when pregnant. Udder and milk infection lasts several months or years and may be the source of uterine infections during subsequent pregnancies.

Diagnosis

Brucellosis should be suspected whence a cow aborts unexpectedly, except in a brucella-free herd.

Confirmation requires bacteriological examination, culture of the organism or serodiagnosis, usually by veterinarians,

Control

Brucellosis can be controlled through strict hygiene in the handling of potentially infected maternal and by vaccinating all animals. To eradicate the disease all infected animals must be slaughtered.

Bulls should not be vaccinated. Strain 19 organisms have been isolated from the genitalia of vaccinated bulls (lambert etal; 1964) . These could infect their seminal vesicles, epididymicle and tests. Bulls often stay in the herd for short times, during which they do not transmit the disease naturally. However, bulls at artificial insemination centres must be rigorously rested for the disease.

Prevention of the disease in human is contingent upon the control of the disease in animals. Once the incidence of the disease id substantially reduced by vaccination, a test and slaughter programme can be attempted to eliminate infected animals. Once a herd has been certified as being free of the disease, continuing vaccination may not be

necessary but the herd must be kept closed. Symptoms of infection in human include fever and headache.

Some temperate countries such as Denmark, UK, the Netherlands and Romania have eradicated thdie disease; however, the disease is prevalent in many developing tropical countries.

Ii Trichomoniasis

Incidence and Transmission

About 60 years ago, trichomoniasis was an important cause of infertility in cattle, in many countries. The disease causes endometritis,,pyometra, abortion and sterility. It is a venereal disease spread at service or by artificial insemination with improperly treated or handled semen. It is sometimes called Borone venereal Trichomoniasis, its incidence has been greatly reduced where artificial insemination is widely used , as sin the UK, the Netherland, France and Cyprus.

The incidence of trichomoniasis in Africa and the tropics is not widely reported, partly because diagnosis is complex and time –consuming. Consequently, it is not clear if the disease is widespread. In Nigeria Akinboade (1980) found an incidence of 14-9% among slaughter animals.

Trichomoniasis is called by Trichomonasfetus, a protozoan about 15m long with an undulating membrane. In bulls, the trichomonads normally colonise thcrgpts of the external mucous membrane of the penis an prepuce.

Since these crpts are deeper in older bulls, the prevalence of the disease tends to increase with bull age. Infection does not induce any local antibodies or specific agglutinins in the blood of bulls. Bulls carry the disease for long time without showing symptoms.

Cow and heifers that have never been exposed to the disease become infected following natural service by carrier bull or artificial inseminations with contaminated semen. Following natural service, the protozoa first multiply in the vagina and cervix for about 3 weeks. In about a quarter of the cows, the organism does not migrate to the uterus. With intra uterus artificial insemination, the uterus is directly infected.

Trichomoniasis causes infertility; repeat breeding, delayed return to oestrus after mating, early embryonic death and sometimes, abortion. Withdrawing infected cows from breeding for at least 3 months subsequently use of clean bulls or artificial insemination can be help control the disease.

DIAGNOSIS

A low 60- to- 90 –day non-return rate, together with a large number of repeat-breeding cows that exhibit purulent vaginal discharge endometritis, abortion and pyometra, might indicate trichomoniasis. The symptoms of trichomoniasis and campylobacteriosis are

similar. Both lead to irregular inter-oestrous intervals. They are best differentiated by isolating the causative agents, Treatment and control.

Treatment of infected cows with vaginal antiseptics has not been very successful. in animals with pyometra it is better to enucleate the corpus luteum or to lyse it with prosglandins. Treatment may be repeated 10 to 11 days later.

Trichomoniasis is a ‘’self –limiting ‘’ disease in the non-pregnant cow with an involuted uterus. After being sexually rested for 3 or 5 cycles, many cows develop some immunity and their fertility improves. Only clean bulls or semen should be used for breeding and cows with abnormal genetaltracts should be culled. ‘’carrier’’ bulls and sexually active oxen can re-infect treated, recovered and subsceptible females and should therefore be culled. Carrier bulls can be treated but treatment is lengthy and should not be considered unless the bull is very valuable.

Iii Campylobacteriosis

Incidence

Abortion in cattle and sheep was first associated with vibriomicorganisma in 1981 (Laing. 1963).

The organisms were first named vibrio foetus by Smith (1918), and later campylobacter species.

The species most commonly encountered in th bovine genital tract are campylobacter subsp. Fetus serotypes A, C. fetus subsp. Serotype A and c, fetus subsp. Detusserotypw B. of these, indertility in cattle is most often associated with C. F venereals A (90%) and C. F. fetus B (10 %) and only rarrlyC.F.fetus A and B (vandeplassche, 1982),.

