DETERMINANTS OF ONSET OF PUBERTY IN WEST AFRICAN DWARF BUCKS RAISED UNDER INTENSIVE MANAGEMENT

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ABSTRACT

Production of the West African Dwarf (WAD) goat plays a vital role in the livelihood of rural populations as its sales either as live animal or meat augments household income. The determination of the onset of sexual maturity in male domestic animals, defined by the first appearance of mature spermatozoa in the cauda epididymis is vital in andrological studies. There is a dearth of information on the onset of puberty in WAD bucks raised under intensive management resulting in sub-optimal utilization of theirversed reproductive potential. This study was designed to investigate somatic parameters, testosterone concentration, spermiogram, testicular and epididymal histology as indicators of onset of puberty in WAD bucks raised under intensive management.

Sixty WAD kid bucks, obtained from 80 oestrus-synchronised and naturally mated adult WAD does were used for the study. The kids were nursed by the dams till sixth week post-kidding and thereafter fed forage supplemented with concentrate at 500 g/animal/day till end of the experiment. Water was provided *ad libitum*. Body Weight, Somatic parameters: [(Scrotal Length (SL), Scrotal Circumference (SC), Crown-Rump Length (CRL), Height At Withers (HAW)] and blood sample for serum testosterone were obtained from the bucks weekly (1-18 weeks). Epididymal semen characteristics (sperm motility and concentration), testicular and epididymal histology were investigated weekly (4-18 weeks). Data were analyzed using correlation regression and one-way ANOVA at α 0.05.

Body weight and somatic parameters of bucks increased significantly during the first twelve weeks, while no significant increase was observed from weeks 12-18. Age was positively correlated with SL (r = 0.912), SC (r = 0.804), CRL (r = 0.625), HAW (r = 0.691) from 1-12 weeks. Testosterone concentration fluctuated in the first eight weeks of life with a non-significant increase from week 9 - 12. There was a significant increase in testosterone concentration in the bucks between weeks 12 (6.12$\pm$0.15) and 13 (10.20 ± 0.68ng/mL). Testosterone concentration peaked at week 14 (11.25 ± 1.75 ng/mL) but thereafter declined till week 18. Sperm motility and concentration significantly increased from 60.50±10.08 to 82.30 ±15.70 % and 89.30 ± 9.20 x 10^6 to 125.3 ± 16.70 x 10^6 sperm/mL respectively, between weeks 13 and 14. Canalisation of the seminiferous tubules was absent in the bucks till week 12. The first observation of elongated spermatids in the

lumen of seminiferous tubules was at week 12, while mature spermatozoa were first observed in the cauda epididymis at week 13. Epididymal epithelium changed from simple cuboidal (4-12 weeks) to pseudo-stratified columnar (12-18 weeks). Luminal diameter of seminiferous tubule and ductal diameter of epididymis significantly increased between weeks 13 and 14 from 32.73 ± 0.44 to 78.59 ± 9.18μm and 68.52 ± 12.35 to 102.14 ± 23.76 μm, respectively with no significant difference thereafter.

Marked changes in somatic parameters, testosterone concentration, epididymal semen characteristics, testicular and epididymal histology were indicative of the onset of puberty which occurred between weeks 13 and 14 post-kidding in West African Dwarf bucks raised under intensive management. This period is therefore recommended as the earliest time for harvesting of semen for andrological purposes.

Keywords: West African Dwarf buck, Age at puberty, Intensive management, Spermatozoa.

Word count: 481

CERTIFICATION

We certify that this work was carried out by Olugbenga Atanda ADEDEJI in the Department of Theriogenology, University of Ibadan.

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DEDICATION

This research work is dedicated to God Almighty and my family - my wife, Mrs. Gladys Bose Adedeji and our children Victor Oluwaferanmi, Victoria Oluwafikemi and Veronica Oluwafunto.

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ABBREVIATIONS

ADG	-	Average daily growth
AI	-	Artificial insemination
ANDDA	-	American Nigerian Dwarf Dairy Association
ANOVA	-	analysis of variance
Avgr	-	Average growth rate (kg) per month.
BCS	-	Body Condition score
BDL	-	Body Length
Bw	-	Birth weight (Kg)
CB	-	Fore Cannon Bone Length
CD	-	Chest Depth
CIDR	-	Controlled internal drug-releasing device
CRL	-	Crown-rump length (cm)
EO	-	Eosin-nigrosin stain
EP	–	Epididymis
EWS	–	Ejaculate (Semen) with spermatozoa
FAO	-	Food and Agricultural Organization
FSH	-	Follicular stimulating hormone
HAW	-	Height at Wither (cm)
HG	-	Heart Girth
HW	-	Hip Width (Pin Bone Width)
Kw	-	Kids weight (Kg)
LGA	-	Local Government Area
LH	-	Luteinizing hormone
MAP	-	Methyl acetoxy progesterone
MBw	-	Mean birth weight.
MKw	-	Mean kid weight.
NSS	-	No spermatozoa in the semen
NVRI	–	National Veterinary Research Institute
PMSG	-	Pregnant mare serum gonadotropin

PPR	-	Pestes de petit ruminantum
RH	-	Rump Height
SEM	–	Standard Error of Mean
SC	-	Scrotal circumference (cm)
SL	-	Scrotal length (cm)
STs	–	Seminiferous tubules
TE	–	Testis
USDA	-	United States Department of Agriculture
WAD	-	West African Dwarf
WE	–	Wells and Awa stain
®	-	Trade mark

CHAPTER ONE

1.0 Introduction

The West African Dwarf goat is domesticated specie of the Southwest Asia and Eastern Europe goat, from Caprinae subfamily in the Bovidae family (Nomura, 2013). The domestic goat is one of the oldest domesticated specie (Ensminger and Parker, 1986). The goats are raisedfor dairy, meat, hair, hides and recently as pets. The females are does or nannies, and the males bucks or bellies. The offspring are kids. The orchidectomised males are called wethers. The meat from the young goats is known as kid and from adult is sometimes called chevon, or mutton (Ensminger and Parker, 1986). The Nigerian Dwarf goat originates from West Africa (Anon, 2011). They have small stature, gentle and friendly, and so are good as companion pets. Historically goat breed in United States are kept in zoological gardens (Nomura, 2013). Exactly how the West African Dwarf (WAD) goats came to American soil is not clear. It is however postulated that the remnants of the goats loaded into the vessels as food for the big cats in transit are kept in the zoos. They are used in the country as part of zoological exhibits and for research purpose in academic institutions (Nomura, 2013). These WAD goats were indiscriminately referred to as "pygmies" because of their small size. Two distinct types were identified by the early breeders, the short legged, and heavier bodied, round-boned typical of the Pygmy and the more refined, angular type that is today called the Nigerian Dwarf (Nomura, 2013).

Goats are kept specifically in any community for the value attached to their production. An average of four goats per household are kept in the humid part of Nigeria, larger numbers are in the savannah parts of the country (Matthewman, 1979). The population in Africa was estimated at 171 million (FAO, 1991), with 22 million in Nigeria. While the estimation by RIM., (1991) in Nigeria was 34.5 million

Meat production forms the major purpose of keeping goats (Williamson and Payne, 1978). with about 20% consumed in Nigeria (Brinkmann and Adu, 1977) With the current global

concern for improving the economic status and welfare of people, commercial production of this breed will improve the standard of the farmers especially in rural settlements(FAO. 1991).West African Dwarf goats are trypanotolerant with easy adaptation to the environment, favorable records of fertility and fecundity, short gestation period (145 to 152 days, or 150 days) and ability to survive under conditions that other species cannot tolerate (CCFAS, 2014). These qualities have attracted the interest of researchers to investigate the productive potential of this breed.

In Portugal, Eloy and Santa rosa., (1998) as well as Silva., (2000) showed the relationship between testosterone level and sexual maturity in WAD and Saanen goats respectively, in Dublin, Trejo *et al.* (1988) observed relationship between growth of the testicle, semen quality, spermatozoa reserves and production of testosterone around puberty in kidand in 2010 observed positive correlation between the body weight, testosterone and scrotal circumference (SC) with age at penile detachment. In Ibadan, Nigeria, Oyeyemi *et al.* (2011) and (2008) showed the effect of feeding WAD buck with dussa and poultry waste on spermiogram, and pumpkin plant on semen characteristic and sperm morphology respectively. Daramola *et al.* (2007) induced puberty in WAD buck-kid at five months using exogenous melatonin, while Bitto and Egbunike, (2006) observed that WAD goats are not seasonal breeders in their native tropical environment

The gestation period of the doe was estimated at an average of 150 days (Salem *et al*., 1982). Twining and triplets are common in goats, they rarely produce more (Anon, 2015). The sex ratio reported by Kumar *et al*. (2001) for males ranged from 52.8 to 57.6%. He concluded that frequency of male births was a little higher in summer than winter, however, statistically year and season had no influence on their sex ratio (Tomar *et al*., 1995).

The reproductive activities of WAD bucks begin with the initiation of sexual maturity (Jimeno*et al*., 2001). Sexual maturity is the period that the reproductive organs are physiologically active. This is the time when the male displays sexual behavior such as mating, ejaculation of live, and viable spermatozoa with the ability to reproduce (Jimeno *et al*., 2001). In the male, Puberty is indicated by their copulatory ability and production of fertilizable spermatozoa. In the female, it is characterized by the manifestation of estrus

and ovulation (Berkeley, 2013). The male gamete in sexually reproducing organisms is spermatozoa. This is produced by spermatogenesis (gametogenesis), controlled by the androgen - testosterone. Testosterone causes physiological and behavioral changes characteristic of puberty or sexual maturity. It produces stimulatory effect on spermatogenesis (Schlatt *et al*., 1993), thereby leading to the production of mature male gametes known as spermatozoa. The female equivalent of gametogenesis is oogenesis.

Body measurements and weights and especially the accuracy of functions applied in predicting them in live animals are important tools in experimental and selection practices (Cam *et al*., 2010). It is of economic value in livestock industries especially in extensive system, where it plays important role in breeding program and market evaluation (Afolayan *et al.*, 2006). Body measurements are useful in livestock production as a measure of performance (Janssens and Vandepitte, 2004), especiallythe phenotypic measurements (Janssens *et al*.,2004) such as Body weight, Height at wither, Crown to Rump length and Body score, where apositive relationship occur between the body weights, reproductive performance (Snyman, 2010a) and body measurements (Cam *et al*., 2010)

The primary organ of reproduction in the male animal is the testis; which produce sperm cells also known as the male gametes and androgen the male sex hormone. Epididymis is a highly convoluted duct closely attached to the testes (Oyeyemi *et al.,* 2018). The epididymal functions include transportation, storage, maturation and absorption of spermatozoa, with the ability to make a progressive move to fertilise the ovum (Cornwall, 2009).

The reproductive importance of gonad measurement (Scrotal length (SL) and Circumference (SC)) in small ruminants has been established. Neary.,(2014) observed that SC measurement is a reflection of a ram's breeding ability and testicular size (Ashwood, 2009).The development of the testis and epididymis are affected by many factors like species, breed, body weight, age, nutrition and environment (NseAbasi, 2015). There is a relationship between the quality of semen and the size of the testicle such that improvement in each causes improvement in the other (Ashwood, 2009). In this respect the number of spermatozoa and the volume of ejaculate are determined by the testicular size

(Ashwood, 2009) thus making it essential in selection program in animals (Akpa *et al.*, 2012). The scrotal circumference (SC) measurement and other characteristics of the testis can be used to evaluate the breeding soundness of a buck (Neary, (2014). Ashwood., (2009) further observed a direct relationship between the scrotal circumference measurement, size of spermatozoa producing tissue, spermatozoa normality, onset of sexual maturity in bull and the fertility of female progeny (Ososanya *et al*., 2014).

1.1 Justification of the Project

Puberty has been described in many ways such as: the period when the male animal becomes physiologically active leading to mating, ejaculating live and viable matured spermatozoa capable of reproduction (Hulet and Shelton, 1988). It has also been described as the capacity of an organism (animal) to reproduce(McNamara, 2004)and ability to perform the five major sexual acts - mounting, intromission, ejaculation, relaxation and dismounting.However considering the time (Dott, 1967) of first appearance of mature spermatozoa in the cauda epididymis may describe the onset of puberty. Age at sexual maturity has been estimated by several authors, for example Gauthier *et al*. (2001) and Raji., (2016) under intensive and extensive management observed sexual maturityof WAD goatsat the age of 20 and 24 weeks respectively, while Nishimura *et al.* (2000) reported 17 weeks in Japanese Tokara goats.

The determination of body weight, estimated between 40 to 60% (Chemineau *et al.,* 1991) of the adult body weight, linear body dimension, scrotal biometry, testosterone profile, and testicular histologywill serve as a guide to determine the onset of puberty in this study.

1.2.1 General Objective

The study was aimed at determining the initiation of sexual maturity by first evidence of mature sperm cells in the cauda epididymis and inter-relationship of some reproductive parameters of male WAD buck.

1.2.2 Specific Objectives

The objectives are:

(i) To determine changes in the body weight, linear body dimension and scrotal biometry in male WAD goat from four to eighteen weeks post kidding.

(ii) To determine the first appearance of matured spermatozoa in the cauda epididymis and their relationship with the sequence of testosterone production in male WAD goat from four to eighteen weeks post kidding.

(iii) To determine the testicular Histological changes associated with onst of puberty in male WAD goat from four to eighteen weeks post kidding.

1.3 Statement of problem

The onset of puberty evidenced by the first appearance of mature sperm cells in the cauda epididymis of WAD goat is yet to be established, thereby resulting in suboptimal utilization of their reproductive potentials..

CHAPTER TWO

2.0 LITERATURE REVIEW

The West African Dwarf (WAD) goat is an important specie of livestock indigenous to the southern part of Nigeria. It has the following qualities, easy adaptation to the environment, and short gestation interval of 150 days on average, with records of fertility and fecundity (Amnate *et al.*, 2016), relative trypanotolerant(Osaer and Goossens, 1999) and ability to survive under condition that other species cannot tolerate Salem *et al.*(1982).

2.1 Breeds and Purpose of Goat

George OrwelI., (1984) in his submission on the breeds of Goat, observed that 'all animals are equal but some are more equal than others'

All goats are considered meat goat regardless of its breed, since they are eventually slaughtered as table meat after observing their specific purpose (Devendra and Burns, 1983) however, some breedsare specifically bred and are generally good for production meat because of their genetical makeup.

2.1.1 Meat Goat Breeds

2.1.1.1 Pygmy

Pygmy goats originate from Fouta Djallon Plateau in West Africa, and in Nigeria it is called West African Dwarf (WAD) goat. Its presence in North America was a result of the 18th century slave trade business. It is the most common breed in West Africa; they are used for production of meat (Devendra and Burns, 1983).

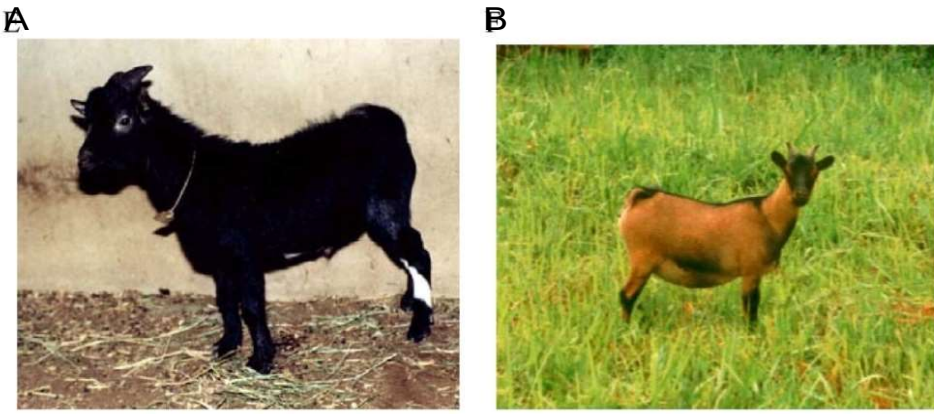


Figure 2.1 Typical West African Dwarf goats Buck (A) and Doe (B).

Source: University of Nigeria Nsukka.

2.1.1.2 Boer

Boer goats originate from South Africa. Its name in Dutch word mean “Farm”, but they are meat animals. They are crosses derived from the indigenous goats Namaqua Hottentot, (Casey and Van Niekerk, 1988). This is to meet the qualities required for meat type by the ranchers in the Eastern Cape Province in the early 20th century. And since 1970, have been used for the National Sheep and Goat meat Performance Testing Scheme.

2.1.1.3 Feral Goatstock

Historically, Feral Goatstock was introduced by the Europeans to Australia and New Zealand when they were colonized (Johnson, 1985). They are good fiber (cashmere) and meat producer.

2.1.1.4 Australian Kiko

This breed of meat goat is a cross between feral goatstock and dairy breeds (Johnson, 1985).

2.1.1.5 Nubian

The Nubian goat or Anglo-Nubian breed is a dairy goat and is a crossbreed found in England and the United States. They are good milk and meat producer (Momani *et al.,* 2012).

2.1.1.6 Spanish goat

The Spanish goat is found in the Edwards Plateau of central Texas. They are meat animals but used purposely for clearing weed, or pasture maintenance (Paschal, 1990).

2.1.1.7 Tennessee Wooden-leg

This goat is nervous, it exhibits stiffness of neck and leg muscles when frightened, falling and fainting. They suffer from hereditary myotonia. This usually last about 10-20 seconds. They are meat animals, with small population in the US, about 3,000 head (Karen Klausky and Laura Tourte, 1995).

2.1.2: Fiber Breeds

The Angora breeds are good cashmere and dairy animals. They are not prolific litter producer, though small in size, but good fiber producers. The fibers produced are called mohair and Cashmere (Cheryl and Smith, 2017), they are used in many textile industries. They produce the finest fiber, which is economically more rewarding than the coarse type.

2.1.3: Dairy breeds:

The Nigerian West African Dwarf goat is also a dairy breed which can be easily milked with hands (Anon, 2011).The exotic dairy breeds are of two types: The temperate breeds are European in origin, they include Alpine, Saanen, Toggenburg, Oberhasli. They are collectively known as Swiss breeds in United State. They appear calm and characteristically with upright ears. The floppy-eared Nubians are more energetic (Mother Earth News, 1992). They do well in cool climates and are good milk producers. The tropical breeds include the LaMancha and Nubian, they cope better in hot weather. LaManchas are not good milk producers, characteristically they may have tiny ears or none at all with laid-back.

2.1.4Animal management System

The management of livestock can be broadly divided into Extensive and Intensive management systems. On the basis of primary purpose, these can be classified as subsistence or commercial. The traditional management system in sub-Saharan Africa is further divided into categories: the extensive (pastoral), semi-intensive (agro pastoral) and intensive systems

2.1.4.1 Extensive Animal husbandry (or pastoral system)

The extensive management system is primarily practiced to meet family needs with little or no commercial exchanges. Many families keep few sheep and or goat for occasional consumption or to meet immediate financial needs in urban community or village setting. Little or no investment is made into the feeding or health care of the animal. The animal scavenges for a large part of their required feed and supplemented with household remnants or kitchen waste when available

Nomadism and Transhumance are types of extensive system of management. The herdsmen and their animals are always roaming in search of food (pasture) and water. In this system survival is mainly on animals, the Maasai of Kenya and Tanzania are examples of Normadic and Transhumant tribes are the Fulanis of West Africa and Wagogo and Wasukuma of Tanzania (Das and Sendalo, 1989). The animals graze on communal land and animal herds owned by different families or individuals. They compete for grazing and water, and confined in the night in a constructed enclosure in most cases using thorn bushes, poles and palm leaves.

In extensive system the breeding cannot be controlled, no supplementary feeding and Veterinary attention, except occasionally where there is government extension service. Malnutrition is the major limiting factor for effective small ruminant production especially in the dry season. This leads to low resistance and therefore susceptible to disease outbreak. Common among the diseases are: Peste des petits ruminants (PPR), contagious pleuropneumonia, contagious ecthyma, goat and sheep-pox, footrot and trypanosomiasis.

2.1.4.2 Semi-intensive Animal husbandry (Agro Pastoral System)

Semi-intensive system is commonlypracticed where there is enough rainfall and farming is possible. Crop production is the major means of survival, small ruminants are kept only as alternative against crop failure and source of income, it gives about 50 percent of house revenue and it may be the only means of subsistence in time of drought (Das and Sendalo, 1989). The animals are allowed to graze usually in the morning or late evening. Herding in this system is practiced to control grazing, raiders and predators. They complement crop production by feeding on crop residues and by-products, while their manure fertilizes the land. Supplementing their feeding are crop residues, household wastes like cassava and banana peels and vegetables, at night they are kept in pens similar to what is observed in extensive system. Sometimes they are tied to pegs around the house. The breeding is not controlled and veterinary service is minimal.

Under agro-pastoral system the land available for the animals is limited, and the number of animalsis usually smaller (1-20 goats) when compared with the extensive system (Das and Sendalo, 1989). This system is the most common practice for small ruminant production in

Tanzania. Like in extensive system availability of enough feeding and poor management practices result in lowered productivity. The sedentary nature of this system will require supplementing their feeding to improve their reproductive potential.

2.1.4.3 Intensive Animal husbandry

The intensive system is practiced in areas that are well populated and there are intense agricultural activities. Here, land and labor scarcity are the major limiting factors to small ruminant production. Four methods are adopted in this management: tethering, stall-feeding, intensive use of cultivated forages/pastures and integration with tree crops.

Tethering is a widespread system of small ruminant management practiced by small holders in sub-Saharan Africa, adopted to prevent animals from destroying crops and enable farmers to carry out other farming activities. Few goats are kept per household (1-10) in Tanzania, Nigeria, Kenya, Cameroon and The Gambia (Wilson, 1986) they are tied to poles, pegs, trees,or uncultivated land near to the owners house. Their feeding is supplemented with brewer or maize grains, banana peels, bean/pea leaves and house hold wastes. The management system is similar to agro-pastoral system. Tethering has been associated with low weight gains and predispose to heavy helminthiasis and mineral deficiency.

Stall-feeding (zero) grazing is commonly practiced in densely populated and intensely cultivated areas usually associated with small holder dairy goat keepers and research institutions. Flock size is determined by the owner's capital base and land availability. They are confined and food is cut and carried to them, household wastes are given as supplements, fodder crops are grown and concentrates are also provided. In West Africa strip farming, using a high quality leguminous plants such as *Leucaena Leucocephala* and *Gliricidia spp.* is adopted and increasessmall ruminant production.The animals under this system requires high nutrient food, proper veterinary care and well constructed house usually with slatted or concrete floors thatched with grass or iron roof. High incidence of ectoparasites (fleas, mange mites and lice) and endoparasites (helminthes and coccidia) and pneumonia are common in this system due to poor hygiene.

Intensive use of cultivated forage or pasture is a high capacity investment. It involves cultivation of forages or grasses, with shifting pasturing and cultivation. It has a high potential for increased productivity.

Integration with tree crops is a farming system whereby the animals graze under the tree crops , protected by the shade, and defecate to fertilize the soil, forming a kind of symbiotic relationship. It is common in some West African countries and Eastern coastline East Africa.

2.1.4.4 Small ruminant feed

Small ruminant nutritional requirement can be met by feeding a variety of feed stuffs, and feed ingredients can substitute for one another to meet the nutritional requirements The feeding programs should therefore take into account theserequirements, feed availability, and costs of nutrients. The provision of feed rich in energy, vitamins, minerals, fibers and water in required proportion are essential for optimum performance. Energy (calories) is usually the most limiting nutrient, while protein is the most expensive. Also the importance of balanced minerals and vitamins cannot be overemphasized, the deficiency and excess can limit animal performance and cause various nutritional deficiency diseases. Fiber content of the feed is necessary to maintain a healthy rumen environment and prevent digestive upset while provision of water *ad-libitum* is important. The exact percentage requirement of these nutrients varies according to weight, age, and physiological state of the animal

a. Forages

Forage is the major source of nutrients for small ruminant. In some cases, it can meet the nutritional requirements of the animal.They are especially high in energy and protein in their vegetative state and contain high moisture. As they mature, palatability and digestibility decline, and so it is important to practice pasture rotation to keep the plants in a vegetative state

In Ghana Karbo*et al.,* (1993) observed *Cajanus cajan*and *Leucanea Leucocephala*and *mucuna spp*as the most preferred forages by small ruminant(Avomyo *et a*l., 2000). They

are rich in protein:*Cajanus cajan*(26.3%) and *Leucanea Leucocephala*(18.7%). The macro and micro mineral content are highly appreciable and can meet the nutritional requirement. *Gliricidia sepium*is the least preferred (Karbo *et al*.,1993), because of the repulsive odour and toxic substance in its leaves and stem, but considered a good fodder for small ruminants and could be used as protein supplement (Ranjhan, 2001). As good as these forage are, they contain anti nutritional factor (coumarin) which changes to dicumarol in the damaged leaves,may reduce their consumption or cause weight loss (Karbo *et al*., 1993).

b. Concentrate

Concentrates are feed used with another to improve the nutritive balance of the total or complete feed. They are essential in high producing animals and in situation when the nutrient produced by forage is not sufficient to meet the need of the animal or in some cases when it is economical. There are two types of concentrates: Energy and Protein

The energy feeds provides the Calories but low in protein (8-11%). This includes maize, barley, wheat, oats, milo and rye. The inclusion of grains in small ruminant feed is not necessary except when they are below six weeks of age. This is because they are rich in phosphorus but low in calcium, the result of which may lead to formation of urinary calculi (kidney stones) in wethers or in active males. The ratio of Calcium to Phosphorus is 2:1. Inadequacy may lead to hypocalcemia in pregnant or lactating goats