The incidence of compylobacteriosisin the tropics varies, from 6.1% in India to 11.5% in Malawi, and 33% in Zimbawe (Terblanche, 1979).

Transmission and Pathogenesis

Compylobacteriosis is a venereal disease and although transmission via fromites and between bulls ahas been suggested , this is likely, events subsequent to infection are similar to those described for trichomoniosis except that the migration of the organisms form the vagina an cervix appears faster.

In cow, infectious is initially acute but

Infection in associated with infertility and the chronic phase with abortion. Although abortion may also occur in the acute stage. catarrhal vaginitis in the acute stage.

Catarrhal vaginitis in the acute phase results in an increase production clear, cloudy or muco-purulent discharge for 3 to 4 months. Abortion may occur are any time but usually occurring 5 to 6 months after endometritis and placentitis have occurred? The animals may recover spontaneously after 2 to 3 months despite the continued presence of the bacteria in the vagina. The bacteria may migrate into the oviduct and cause more permanent infertility due to salpingitis.

As with trichomonatis , infected females should be sexually rested. The antibodies that develop in the uterus are dominated by IgG which results in rapid phagocytosis of C. fetus and recovery of the uterus in about 2 months. However, animal that recover may be less fertile than normal. The fertility of the herd will remain low as long as susceptible heifers and cows are present and infected bulls used.

Diagnosis

Breeding records showing low non-return rates, many repeat breeders and a high incidence of abortion at mid-term suggest campylobacteriosis .isolation of C. fetus from the bull or cows will confirm the diagnosis.

Although control of the disease centres around preventing the production and spread of infection, this may be difficult in herds that use a communal bull. If more than one bull runs with th herd, it may be difficult to determine which bulls are infected. Artificial insemination with semen from uninfected bulls is thus one of the best waps to control the disease. Where this is both feasible, sexual rest of affected females combined with vaccination may be the best approach

Iv Leptospirosis

Importance and transmission Bovine leptospirosis is a systemic disease characterized by fever andsometimes, mactitis and abortion. Leptospirosis should be suspected when abortion occurs in cows showing other symptoms bude as icterus and hoemoglobinia .it is one of the most widespread zoonose.

The disease is caused by leptospirabacteria .these are spirochactes, Some 120 leptospira serotypes have been identified by the world health organisation. The serotypes associated withbovine abortions are leptospirapomana, L. cannicola, L. Australia, L. icterohoemorrhagica and L. grippotyhosa.

They are all sensitive to antispative and desiccation and their virulence and pathogenicity are highly viable. Animals infected with leptospira excrete the bacteria in their urine, direct or infect contact with the urine of infected animals is the major route of infection in both animals and man. The usual route of infection is via the digestive tract, but the disease may be contacted via the respiratory and reproductive tracts, eyes or skin. In cows, infection is often followed by pyrexia and reduced milk production.

Diagnosis

Leptospirosis should be suspected following abortion associated with acute illness and the presence of blood in the milk for some days. However, leptospirosis can cause abortion without giving any other obvious symptoms (Stoenner, 1968). Leptospirosis is usually diagnosed from blood serology, despite major difficulties with interpreting fitness, usually be veterinarian.

Leptospirosis can be self- limiting. Therefore, all newly purchased animals should be kept in quarantine and tested for the disease. Hygiene measures outline earlier for brucellosis should be applied in case of an abortion. Rodents on the farm should be controlled an contamination of milking places should be avoided by isolating infected animals'

Treatment with treatment with streptomynia readily eliminates kidney infection, protecting the herd and people handling the animals. Each aborting cow should therefore be treated with streptomyain at 25mg /kg body weight. Cows usually abort once and may not have to be culled. However, cows that recover can be re-infected.

Annual vaccination of animals in areas where the disease is prevalent is recommended.

V. Salmonellosis

Salmonellosis is an important cause of abortion in cattle. It is also a zoonosis. Salmonella Dublin and S. typhimurium are the most common causes of salmonellosis in cattle.