Protein supplements contain high level of protein (15%) which may be of either plant or animal source: soya bean meal, cottonseed, groundnut cake or fish meal. In ruminants protein quantity is more important than the quality since most of the proteins required by ruminants are produced by the microorganism in the rumen. Excess protein is not stored but converted to energy or eliminated as nitrogen by the kidney

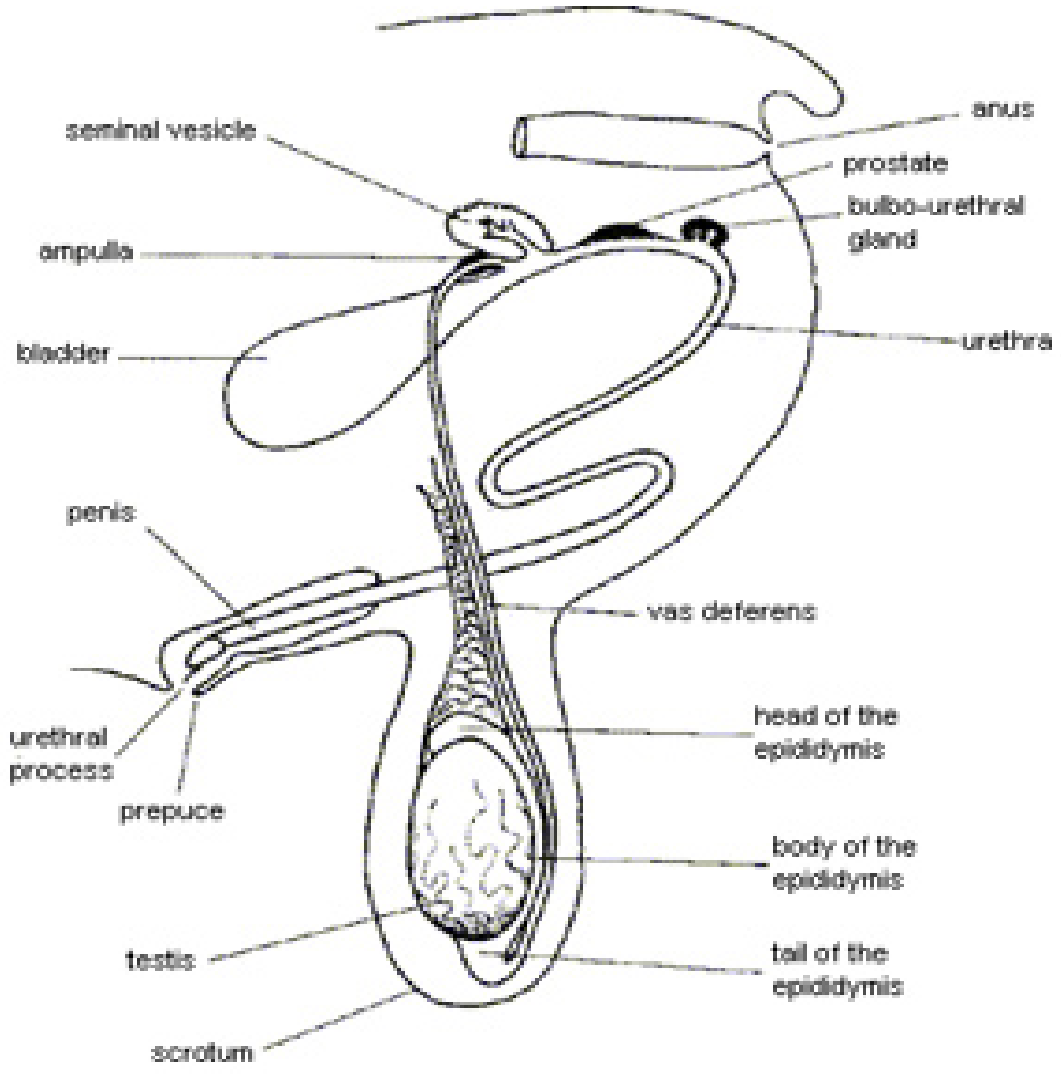
2.2.0 Male Reproductive System in animals

The scrotum, testes, spermatic ducts, sex glands, and penis form the main male reproductive system in animals. Physiologically they produce spermatozoa, androgen and the accessory fluids which are delivered into the female vagina during copulation (Taylor, 1999).

2.2.1 Testes

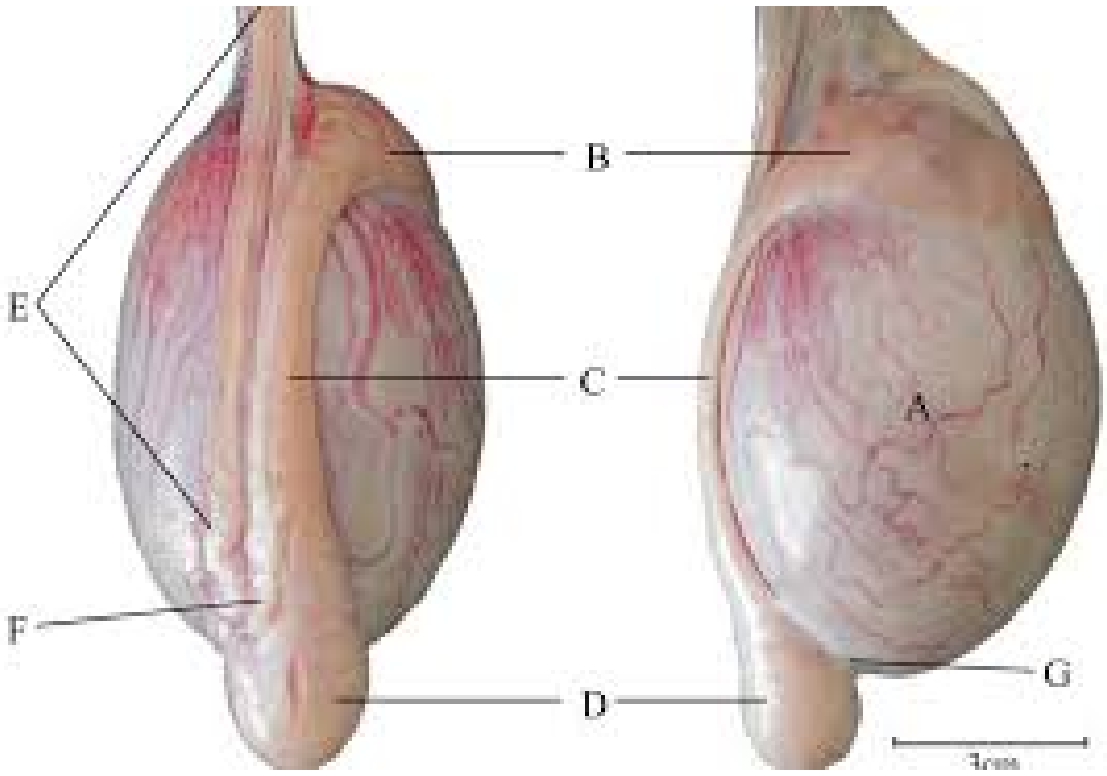
The primary organ of reproduction in male is the testis; they produce sperm cells, and androgens. In males at birth the gametes are not present in the testes. In the seminiferous tubules, there are germ cells which undergo continual cell divisions to produce spermatozoa throughout life (Hill, 2017)

The descent of testes is caused by shortening of the ligament (gubernaculums). It draws the testes closer to the inguinal canal and with the aid of intra-abdominal pressure the testis is pushed into the scrotum by the influence of the gonadotropic hormones and androgens (Senger, 1999). An abnormal physiological condition where one of the testes fail to descent is called unilateral cryptorchidism, while when the two fail to descend is bilateral cryptorchidism. The bilateral cryptorchids are sterile while the unilateral cryptorchids are usually fertile because of the descended testis. Surgery is usually the option for the treatment, but to avoid perpetuation of undesirable trait, it is not advisable because they could be genetically transferred (Lush *et al.,* 1930).



Langston University, Goat Research

Figure 2.2.1.1a The Male Reproductive system and descended testis in the scrotum of goat



Karl J. Campbell

ResearchGate, Island Conservation

Figure 2.2.1.1b Goat testes and Epididymis:
Key: A = testis, B= epididymal head, C = epididymal body, D = epididymal tail, E = vas deferens, F = attachment site of 'epididymal ligament (mesorchium) connecting epididymis to tunica vaginalis, G = epididymal ligament (mesoepididymis) connecting epididymal tail to testis

2.2.1.1 Anatomy and Physiology of Testis.

The testis is covered by the tunica vaginalis. It consists of three parts, the outer layer - tunica albuginea, it is supplied with numerous blood vessels, then, the functional layer - the parenchyma, which is yellowish in color. Connective tissue separates the two testes (Figure 2.3). Within these segments are the seminiferous tubules which contain the Sertoli cells (spermatogonia). These produce both androgen binding protein and inhibin by the influence of Follicular stimulating hormone (FSH). The spermatozoa are produced in the seminiferous tubules, small convoluted tubules joined to the rete testis, connects with the vasa efferentia, and converge into the caput of the epididymis (Khamas *et al.,* 2014).

Leydig cells are within the parenchyma between seminiferous tubules of testis. They produce testosterone and some quantities of other androgens under the influence of Luteinizing hormone **(**LH). The function of Testosterone include the development of secondary sexual characters, functioning of the accessory glands, production of sperm cells, transportation and its deposition into the female reproductive tract(Sorenson,1979), maintenance of the male duct system, and optimum condition for spermatogenesis. Normal body temperature has not been observed to affect the function of Leydig cells (Sorenson, 1979).

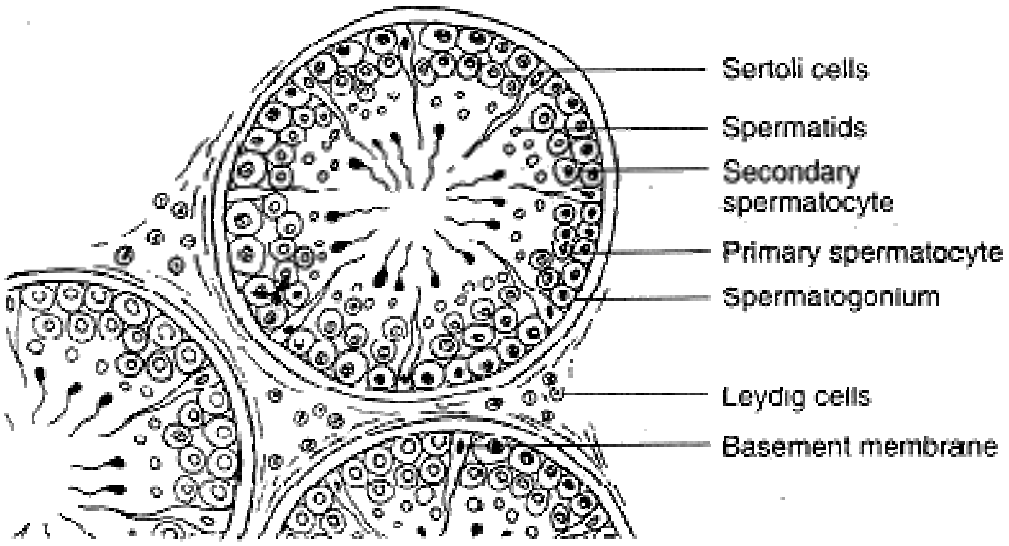


Figure 2.2.1.2: Diagram of testis, showing segment of parenchymal tissue containing seminiferous tubules and interstitial tissue (Sorenson, 1979)

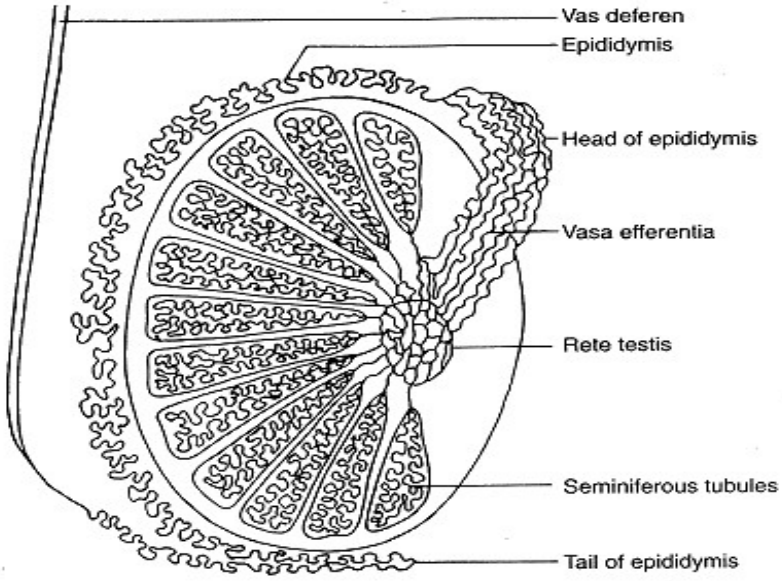


Figure: 2.2.1.3A section of parenchymal tissue, with seminiferous tubules, rete testis, the epididymis, vasa efferentia and vas deferen (Sorenson, 1979)

2.2.1.2 Spermatogenesis

Spermatogenesis is the developmental process of the sperm cells within the male reproductive organs, the testes, from the stem cell to mature spermatozoa. The stem cell develops into mature spermatozoa in three stages: The **mitotic**(spermatocytogenesis), the **meiotic** and **spermiogenesis**.

Theproduction process occurs in the seminiferous tubules, through which the spermatozoa are also transported to epididymis where they are stored until it is ready to be transported out of the testis. The wall of the seminiferous tubules contains numerous sertoli cells that serve the purpose of supporting and nourishing the immature sperm cells during development by giving them nutrients and blood supply. They move the immature sperm cells from the basal surface of the seminiferous tubules to the central portion.

The immature sperm cells called spermatogonia arederived from the stem cells. The stem cells havenucleus containing chromosomesthat divides by mitotic division into two,one of the halfgrows to become future sperm cell while the second remain as stem cell, for continuous source of stem cells. The spermatogonia called the primary cells move from the basal part of the seminiferous tubules to the central part then attached around the sertoli cells, increase the cytoplasm around its nucleus and develop organelles. Here the primary sperm cell divides into secondary sperm cell, during which there is splitting of the nuclear materialto form secondary sperm cell (spermatocyte) by first meiotic division and by the second meiotic division spermatid is produced (Charlotte, 1999). The secondary spermatocyte undergo some changes such that the nuclear substances become condensed and oval in shape to form the head of the spermatocyte with a cap on the head called acrosome, which is important in helping the matured spermatozoa penetrate the egg during fertilization.The cells are joined together by cytoplasmic bridges until they are fully differentiated into spermatozoa. They undergo changes to form the tailpiece of the sperm cell, which contains a long slender bundle of filaments that propel the matured spermatozoa by their undulating movement through the seminiferous tubule to the epididymis where they are stored

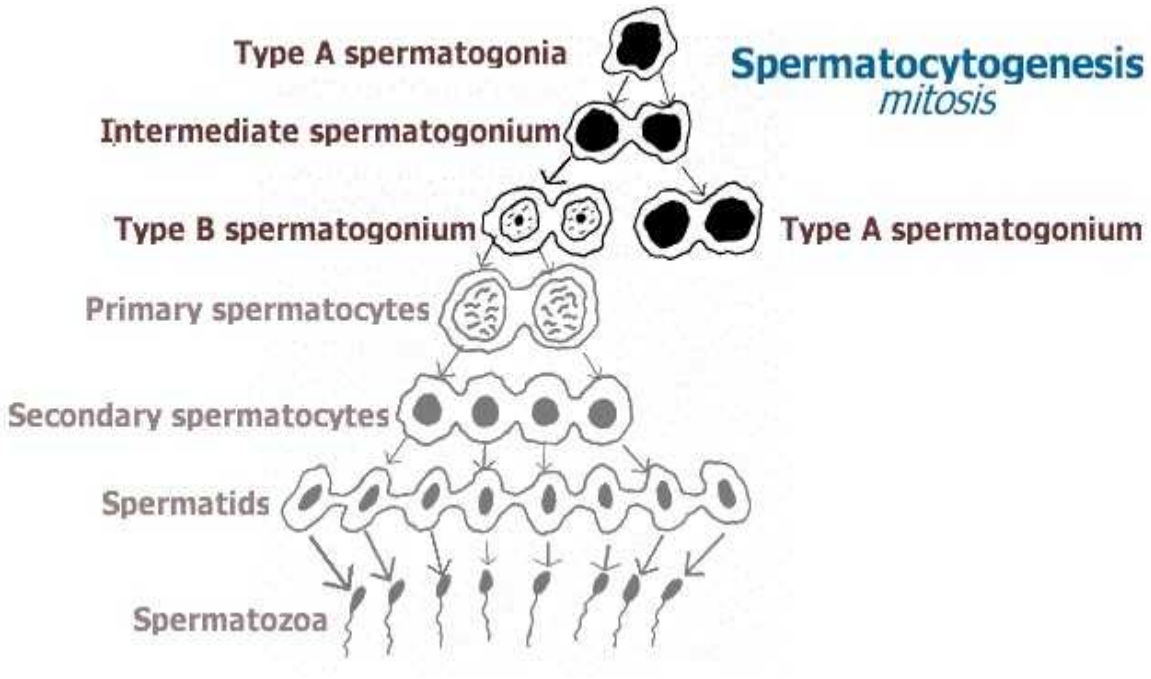


Fig: 2.2.1.4: Diagrammatic representation of the first stage of spermatogenesis, the mitotic or the spermatocytogenesis.

Source: Dr. Charlotte Ownby(1999)

At the spermatocytogenesis the stem cell (type A spermatogonia) divides by mitosis to produce the type B spermatogonia which starts the differentiation process. They arespherical or oval in shape and occupy the basement membrane of the seminiferous tubule. Karma and Devi., (2012) observed transformation of gonocytes by mitotic division to form stem cell (prespermatogonia) at 2 months in Assam goat, and Hamano *et al*., (2001) at 3 months in Japanese black bull. With increase in age the central gonocyte moved to the periphery of the sex cord (Lee and Burger, 1983)by a series of mitotic divisions. Prespermatogonia cells formed give rise to spermatogonia.

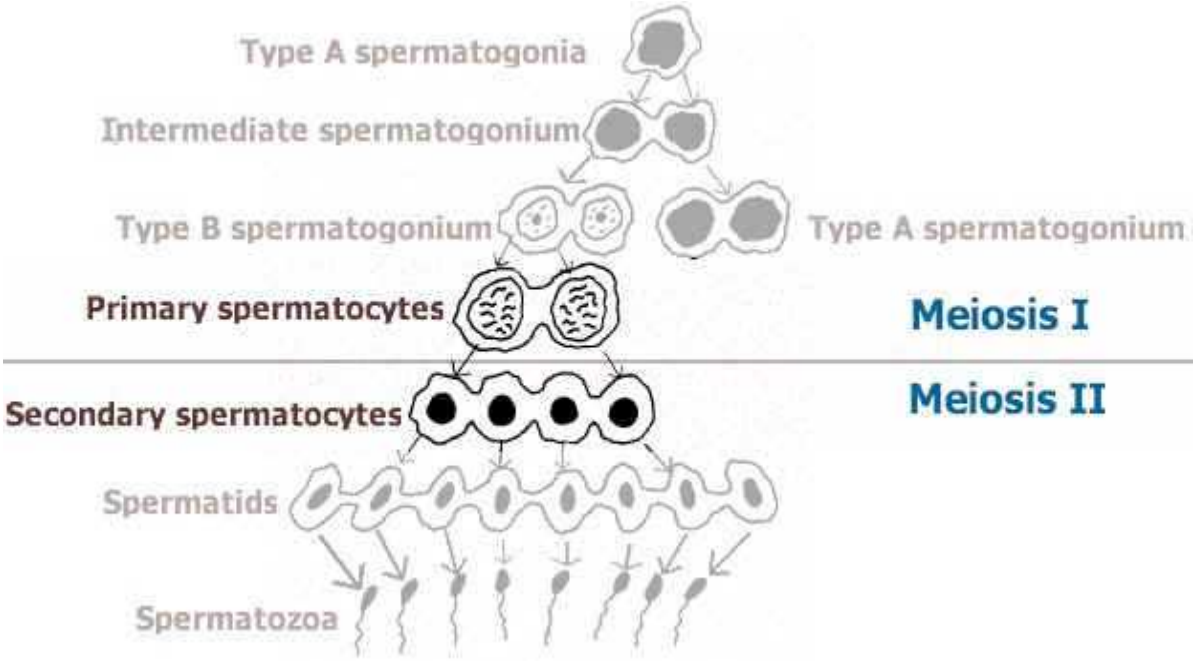


Fig: 2.2.1.5 Diagram showing the meiotic division stage of spermatogenesis.

Source: Dr. Charlotte Ownby(1999)

At spermiogenesis, the spherical spermatid metamorphosed into enlongated spermatozoa (Charlotte, 1999), no more division at this stage, but there is formation of the acrosome, flagellar apparatus, the excess cytoplasm is detached in the Sertoli cell, and the spermatozoa are released into the seminiferous tubules. The remnant cytoplasmic droplet is released in the epididymis during transit, making it capable of passing through the reproductive tract of the animals for eventual egg fertilization.

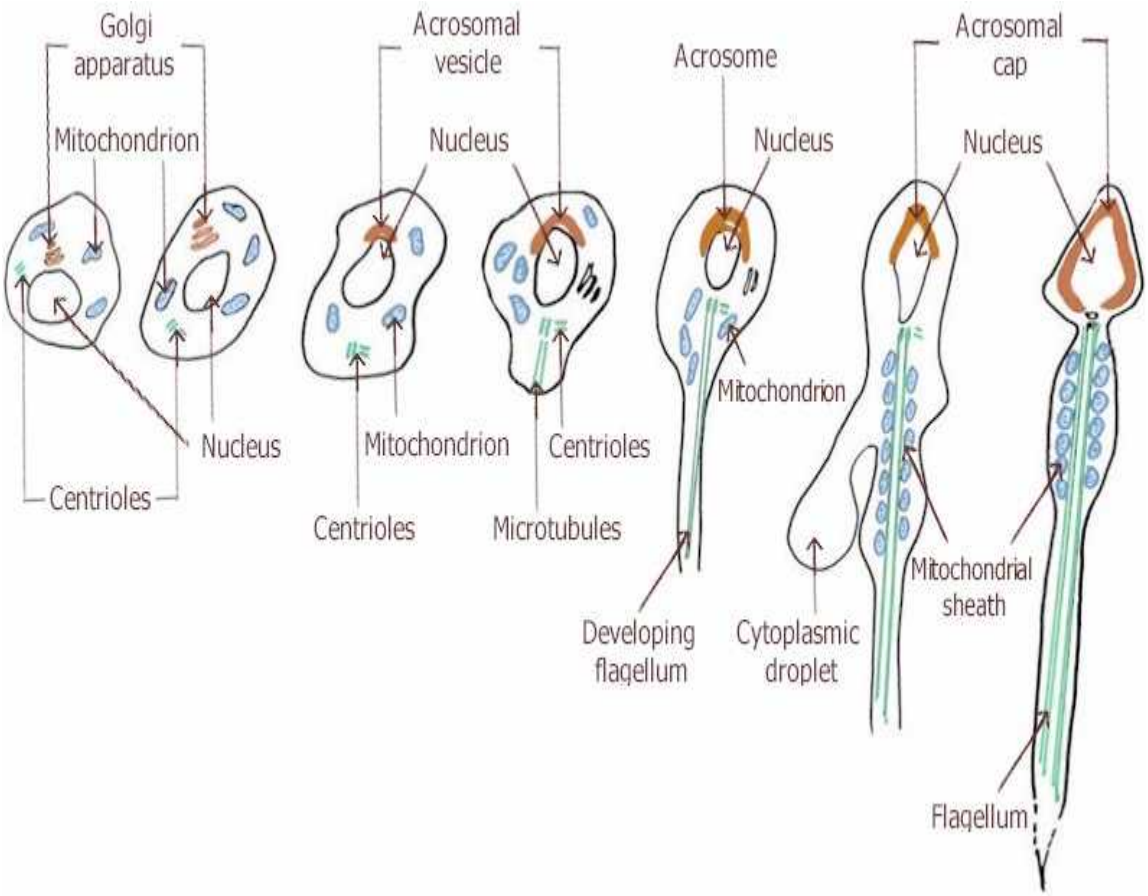


Figure:2.2.1.6 Diagram showing the transition process from spermatid to spermatozoa

Source:Dr. Charlotte Ownby(1999)

At this stage the remnant cytoplasmic droplet is detached later in the epididymis during transit, making it capable of passing through the reproductive tract of the animals for eventual egg fertilization.