Infected animals excrete the organisms in their faeces, contaminating pastures, water supplies and housing. From these, the bacteria infect healthy animals. Typical symptoms of salmonellosis

Include septicaemia, pyrexia and dysentery. Pneumonia also occur. The bacteria are attracted to the uterus and together with severe entries, caused by endotoxins and painful arthritis, cause abortion (Vande Plassche, 1982).the primary cause of abortion is the release of prostaglandin (PGF2x)induced any salmonella endotoxin. Following abortion, the uterus may become severely inflamed, resulting in the death of the cow. Cows that recover may continue to excrete the bacteria for years. Aborted foetuses show no striking features but membranes retained in about 70% of the case, are oedematous and yellow, with pus-like exudate. A tentative diagnosis based on these signs can be confirmed by isolating the bacteria from the stomach (abomasum) contents, liver of joints of the foetus, from the placenta or from the dam's faeces.

Salmonella can be passed to human, aborted material should therefore be handled with extreme care, it is difficult to cure carrier animals ,and the best control measure is therefore be handled with extreme care, it is difficult to cure carrier animals and the best control measure is therefore to all animals that react positively to tests fo salmonella. All animals thought to be infected should be isolated subject to

confirmation by isolating the bacterial. This approach is likely to result in better control of the disease than vaccination.

Vi non-specific bacteria infectious, many species ofbacteria of bacteria inhabit the vagina, uterus and cervix of cows. Some are symbionts that become pathogenic when the animal is stressed' others are immediately pathogenic. Eduvieetal (1984) and El-Azabetal (1988) isolated stapyloccusaureus, Escherchia col, Pseudomonas Pyicyanca, Corynebacteriumps#yogenes, Proteus mirabilis, Streptococcus spp, psdteurellanulticida, proteusvulgais . Klebsiellassp and several anaerobic microorganisms from the uteri of cows with a history of repeat breeding retained placenta and metritisas well as from the uteri of normal suckling cows.

Mycobacterium tuberculosis was isolated by Mohntyetal (1980) from a Haryana heifer that was a chronic repeat breeder. Listeria monocytogenes and also causes abortion in cattle. When the organism infects a pregnant cow, it invades the foetal nervous system and forms necrotic foci on the liver, lungs and spleen (Watson, 1979), killing the foetus.

Vandeplassche (1982) indicated that although the organisms are easily eliminated from the uterus, they may persist in the mammary system. Antibodies to Listeriare short-lived and immunity is thus only temporary and cows can be re-infected. Treatment is often futile, even with antibiotics,

14.4.5.2 Viral Infections

Several viral disease, including infectious bovine rhinotracheitis (IBR), bovine virus diarrhoea/mucosal disesea (BUD/MD), pare-influenza-3. G-up, infectious fibropapillonea and epizootic bovine abortion have been associated with cattle infertility (Mckercher, 11969). The major infectious are described below.

I, Infectious Bovine Rhinotracheitis

Infectious bovine rhinotracheitis (IBR) is caused by a herpes virus. Its incidence in Africa is not widely reported but a study by ILCA on two populations of indigenous Ethiopian Zebu cattle indicated a prevalence of over 50% (Tekelye Bekeleetal, 1989b) IBR can affect there sporatomy, reproductive, nervous and digestive systems of cattle. The disease can be transmitted sexuallyor by droplet inhalation; in its venereal form. It has been associated with infertility. After invading the uterus the virus may remain dormant for several months.

Abortion occurs after 4 to 7 months. The foetus dies soon after being invaded by the virus. Thedead foetus may be retained for several days and appear mummified when finally expelled. Haemorrhagic fluid and oedema may be seen in the foetal pleural and peritoneal cavities with focal necrosis, particularly of the liver,

The above signs indicate IBR. The presence of the disease can be confirmed by isolating the virus from the foetal placentomies or swabs from the nose, eye, penis or prepuce. The virus grows best in bovine foetal kidney cell cultures, it can be identified by semen neutralization or immunofluorescence inhibition tests usually by veterinarians.

Control measures against IBR vary. In Switzerland and Denmark all cattle are tested for IBR and those reacting positively to the test are slaughtered. France monitors the disease in bulls because it can be spread in semen .in the federal republic of Germany, AT bulls must be vaccinated; none of these systems is used in the tropics.

Ii. Bovine Virus Diarrhoea

Bovine virus diarrhoea/mucosal disease (BVD/MD) is widespread. It is caused by a Toga-virus. Infection may be acute, mild or chronic, when the virus infects a pregnant cow it may also infect the foetus and kill it. Calves born a live may be stunted, with cerebellar hypoplasia, brain cavitation and mucosal ulceration. These sign aid diagnosis. Confirmation is by the deawnstration. Of antibodies in foetal blood prior to ingestion of colostrum. A double sample with dam's blood is very helpful. A herd test will indicate if BUD/MD was prevalent at the time of abortion.