2.2.1.3 Relationship between sertoli cell and developing spermatogenic cell

Anatomically, there is a close contact between sertoli cell and spermatogenic cell throughout the process of differentiation, this relationship provides structural and metabolic support for developing cells (Charlotte, 1999). Sertoli cells are found in the basement membrane of the seminiferous tubules, it is identified with vesicular, oval, basally position nucleus and nucleolus. The sertoli cell produces an endocrine hormone called inhibin. It causes the pituitary to reduce the secretion of follicular stimulating hormone (FSH)

2.2.1.3 Blood-testis barrier

The occurrence of a tight junction in between the sertoli cells inhibits the movement of large molecules from the blood into the lumen of the seminiferous tubule. The spermatogonia are located at the basal compartment (deep to the level of the tight junctions) while the primary, secondary spermatocytes and spermatids are in the adluminal compartment(Charlotte, 1999). The blood-testis barrier has been observed to prevent an auto-immune reaction. It is however observed that immune tolerance has been established long before the appearance of mature sperm and their antigens (Charlotte, 1999), indicating that a male animal can make antibodies against his own spermatozoa, evidenced by the inflammation of the testis after injection of sperm antigens and reduction of fertility(Charlotte, 1999). Thus, suggesting that the influence of blood-testis barrier may prevent sperm protein from producing immune response.

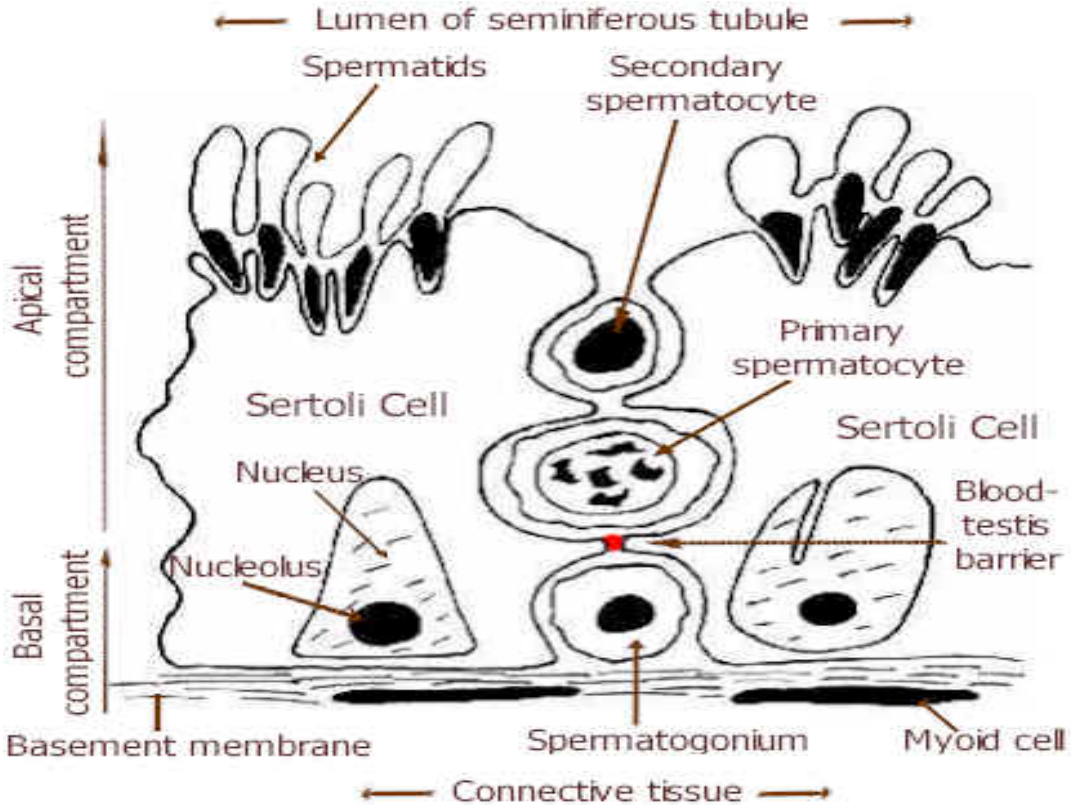


Figure 2.2.1.7 Diagram showing the blood-testis barrier within the seminiferous tubules of the testis

Source: Dr. Charlotte Ownby(1999

2.2.2 TheScrotum and Spermatic Cord

The Scrotum is a sac of skin anatomically divided into two containing the testes situated between the two hind limbs in most animals. The scrotum contain three layers; The Skin forms the outer layer and contain sweat and sebaceous glands, then the *tunica dartos,* a layer of smooth muscle fibersand tunica vaginalis (Senger, 1999).

Spermatic cord consists of smooth muscle fibers, connective tissues including part of the vas deferens. It links testis to the testicular arteries, Venus plexus, and the nerve trunks. The spermatic cords and scrotum perform the temperature regulatory function for the testes (Senger, 1999).

2.2.2.1 Temperature regulation in the testis

The importance of temperature regulation in the testis cannot be overemphasized, because at high temperature the cells of the seminiferous tubules begin to degenerate, which may invariably lead to sterility. This may occur in an insulated scrotum or a pathological adherent of testis against the abdomen. When the temperature of the testis is as high as that of the abdomen or in an undescended testis sterility ensues. In bilateral crytorchid the animal is sterile, because spermatogenesis stops at a temperature as high as the normal body temperature (Mieusset *et al*., 1992) however; low ambient temperature has not caused any decrease in fertility.

The mechanism by which the scrotum and spermatid cord regulate temperature in the testis involve contracting and relaxing the testes as ambient temperature increases by the action of two smooth muscles, the *tunica dartos, in* the spermatid cord. They respond to changes in temperature at puberty when sensitized by testosterone. During the cold weather, these muscles contract and cause the scrotum to contract thereby shortening the spermatic cords and testicles drawn toward the body, while in hot weather, relaxation of the muscles and scrotum occur, causing lengthening of the spermatic cord, and drawing the testes away from the body.

Cooling Mechanism of the Testis

The process by which the testis is cooled occurs in two ways:

By the sweat and sebaceous glands activities in the skin, and heat exchange process in the circulatory system

The sweat and sebaceous glands are active and sensitive during the hot weather thus stretching the scrotum creating more surface area for evaporation and cooling, by this process the scrotum and the testes temperature is reduced, though naturally the temperature of the external scrotum is about 2 to 5^{o}c lower than the testes inside (Arunachalam Kumar, 2014)

The temperature regulation of the testis by exchange of heat in the circulatory system is brought about by the extension of the spermatid cord when there is increase temperature leading to increase surface area for heat exchange (Senger, 1999) in which there is exchange of arterial blood with venous blood (Figure 2.2.2.1.1)transporting blood with low temperature back to the heart before returning to the testis.

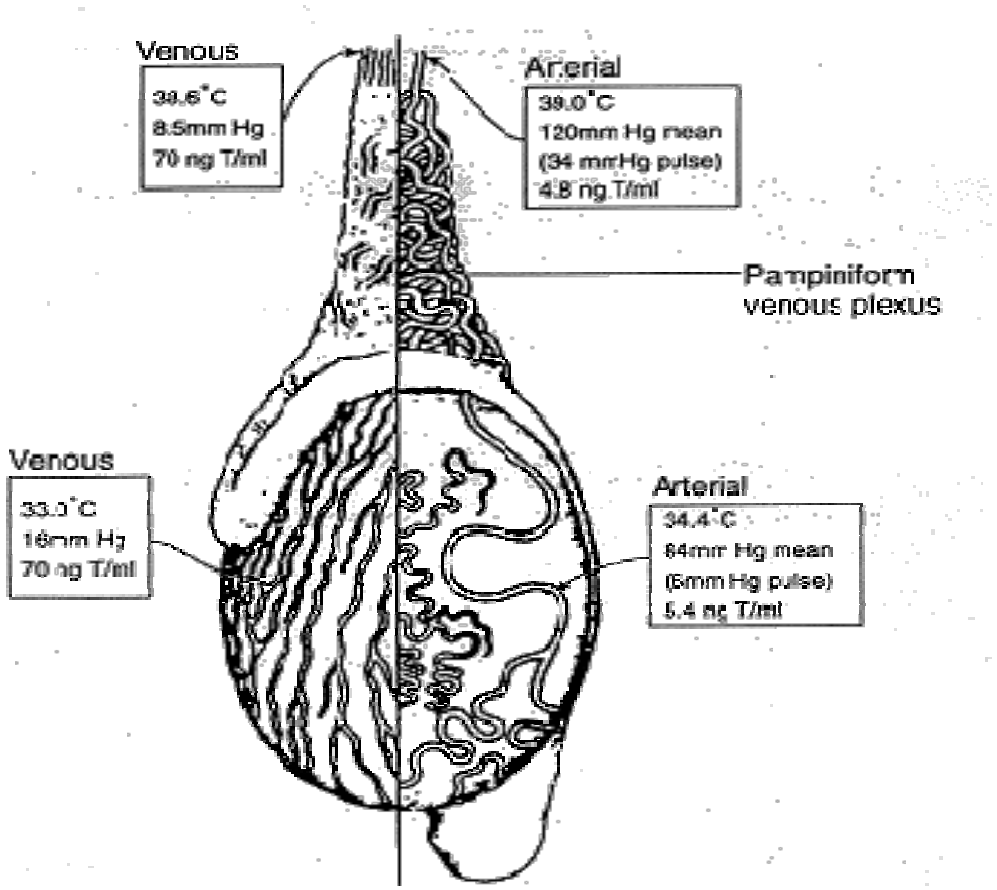


Figure 2.2.2.1.1 Diagram showing the exchange of heat through the circulatory system (Setchell, 1977)

2.2.3 The Epididymis

Epididymis is a convoluted duct, made up of three layers: the outer layer-tunica serosa, middle layer-smooth muscle and the inner layer -epithelial layer (Khamas *et al.,* 2014) Anatomically it is made up of three parts, the head known as the caput at the apex of the testis, (Hemeida, 1978 and Nistal, 1984), the body called which joined the third part cauda epididymis at the tail of the testis.Maturation, acquisition of progressive motility and ability of the spermatozoa to fertilize including its transportation, concentration and storage are some of the major functions of the epididymis in reproduction (Cornwall, 2009)

2.2 3.1 Spermatozoa Transportation

One of the important role plays by epididymis is the transportation of sperm cells from where it is produced in the testis to ductus deferens of the male reproductive system. This takes about ten days through the epididymis in sexually matured male animal (Bernard *et al.,* 2015) depending on many factors of which pressure from the site of production is essential. The spermatozoa are released into the epididymis through the rete testis and vasa deferens as soon as they are produced, and forced through the epididymis especially in sexually inactive male. The movement of spermatozoa (Van Der Horst *et al.,* 1999) is facilitated by the effect of cilia lining the epithelium of the epididymis, the peristaltic contraction of the muscle of the epididymis and its pressure on the vas deferens and urethra.

2.2 3.2 Spermatozoa Concentration

Spermatozoa concentration in the epididymis is brought about by the absorption of fluid suspending the sperm cells during transportation by the epithelial cells, principally at the caput and proximal end of the corpus (Bernard *et al.,* 2006).

2.2 3.3 Spermatozoa Storage

The cauda epididymis (tail) is responsible for storage of already concentrated spermatozoa transported from the Corpus (body) where there are optimum conditions for its preservation for an extended period beyond 30 days (Orgebin-Crist *et al.,* 1975), and in

bats, for many months and still retain their function (Gopalakrishna*et al.,* 1980). However, high percentage of non fertile spermatozoa may be found in the ejaculate (especially in the first few ejaculates) of an animal on long sexual rest (Martin-DeLeon *et al.,* 1973).

2.2 3.4 Spermatozoa Maturation

Spermatozoa maturation occurs in the epididymis. The spermatozoa entering epididymis through the caput epididymis have cytoplasmic droplet on their neck are immature, immotile and incapable of fertilizing (Weissenberg *et al.*, 1996). Passing through the epididymis the sperm cell lose the cytoplasmic droplet and gradually become motile and fertile. It has been observed that cauda epididymis also recognize abnormal and dead spermatozoa (Weissenberg, *et al*., 1996) and develops a mechanism to neutralize or destroy them (Bernard *et al.*, 2015).

2.2.4 The Vas Deferens and Urethra

Anatomically it is a muscular tube, enlarged at its distal end where it joins the Urethra to form the Ampulla. Its major function is transportation of spermatozoa (Arthur, 2009) from epdidymis to the urethra. Ampulla is assumed to be a brief storage depot for semen before it is discharged into the urethra (Arthur, 2009). The urethra is an excretory duct for urine and semen, extending from the ampulla to the anterior opening of the penis (Arthur, 2009).

2.2.5 Accessory Glands

The accessory glands includethe following vesicular,prostateand bulbourethral glands.Their secretions, which form the bulk of the fluid volume of semen discharged into the urethra includes buffers, nutrients and other substances. They make motility and fertility of the sperm cells possible(Ashdown and Hancock, 1974).

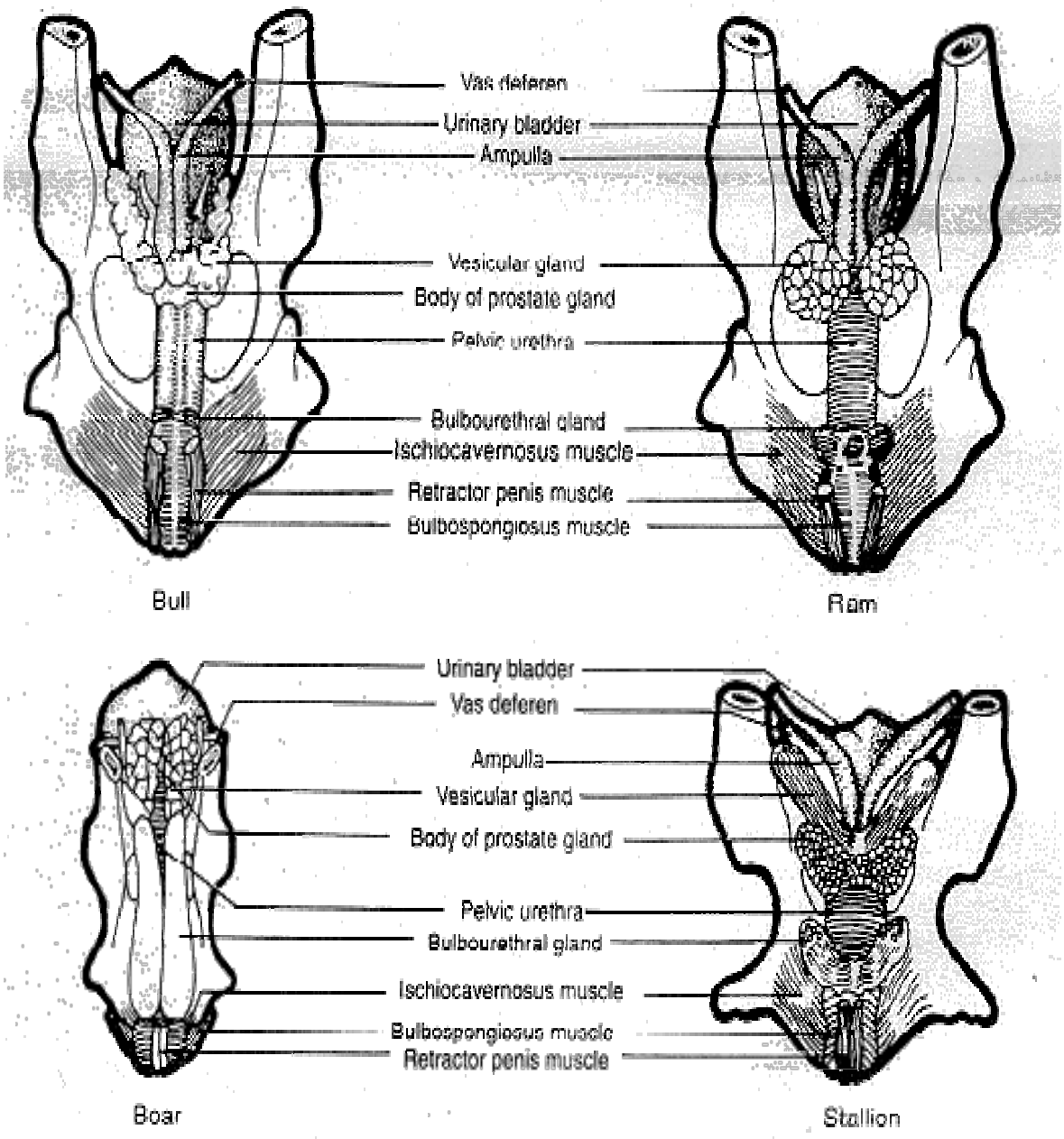


Figure 2.2.5.1 Diagram showing the accessory glands the ampulla and urethra. (Ashdown and Hanccok, 1974)

2.2.6 Vesicular Glands

The vesicular glands are paired lobular glands (Michael *et al*., 2010). Their secretion contains fructose and sorbitol (El-Hakim and Assaad, 2006), the major source of energy for spermatozoa. Also present are phosphate and carbonate buffers which help maintain the pH balance of the semen, and survival of spermatozoa. (Arthur, 2009)

2.2.7 Prostate Gland

Prostate gland is located along and surrounds the urethra, immediately behind the vesicular gland. It does not contribute much fluid in most species (Sinauer Associates, 2008). Its secretions contain high inorganic ions including sodium, chlorine, calcium, and magnesium (Nalbandov, 1964).

2.2.8 Bulbourethral Glands

The bulbourethral also known as Cowpers gland contribute little to the fluid of semen. The secretion flushes urine residue from the urethra before ejaculation. Its secretion coagulates in boar, this hinders flowing back of semen into the vagina of sows after ejaculation (Nalbandov, 1964).

2.2.9 Penis

In males penis is situated dorsally around the urethra at the point of its exit from pelvis. It is fibro-elastic and contain small amount of erectile tissue (Beckett and Wolfe, 1998). The free end of the penis, called glans penis is homologous to clitoris in female, it is supplied with sensory nerves. The penis is S-shaped bend(sigmoid flexure) in bull, boar, and ram, which allows it to be drawn completely into the body. The pair of retractor muscles, relax and contract to cause extension and relaxation of the organ (Beckett and Wolfe, 1998).

2.3.0 Solid feed and supplementation

2.3.1 Pre-weaning

Kids begin to eat grass and forages about 1 week of age and starts ruminating at about 2 weeks (Mowlem, 1984), from this period it is important that they are fed *ad-libitum* with good quality hay or chaff with suitable concentrate feed and Vitamins with fresh energy and protein sources, to give them a sound take-of

2.3.2 Early weaning

Early weaning of ruminant animals depends solely on the physiological state of the kid especially during development of the rumen. In United States 70 percent of kidss are weaned at 7 weeks, but with proper care and management, in 4 to 5 weeks kidss with adequately developed rumen can be weaned (Kehoe *et al.*, 2007) with feed supplement containing high energy, 18-25 per cent protein from age 1 week to the first 2 weeks after weaning, to 16 per cent protein at 8 weeks of age (Mowlem, 1984).

2.3.3 Weaning

The age at weaning of kids depends on economic and management considerations. They can be weaned as early as 8 or 10 weeks of age and weight of about 10kg with a higher standard of husbandry, this will enable the kid overcome weaning shock better (Mowlen, 1984).The weaning of the kid can be done abruptly or gradual by reducing the amount of milk fed and the number of feeding per day. Weaning weight is influenced by genetic, physiological and environmental factors (Mandal *et al.,* 2006), such as the breed, birth weight, managerial practices, the health status, state of the doe, economic and replacement policy. In sheep, Fasae *et al.* (2012)observed that the growth rate of Yankasa lambs was faster compared to WAD and the crosses as crosses had a better growth rate relative to WAD lambs. They attributed the differences in the various breeds to the effect of gene rather than environmental factors. In Boar, Kiko and Spanish goats, Browning and Leite-Browning., (2014) observed that the pre-weaning Average daily growth (ADG) is higher with the single than the multiplebirth reared and male than female kids. This may be due to competition among multiple kid litters for maternal resources (Browning and Leite-

Browning, 2014).If kids are to be weaned early they should have access to high-quality feeds, minerals and vitamin premix with water given *ad-libitum*. Inclusion of some high-quality roughages, such as chaff in the ration will assist rumen development (Mowlen, 1984).

2.3.4 Post-weaning

During the post weaningperiodfeed containing 16 per cent protein can be gradually reduced to 10 to12 percent when kids are 6–7 weeks old, till when they are 12 to 14 weeks when they can be reared solely on good quality grass. At 7 months less expensive feed can be adopted, taking into consideration that over fatness at kidding may cause dystocia and also have an adverse effect on milk production (Mowlem, 1984). Though rearing kids on pasture is more economical, kids reared under intensive management after weaning grow faster. The consequent low energy intake at pasture and internal parasitic load are challenges that should be properly managed (Mowlem, 1984).

Table 2.3.1: The minerals and vitamins for goat feeds/kilogram of dry matter

Sodium	2.0g
Magnesium	2.0g
Sulfur 1.5g	
Copper 10mg	
Cobalt	0.1mg
Zinc 75mg	
Manganese	50mg
Iodine	0.2mg
Selenium	0.1mg
Vitamin A	5000IU
Vitamin D	1400IU
Vitamin E	100IU

Source: Morand-Fehr., **(**1981)

Table 2.3.2 The feed schedules used for kid rearing at 10-week postweaning

Age	Milk fed/ml/day
1 to 6 weeks	3 × 750 ml.
7 to 8	2 × 850
9	2 × 570
10	1 × 570

Source: Morand-Fehr., **(**1981)

Table 2.3.3 The feed schedules used for kid rearing at 6-week pre-weaning

For Kids to 6weeks

Age	Daily milk
1 to 4 weeks	Ad-libitum
5	Reduce tohalf the quantity taken the previous day
6	Reduce the quantity to half of the previous day
7	Giving milk should be stopped

Source: Mowlem, (1984).

In the feeding of goat as shown in tables 2.3.2 and 2.3.3 (Morand-Fehr, **(**1981), the milk fed is gradually reduced with age. Feeding milk for long period is not necessary especially for specie that starts ruminating at 2–3 weeks (Mowlem, 1984).

2.4.0 Sexual maturity in Goats

In management practices, sexual maturity is important in breeding program for separation and early selection for desired sex for breeding, time of castration and improvement of the herd (Pacheco *et al*., 2009). It is characterized by the beginning of reproductive activities, but to reach its full reproductive potential, it must attain sexual maturity, when the sexual instinct is displayed. This has been described in theriogenology as the age when the male animal shows the ability to mate a female animaland ejaculate semen with live, viable and matured spermatozoa that would bring about pregnancy (Jimeno *et al*., 2001), while Gordon., (2004) defined same as the age when a male animal displays the five major sexual acts- mounting, intromission, ejaculation, relaxation and dismounting.

In selection of bucks for breeding program, display of mating behavior form an important criterion, especially early sexual behavior to evaluatethe reproductive ability of an animal intended for genetic selection to reduce generation interval (Madani and Rahal, 1988).

In this regard the age, the birth weight, the weight gain, and the scrotal biometry (SC)in goats have been described as important sexual maturity indicators (Girao *et al.*, 1996).

Testosterone has been observed as an important hormone of reproduction in the male, highly essential factor in sexual behavior; spermatogenesis and secondary sexual characteristics (Hafez, 2004). This is important in young sire selection and characterization of sexual maturity in animals (Eloy and Santa Rosa, 1998). It has a direct relationship with the age(Silva, 2000), season (Delgadillo and Chemineau, 1992), protein intake (Azevedo Neto, 2005) and pulse frequency of luteinizing hormone (Delgadillo and Chemineau, 1992). It isinvolved in the initiation of sexual maturity, and spermatogenesis (Eloy and Santa Rosa, 1998). Eloy and Santa Rosa.,

(1998) observed sexual maturity in buck at 4 months of age, though recommended that the buck should be allowed to reach 1 year of age before it is used for breeding. The number of bucks needed for a group of does in breeding is called "Buck Power" (Noble, 2004). Sexual maturity in doe is reached when she exhibits her first estrus and ovulation (Noble, 2004). It could be between 4 to 12 months of age. This however depends on the genetic makeup of the doe, the breed, birth weight and season, feeding, and the health status (Noble, 2004). The reproductive traits in male goat are affected by many factors: nutrition, genotype, season, management, disease including the level of parasitic infestation (Barth and Oko, 1989). In the tropics seasonal factors have little effect on the reproduction of indigenous goats, the direct effect on male reproduction is minimal, but fluctuation in availability of nutrition by its seasonal effect on vegetation plays an important role in modulating their sexual activities (Delgadillo *et al*., 1997). The genetic influence of male goat on the herd is also affected by length of day light. It has been observed that bucks perform better in late summer and fall (Senger, 1984) in terms of libido, fertility, and semen production, coupled with increased production of testosterone and Luteinizing hormone, as the day length prolong the quality of semen reduces with presence of abnormal spermatozoa.

2.4.1 Buck Effect

Buck effect, is a natural method of inducing estrus in female (doe) animal by sudden introduction of a male (buck) animal due to the smell and sight of the buck after a period of isolation usually about three weeks and a distance of about one mile away (Anon, 2011). This does not occur when the buck and the doe are together all the time. However it is observed that sudden placement of a buck with a doe induces an LH surge and ovulation in days (Anon, 2011).With buck effect, estrus occurs within 72 – 144 hrs (Anon, 2011). This method enables the non seasonal breeds to breed round the year by natural mating or artificial insemination. The method is easy and inexpensive alternative to progesterone-induced synchronization program for anestrous females (Wildens, 1999). Introduction of bucks at 28days post kidding has

effectively synchronized estrus in 10 days (Avdi *et al.,* 2004). This however depends on if estrousactivity induced by buck, is initiated before the natural breeding season, otherwise the doe may return to anestrous. The buck effect method, and or with progesterone combined are technique employed out of season (Avdi *et al.,* 2004). Itis based on initiating breeding season early. An adult buck of a year and above has been observed to serve between 10 to 25 does at a time (in one month). This however depends on individual sex drive of the buck.