Iii infectious (contagious) bovine spididymitis and vaginitis complex (Epivag) appear to be confined to east and southern Africa. It was first described in Kenya and subsequently in South Africa. (Arthiur, 1964).Epivage is a venereal disease. It cows the main symptoms of epivage mucosa-purulent discharges from the vagina. Epiva can cause permanent lesions on the fallopian tubes, in the bull, it causes the epididymis to swell, sometimes to the size of a golf ball. The disease can be controlled by slaughtering infected by bulls and by using artificial insemination.

14.4.5.3 Mycoplasmas

Mycoplasmas are infective agents distinct from both bacteria and viruses. Several species of Mycoplasma causedisease in cattle. They have been associated with infertility, but their exact aetiological role is difficult to ascertain because they are present in the tracts of healthy animals .

Mycoplasma ergini,M. allalesceus, M. laidawii, M. bovis,M. bovirhiruw, M.verecurdum and M, conjuctival have been isolated cattle (Trichord and jacobz, 1985).

Mycoplasmas can be transmitted by discharges from the respiratory and reproductive tracts and milk of infected animals. Infected cattle develop antibodies, but these do not give complete protection. Symptoms associated with mycoplasmas can also be observed with other conditions. Diagnosis can only be confirmed by isolating the organism form basal or reproductive- tract mucus and discharged, milk arthral fluids,

foetal tissues or the placenta. Consult Trichard and Jacobsz (1985) for procedural details of culture and serology. The best way to control mycoplasmosis is to call infected animals.

14.4.5.4 endomectritis, metritis and pyometra, and the use of prostaglandins in postpartumuterine pathology.

Some of the systemic and no-specific infectious disease earlier can cause endometritis, metritis and pyometra. These pathological condition are discussed below,

Infectious of the reproductive tract are usually contracted at partition. Non-specific infections of the uterus are more common where the placenta is retained in cows that need assistance with calving and in cows with milk fever. Metritis is often also associated with uterine atony or inertial. Acute metritis causes fever and depression within a week of infection, and is commonly followed by chronic metritis, with persistent purulent vaginal discharge. Specific venereal infectious, such a trichomeniasis, compylobacteriosis and brucellosis, may also lead to metritis.

Pyometra is the accumulation of pus in the uterus. It is a common causes of anoestrus and cows with pyometra should be treated promptly. Postpartum metritis, endometritis and pyometra may be common where cows and heifers are confine at delivery time in a building or area in which others have recently calved. The uterus can resist or eliminate bacterial infection. However this ability is related to ovarian activity, (paisley etal, 1986). The uterus is highly resistant to infection during the oestrogenic phase by very subsequentible during the period of progesterone dominance, becaue (1) PH in the uterus is low, allowing greater bacterial growth, (2) the epithelium is less permeable to bacteria and therefore the leucolytic system is stimulated at a later stage. (3) The appearance of leucovytes in the lumen is delayed (4) the activity of leucovytes is decreased, and (5)uterine secretions have no detoxicating effect,(Paisley etal , 1986). As a result, some vases of metritis resolve spontaneously when the animal's oestrons cycles resume, while others remain chronic.

Cows with chronic metritis are aboestrous and may have a retrained (persistent) corpus luteum. Where a corpus luteum is present, initial treatment should aim at removing it .this is best achieve by an intramuscular injection of prostaglandin. If there is no corpus luteum, endometritos can be treated by infusing antibiotic or sulplcomamides into th uterus. Application should be repeated every 2 days.

For a week .alternatively, about coml of 2% iodine can be unfused into the uterus, the iodine solution is an irritant and stimulates new endometrial growth. Where the oviduct deeper layers of the uterus or the cervix or vagina infected antibiotic should be given intra-muscularly.

Prostaglandin F2x (PGF2x) reduces inhibition by progesterone of the uterine defence mechanism. Oestrogen secreted during the subsequent development of follicle

stimulates myometrial contractions, helping to empty the uterus of lochia and pus. It may encourage phagocylosis.

Several other postpartum conditions can reduce fertility. Cervicitis can vaginitis often follows a delayed or complicated delivery. Metritis may cause abscesses in the uterus; if it spreads to th fallopian tubes it may lead to salpingitis. Scars in the uterus and adhesions between parts of the reproductive tract can result in infertility or sterility. Routine examination of cows 1 or 2 months after delivery can diagnose such conditions early.