2.4.2 Breeding at Puberty in Goats

It has been observed that breeding a goat at 1 year old at about 70kg body weight when sexually matured, (Sakurai *et al*., 2004) is a good practice in livestock management. However growth and development of the doe may be suppressed (Sakurai *et al*., 2004) andabortion, increased post-partum interval, and repeat breeding may occur if the doe does not attain adequate weight before she became pregnant. But does that are sexually mature, healthy with adequate weight, can be pregnant, and deliver safely without any adverse effect on her growth. Doe can produce multiple births - twins, triplets and rarely, more. The sex ratio as observed by Kumar*et al*., (2001) revealed that male sex ranged from 52.8 to 57.6%. He concluded that frequency of male births was little higher in summer than winter, but affirmed that year and season (September to February) with availability of forage would not influence the sex ratio (Tomar *et al*., 1995).

2.4.3 Synchronisation of Oestrus in Goats

Estrus synchronization is a reproductive technical procedure in which animals are brought to estrus and bred within a predetermined period (Omontese *et al.,* 2016). This is either to shorten or prolong the luteal phase of the estrous cycle. The injection of prostaglandin willreduce the luteal phase by inducing early luteolysis, while exogenous progesterone willincrease the luteal phase in similar manner the natural

progesterone produced by the corpus luteum acts. It has been successfully applied using fluorogestone acetate (FGA) Prostaglandin F_2 alpha ($PGF_2\alpha$) (Iliren®) and Pregnant mare serum gonadotrophin (PMSG) by Ince and Koker., (2011) in Turkish Saanen goats.

The use of oestrus synchronisation in goats has many advantages. These include, a betterdetection ofoestrus, application of artificial insemination (AI), multiple ovulation and embryo transfer (MOET), reduced the period between kiddings, easier assembly of litter kids, better management of pregnant does, induction of sexual maturity and efficient use of labor and animal facilities (Anon, 2014). It is important, because estrous and estrus cycle varies and may not be easily detected without the use of buck (Jainudeen *et al*., 2000). Hence the need foradoption of other methods such as AI and MOET, to complement reproductive management, would ensue that genetic material could be easily obtained, transferred domestically and internationally (Anon, 2017).

The various methods used in the synchronization of estrus include among others; changing the patterns of light and introduction of buck (the buck effect), strategic time of injection of hormone with changing of pattern of light and introduction of buck. Thestrategic time of injection of hormone treatment is popular and more convenient. Frequently used hormones are melatonin, progestogens (by oral, injection, or intravaginal releasing devices), gonadotropins/GnRH (or agonists), and PG only or in combination. Breed, breed type, stage of production and environment however, have been observed to influence the success of synchronization in goats (Gordon, 2004).

2.4.3.1 Prostaglandin

Prostaglandin is produced naturally during the estrous cycle from the non-pregnant uterus and when it is time for parturition in goat. Its function is to lyse the corpus luteum making the estrous cycle to start over and to help with the parturition process respectively. Whitley and Jackson., (2004) have shown that hormones such as prostaglandin can also be used for synchronization in cycling females, at dosage of 1.5 to 3 cc in goat twice, and dosage of 5 to 125 milligrams (mg), 11 to 14 days apart (Whitley and Jackson, 2004). Physiologically the second injection increases the chance of lysing the corpus luteum. This will allow the

doe to return to estrus. Frequently used prostaglandin in goat is dinoprost tromethamine, commercially available as Lutalyse^{R} (Pharmacia and Upjohn Co., Kalamazoo, MI).

Combination of the buck effectwith prostaglandin, may also offer a simple and cheaper method in that it reduces the breeding season in natural mating (Whitley and Jackson, 2004). Prostaglandin has also been use as a co-treatment in progestagen-based synchronization protocols in goats for natural mating, artificial insemination and strategic artificial insemination situations (Whitley and Jackson, 2004).

2.4.3.2 Progestagen

Progestagens, natural progesterone produced in the body, is used in estrus synchronization. It produces effect similar to progesterone (Tekoa *et al.*, 2010). Their major function in reproduction includes:

-Extension of corpus luteum lifespan in a cycling doe.

-Inducing estrus and breeding in the non-breeding season, complementing intravaginal sponge for estrus synchronization and out-of season breeding in goats (Whitley and Jackson, 2004). They are inserted into vagina and allowed to stay for 8 to 19 days. Examples are fluorogestone acetate (FGA; Cronogest 45) and methyl acetoxy progesterone (MAP; Repromap and Veramix). Better result have been recorded when use in combination with pregnant mare serum gonadotropin (PMSG), FSH or prostaglandin to synchronize and/or cause a superovulatory response. Synchcronisation and fertility rate similar to result obtained with commercial sponges have been achieved (Whitley and Jackson, 2004) when commercial sponges are impregnated with natural progesterone in higher doses (400-500 mg) similar fertility are also obtained when controlled internal drug-releasing device (CIDR) is used in conjunction with any of the gonadotropins or prostaglandins or the sponge(Motlomelo *et al.,* 2002).

2.5.0 Body Growth and Measurement in Goats

Body growth measurement is important in production management in animals andhelps in achieving many lofty goals especially associated with the health and economic status of animals (Afolayan *et al*., 2006). It can be divided into two (Afolayan *et al*., 2006) major parts; Pre-weaning average daily gain (ADG) or growth before weaning and Post-weaning average daily gain or growth after weaning. The higher the ADG the better in livestock production, it reflects the genetic and mothering ability of the doe at pre-weaning and the nutritional value of the feed at post-weaning. This is especially crucial in determining the economic value of the animal.

The birth weight and the pre-weaning growth of kids, and reproduction characteristics, dressing percentage, meat quality, certain tissue share and others are reliable indicators of the breed efficiency in the production of meat. The birth weight and the growth of kids are mostly under the influence of breed (Mourad, 1993), feeding (Haddad, 2005), type of birth and sex (Kuchtik and Sedlackova, 2005) and season (Jimenez-Badillo *et al.,* 2009). Birth weight of Boer kids was observed to range between 3 to 4 kg, with the male weighing about 0.5 kg heavier than female (Lu and Potcoiba, 1988). The kids' birth weight and the weight at weaning were determined by individual weighing on an electronic scale with accuracy of ± 0.05 kg. In the period from birth to weaning, which lasted for 186 days, kids were with other goats all the time and they consumed pasture grass and browsed while consuming milk by suckling. The ADG was calculated by subtracting the kid birth weight from the weaning weight, divided by the suckling period (Boro Mio oro Mioc*et al.,* 2011).

The type of body weight measurement method employed depends on the management procedure and condition of production on each farm. However the following methods are commonly used, under standard farm practice, properly calibrated livestock scales are used, but where scale is not available and records are not properly kept, procedures employed include, weight band, visual appraisal and body linear measurements. They give estimates of the animal live body weight. The live body weight measurement is important in livestock management, for breeding, correct feeding and health assessment (Slippers *et al*., 2000). Parameters like body length, width of pelvis, height at withers and chest girths are also employed for adequate evaluation of live animals (Atta and El kidirl, 2004).

2.5.1: Estimation of weight in small ruminants

Weight band: This is a specialized devise for measuring heart girth in goat then, converted to kilograms to give an estimate of goat weight. The procedure (De Villiers *et al*., 2010) includes wrapping the devise from a point caudal to the shoulder blade, to the fore-ribs ventrally, at the caudal aspect of the elbow and round back to caudal aspect of the same shoulder blade with the end points of the devise overlapped.

Visual appraisal: This methodis developed overtime by visual estimation of the weight of animals without any devise. Though, this is subject to errors because of breed differences (Otoikhian, 2008), and body structure (Slippers *et al.*, 2000). Red Sokoto goat posses light bones, which make them lighter than their size and also the Boer breed often appear bigger in size (Otoikhian, 2008).

2.5.2 Body Linear Measurements: Linear measurement often used in estimating weight are height at withers, heart girth, chest depth, body length, fore cannon bone, rump height, distance between eyes, ear length, ear width, paunch girth and tail length (Abegaz and Awgichew, 2009).

Height at Withers: This measure the length from the withers of the goat, to the ground in an animal while standing on the four legs equally spaced (Mahmud *et al.,* 2014) placing the vertical arm of the measuring device on the ground at a right angle to the platform and stretched to touch the shoulder at the desired point. This could also be carried out by inscribing the measuring scale to the vertical arm and read the height directly (Orheruata and Olutogun, 1984)

Heart Girth (Chest circumference): This measurement is taken around the chest behind the front legs and withers (Mahmud *et al*., 2014). It is taken to the nearest 0.5 cm. though it varies with posture and when the animal breaths. This is reliable and useful method of measuring weight because a positive correlation exist between chest circumference and body weight, within breeds, sexes, and ages of stock (Atta and El Khidir, 2004), especially in mature animals. However in excessively hairy animals, the hair should be compressed to get accurate measurement.

Body Length (BDL): The body length could be taken as the length from the crown of the head to the base of the tail otherwise referred to as Crown-Rump length, or distance from the base of tail to base of the neck (first thoracic vertebrae), front of the chest or tip of the nose(Fajemilehin and Salako, 2008).

Hip Width (HW): This measure the point of the hip bones on the outer edge on the right and left side (Mahmud *et al.,* 2014). It is also called Pin Bone Width. It can be measured using a pair of large round shaped callipers.

Rump Height (RH): This can also be described as the distance from the surface of a platform on which the animal stands to the rump using a measuring stick similar to measurement of height at withers (Fajemilehin and Salako, 2008).

Fore Cannon Bone Length: This is the measurement of the main lower leg bone from the hock to the fetlock especially in hoofed animals. It is taken by making the animal to stand or holding it to sit on its rump, bend back the hoof of the forelimb at the pastern and the leg itself at the knee then using a ruler or a measuring tape, to measure the length of the fore cannon bone (Mahmud *et al.,* 2014).

Chest Depth: This measures the point between the backbones of the animal at the shoulder to the brisket, between the front legs (Mahmud *et al.,* 2014)

2.5.3 Gonadal measurementsin small ruminants

Many research works have been done on the measurement of gonads in relation to reproductive viability of goats, Akpa *et al.* (2013) observed a relationship between testicular dimensions and body measurements and concluded that testicular length and circumference are significantly correlated with body weight (Bratte *et al.,* 1999) and are measures of testicular size. Other work revealed that a positive relationship exist between semen quality and testicular dimension, which means that if there is improvement in one, there will be improvement in the other. Ashwood*.,* (2009) and Akpa *et al*. (2013), also observed that testicular weight and sperm concentration were positively correlated and that increase in mean testicular weight may be the result of increase in seminiferous tubules size and proliferation of germ cells characterizing higher spermatogenic activity (Melo *et*

al., 2010). In Red Sokoto goat (Akpa *et al*., 2013) also confirmed that testicular size is a good indicator of sperm production potential.

2.5.3.1 Scrotal Circumference (SC) measurement:

The Scrotal Circumference (SC) measurement is taken round the broadest part of the scrotum holding the two fully descended testes at the same level in standing position and placing the measuring tape at right angle to the long axis of the testes, making sure that the cycle of the measuring tape is parallel to the ground (Neary, 2014). Taken the advantage of palpation of testis for evaluation of breeding soundness in buck the testicle can be stabilized and positioned for scrotal measurement. It is a reliable method for accurate testicular size measurement and indicator of breeding ability. This measurement directly indicates the total mass of the testicular tissue, quality of the sperm cells, onset of sexual maturity in bull and fertility in female (Osasanya *et al.,* 2014). A study of thermal stress on gonads of Santa ines sheep by Moreira *et al.* (2001) further confirmed that SC is a viable indicator. It is however observed that factors that affect the function of the scrotum affect the reproductive efficiency of the ram (Akpa *et al*., 2012).

2.5.3.2 Scrotal Length (SL) Measurement

Teodoro *et al.* (2013) observed that the shorter the Scrotal Length (SL), the better the thermal condition. It has been observed that a larger distance between the testicles and the abdominal cavity provides for maximizing heat loss in the area, a factor which helps greatly in thermoregulatory function. Moreira *et al*. (2001) observed a mean SL of 12cm, in Santa Ines rams, before localized heating of the testicles. Teodoro *et al.* (2013) in a study observed SL ranging from 16.5-17.3cm in Santa Ines rams with and without available shade respectively. Osasanya *et al*. (2014) in a study observed SL (cm) of 8.83 in control and 12.75 in the pineapple waste treatment group for 8 month old WAD rams.