Irrespective of the condition, treatment should also aim at restoring the animal's normal status. Thus a persistent corpus luteum must be enucleated or lysed. Inactive ovaries should be stimulated using small doses of oestradiol benzoate (2-5mg im.) or diethylstilbesterol (20mg i.m. or orally). Cows should be given a period of sexual rest of 2-3 cycles after treatment

14-4-5-5 Retained After Birth

Two to 30% of cows retain their foetal membranes for 12 to 24 hours after a membrane, is retained if the cotylecarucular crypt. Membranes retained for more than 2 or 3 days decompose in the uterus, leading to metritis.

The incidence of retain dafter birth id often high in Brucella- infected herds, following a difficult delivery and in cows suffering certain nutritional and mineral(especially selenium) deficiencies. Grunert (1984) categorised the basic causes of afterbirth retention as 'immature placentomes, oedema of the chronic villi, necrosis between chronic villi and the walls of the crypts, advanced involution of the villi, placentitis and cotyledonitis, and uterine inertia.

Cows with retained after birth have poor appetite and reduced milk and meat yield. Their fertility is reduced, especially if metritis develops. Treatment of the cow with retained afterbirth should be aimed at expelling the afterbirth and preventing infection of the uterus. In treating a cow with retained afterbirths it should be remembered that though removing he after birth by hand can be done, it may be harmful to the cow; it may cause haemorrhage, haematomas and vascular thrombi uteri reducing subsequently fertility.

The operator may also fail to remove all the other birth. There is also the risk of contaminating brucellosis from handling retained afterbirth. Intra uterine treatment with oxytetracyclinealone can give good results interns of fertility postpartum.

Proper animal husbandry can reduce the incidence of afterbirth retention. Animals should be sexually rested for at least 2 months after calving, fed a balanced ration, adequately exercised where thy are continuously raised indoors and immunised against prevalent infectious diseases that cause abortion. Animals should not be unduly stressed and proper sanitation and management must be exercised at delivery; selenium.

Should be added to deeds where it is deficient.

Student's self-assessment Exercise (site) 14.1

List any 3 bacteria and 2 viral causes of infertility in cattle

14.5 Conclusion

In this unit, you have learnt the difference between infertility and sterility in livestock, using cattle as a model. You also learnt the various causes of infertility and sterility in livestock. You also studied some of the steps a good farm manager can take to control venereal disease and other management practice that can predispose the animals to infertility and sterility.

Answers to SHG 14.1

The B bacterial infections that can result in infertility are

- Brucellosis
- Cambylobacteriosis
- Leptospirosis

While 2 viral infections that can cause infertility are

-Infectious Bovine rhinotracheitis (IBR)

- Bovine viral diarrhoea/mucosal disease (BVD/MD)

14.5 Summary

Among the common form of functional infertility cows are faulty oestrus manifestation including silent heat, inactive ovaries with anoestrus, cystic ovaries, abnormal oestrous cycle periodicity and repeat breeding due to day or failure of ovulation and fertilization or early embryonic death. These forms of infertility tend to affect individual animals but they are becoming more important as attention is paid to the environmental and health constraints.

Several systemic, genital and non-specific infections of the reproductive tract reduce the fertility Zebu cattle. Some are also important zoonoses. Their exact frequency in many areas is not precisely known and warrants further study.

The best way to control many of these diseases is to prevent contact between herds. If this is not practicable, herd owners should buy virgin heifers as replacement stock. All newly introduced stock should be quarantined for 3 to 4 weeks before joining the herd.

Farmers should not buy bulls that have been used for breeding in other herds unless they are proofed to be completely free to important disease. Semen for artificial insemination should be obtained from reputable centres.

All replacement heifers should be vaccinated with Brucella strain 19 vaccine when 3 to 6 months old. Older animals should be given strain 45/20. Once the incidence of brucellosis has been reduced, the herd should be regularly tested and infected animals culled.

The modified live virus vaccine for infectious bovine rhinotraccheitis confers good immunity, and all heifers should be vaccinated.

Cattle can be vaccinated against both campylobacteriosis and leptospirosis annually. The vaccines are however, expensive and may not be readily available, and even a vaccinated bull can act as a passive vector) after serving an infected cow.

Infections of the uterus can be largely avoided by having cows served and calved under hygienic conditions. Cows should be allowed plenty of room during calving, and the site should be clean. Bedding should be changed after each calving. When conducting obstetrical manipulations, use only disinfected instruments and disinfect both the operator and animal before and after any manipulations. If a birth is difficult or otherwise abnormal, intra-uterine application of a broad-spectrum antibiotic will help prevent infection.

All infertile animals should be examined to determine the exact cause of their infertility. If a cow aborts the aborted material should, if possible be sent to a diagnostic laboratory to ascertain the cause.

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