2.5.3.3 Histomorphometry of sexual development in the male goat.

Histomorphometry is broadly defined as the measurement of the shape or form of a tissue. Literature on this subject is scanty in WAD bucks. However the seminiferous epithelial development follows a definite pattern at different ages after birth in mammals (Kamal *et al*., 2012) including the development of leydig cells in the testis of the pig (Van Straaten *et al*., 1978) and domestic cat (Elcock and Schoning, 1984). Kamal *et al.* (2012) observed a high significant ($P < .01$) increase in the diameter of the seminiferous tubules and its micrometrical parameters in 4, 6, and 8 months old goats, thus indicating positive growth of the tubules with age. But Baishya *et al*. (1986) study of male gonad and thyroid gland in 0–90 days old Assam goat (Capra hircus), reported insignificant increase in diameter of the seminiferous tubules..

2.6.0 Reproductive hormones in Goats

Hormonesare organic substances secreted by specialized cells (glands) in the body, carried to other part of the body that effect physiological changes (Roberts, 1971). They are directly or indirectly involved in reproductive processes and maintenance of internal environment (Roberts, 1971). They are categorized into Primary and Secondary hormones.The primary hormones ((Roberts, 1971) are responsible for reproductive activities such as production of spermatozoa, production of eggs and its release, while the secondary hormones controls the normal functioning of the organism which makes the reproductive activities possible.

(a) **Table 2.6.1 Primary hormones**

Gland	Hormone produced	Functions
Anterior pituitary	Follicle stimulating hormones (FSH	Spermatogenic activities and growth of ovarian follicles
	Leutinizing hormone(LH)(ICSH)	Release of androgen and ovum
Posterior pituitary	Oxytocin	Parturition, contraction of uterus and production of milk
Testis	Testosterone	Maintenance of reproductive ducts system, secondary sexual character, male sexual behavior and spermatogenesis
Ovary	Estradiol	Maintenance of reproductive ducts system, secondary sexual behavior, and mammary gland stimulation in females
	Progesterone	Implantation,pregnancy maintenance and mammary gland stimulation
	Relaxin	Relaxation of uterine cervix, pubic symphysis and inhibition of uterine contraction.
Placenta	Human chorionic gonadotrophin (HCG) in primate	LH like
	Pregnant mare's serum (PMS) in horse	FSH like

Source: (Roberts, 1971).

(b) **Table 2.6.2 The Secondary hormones.**

Gland	**Hormone produced**	**Functions**
Anterior pituitary	Somatotropin releasing hormone (STH)	Body growth and protein synthsis
	Thyroid stimulating hormone (TSH)	For stimulation of thyroid gland, thyroxin, releases and uptakes of iodine by thyroid
	Adrenocortropic hormone (ACTH)	For stimulation of adrenal cortex and releases of adrenal corticoids
Posterior pituitary	Vasopressin (antidiuretic hormone)	Osmotic water balance in the body
Thyroid	Thyroxine	For body growth, development of maturation and oxidation of feed
Adrenal cortex	Aldosterone	For electrolyte and water metabolism
	Corticoids (cortisol, corticosteroid, cortisone)	Carbohydrates, protein and fats metabolism
Pancreas	Insulin	Metabolism of carbohydrates, protein and fats
Parathyroid	Parathormone	Metabolism of calcium and phosphorus

Source: (Roberts, 1971).

2.6.1 Testosterone Hormone in male Goats

Much experimental work has been conducted on animals including non human primates and ascertained that testosterone alone can maintain spermatogenesis, such as suppressive effect of LH/testosterone on LH/FSH secretions (Weinbauer *et al*., 2001)and the use of selective immunization against LH or LH receptor with FSH secretion (Graf *et al.,* 1997). It has been observed that the testosterone level in the blood varies according to age, in the 20th week it was low with serum level ranging from 0.4-5.4ng.mL-1 increase at 28^{th} weeks to 2.6-14.2ng.mL-1. The value again drops to 0.4 -5.4ng.Ml-1 at 38^{th} weeks, indicating that serum testosterone concentrations increases with age to sexual maturity and then declined thereafter (Bras, 2011). Furthermore, decrease in serum LH was observed as the serum testosterone increases (Ahmad, *et al*., 1996) showing the importance of testosterone in the regulation of spermatozoa maturation and the onset of sexual maturity in buck (Roberts, 1971). It was therefore concluded (Bras, 2011) that there is a direct similarity between the testosterone level, andrological parameters and age.

Table 2.6.3. Anglo-Nubian goat testosterone concentrations (ng/mL^{-1})

AGE	MINIMUM	MAXIMUM	MEAN
20weeks	0.9	4.1	2.7±1.4b
28weeks	2.6	14.2	8.5±4.6a
38weeks	0.4	5.4	2.2±2.2b

Source: Luize Eduando Barreto de Souza *et al*, (2011)

The normal reproductive activity in male animal consists of semen production together with libido and the ability to mate (Weinbauer *et al*., 2014). These activities are under the influence of hormones and central nervous system, though environmental factors: temperature, length of daylight, feed, change of environment, and diseases, may influence reproductive performance. The Pituitary gonadotrophic hormones (Weinbauer *et al*., 2014) acts on male reproductive organs to produce the following functions: Folicular stimulating hormone (FSH) promotes development of the epithelium of the seminiferrous tubules and thereby it controls spermatogenesis. Leutinizing hormone (LH) or interstitial cell-stimulating hormone, promote the growth of Leydig cells and control the secretion of testosterone. The development and functions of the secondary sexual character (the outward male characters) and the accessory sexual organs are controlled by testosterone, and so directly affect the composition of semen.

2.7.0 Earlier studies on sexual maturity in goat

Studies have been documented in various aspects of reproduction in goat, this includes, the relationship between testosterone level and sexual maturity by Eloy and Santa rosa. (1998) and concentration, body weight and scrotal circumference in Alpine goat by Trejo *et al.* (1988) in Dublin, correlations between testosterone and scrotal circumference (SC), and body weight in young Boer goat by Bezerra *et al.* (2009) in Brazil.

Also in Nigeria Oyeyemi *et al*. (2011), showed the effect of feeding WAD buck with maize bran and poultry waste on spermiogram and semen characteristics (Daramola *et al*., 2007) and induced puberty in WAD buck kid at five months using exogenous melatonin.Bitto and Eghunike., (2006) showed the effect of season ondaily sperm production, and daily sperm production/gram testis, gonadal and extra-gonadal sperm reserve in WAD bucks in their native tropical environment. Bitto *etal*.(2008) further observed that WAD buck breed throughout the year.Various studies have also reported different periods of sexual maturity in breeds of goat: some authors reported 20 weeks in goat raised on intensive and semi-intensive systemothers observed between 17 and 24 weeks.

2.8.0 The need for this study

As important as sexual maturity is in the reproductive process of animals, information in literature has left a gap: the onset of puberty in WAD male goat has not been properly addressed and documented. The period of onset of puberty is an important factor in breeding program in any herd. It enables good management practices, including early and prompt separation of sex to avoid inbreeding, selection of sire for breeding program, early semen collection for Artificial insemination and to avoid wastages as to when the buck should be put into reproductive use. Therefore more studies and in particular, the time of initiation of sexual maturity by the first appearance of mature spermatozoa in the cauda epididymis in WAD male goat need to be carried out to maximize the reproductive potential of this breed.

To successfully achieve this, some reproductive parameters, such as the body weight (BW), linear body measurement (crown-rump length (CRL) and height at wither (HAW)), scrotal biometry (scrotal length (SL) and circumference (SC)), testosterone production and the testicular histology would be studied as determinants.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Location

The research was conducted at Joseph Ayo Babalola University Teaching and Research farm Goat Unit, Ikeji-Arakeji, Oriade Local Government Area (LGA), Osun state, South Western Nigeria Longitude 7°41′00″N 4°49′00″Eand Latitude 7.68333°N 4.81667°E. The University is located in the tropical rainforest zone, characterized by tourist attraction, such as swamps, rivers, waterfall and living springs at Erin-Ijesa (Odunlami *et al.,* 2011).

3.2 Management:

3.2.1 Study animals and grouping:

Eighty WAD does were assembled, acclimatized and synchronised (Whitley and Jackson, 2004) with Estrumate (cloprostenol sodium (equivalent to 250mcg cloprostenol/mL) injection twice (eleven days) interval and bred by natural mating to produce the kids for this study. Sixty male kids (above 1kg by weight) that resulted from the synchronised does were kept with their dams for six week to feed on milk and from then fed on feed concentrate (Energy 2180 kcal, Crude protein 13.6%,) at 10% body weight per day and supplemented with forage to eighteen weeks of age.

3.2.2 Housing: The house was constructed 270 height x 240 cm width with open passage on a fenced plot of land. Cement block was used half the height of the house, and completed up to the roof with open wire mesh on the outside. The inside was partitioned into 120 x 150 cm per pen. The kids were kept in twelve pens of five and vaccinated with Pestes de petit ruminantum (VOM) and dewormed with Piperazine Liquid dewormer.

3.2.3 Feeding: The animals were fed with compounded ration500g/animal /day (Table 3.2.1) containing 13% crude protein and 2180 KcalEnergy, in the morning and allowed to graze forage in the evening. Salt lick was also provided. Water was given to the bucks*ad-libitum.*

Figure 3.2.1 Some of the WAD does synchronised forthe production of kids for the study

Figure 3.2.2 Some of the WAD Bucks used for mating of does to produce kids for the Study

Figure 3.2.3 Natural mating Procedure of the synchronised does

(Showing one of the mating peer)

Figure 3.2.4 One of the synchronised does and her twin kids

Table 3.2.1 Proximate analysis of the compounded feed for the buck kids

Diet	Quantity (%)	Energy (Kcal)	CP(%)	Ca	P	Fat	Fibre	Meth.	Lysine
Corn bran	**50**	**2150**	**5.5**	**0.005**	**0.045**	**1.4**	**6.0**	**0.09**	**0.125**
BDG	**25**	**495**	**4.5**	**0.05**	**0.04**	**1.5**	**5.0**	**0.10**	**0.225**
PKC	**20**	**435**	**3.6**	**0.042**	**0.032**	**1.2**	**2.4**	**0.078**	**0.128**
Bone	**1.5**	**-**	**-**	**0.555**	**0.225**	**-**	**-**	**-**	**-**
Limestone	**3.5**	**-**	**-**	**1.225**	**-**	**-**	**-**	**-**	**-**
Total	**100**	**2180**	**13.6**	**1.877**	**0.342**	**4.10**	**13.4**	**0.268**	**0.478**

Key: BDG = Brewery Dry Grain. PKC = Palm Kernel Cake

CP(%) = Percentage Crude protein. Ca = Calcium. P = Phosphorus

Fat = Fat. Fiber= Fibre. Meth.= Methionine. Lysine= Lysine

SECTION ONE

3.3 Investigation of the body weight, linear body dimension and scrotal biometry (somatic parameters) in male WAD goatfrom four to eighteen weeks post kidding.

3.3.1 Data collection and Procedure:

The collection of data was done between December 2015 and March 2016 from four to eighteen (4-18) weeks post kidding and the following data were collected:

Protocol of study: All measurements were taken at four weeks intervals for the first 12 weeks and weekly thereafter to 18 weeks.

3.3.2 Measurement of body weight: A hanging scale was used and values were recorded in kilogram. The Average weekly weight gain (ADG) and Growth rate (GR) were calculated in kilogram and percentage respectively;

$$\text{AWG} = \frac{\text{Initial weight} - \text{final weight}}{\text{Period (wks)}}$$

$$\text{Growth rate: GR} = \frac{\text{Present growth value} - \text{Past growth value}}{\text{Past value}} \times 100$$

3.3.3 Measurement of Linear Body dimensions: Height at Withers and Crown-rump length (Abegaz and Awgichew, 2009) were measured in centimeter using measuring tape.

3.3.4 Scrotal biometry: The scrotal length (SL) and scrotal circumference (SC) were measured in centimeter using measuring tape.

3.3.6 Data Analysis

The data were analyzed using one way analysis of variance (ANOVA). Significance was at $p<0.05$.

SECTION TWO

3.4 Investigation of the first appearance of matured spermatozoa in the cauda epididymis and testosterone production in male WAD Kids from four to eighteen weeks post kidding.

3. 4.1 Detection of spermatozoa

3.4.1.1 Orchidectomy

Standard procedure for open castration following Intrascrotal injection of local anesthetics - lidocaine + adrenaline (20mg+0.0125mg/ml), was used (Deborah, 2015).

Orchidectomy was performed on four (4) bucks per week from four to eighteen (4-18) weeks

3.4 1.2Measurement of testicular weight

The testes after orchidectomy were weighed on a digital electronic weighing scale and the reading taken.

3.4.1.3 Semen collection and Evaluation

Semen samples were immediately collected from the cauda epididymis after orchidectomy by slit incision.and analysed for motility and morphology using Zemjanis (1977)and Oyeyemi *et al.* (2009) method.

Motility

The percentages of sperm cells moving in a unidirectional progression over a field on the slide under a light microscopewere observed byZemjanis, (1977) method. A drop of the semen was placed on a warm slide and mixed with a drop of warm sodium citrate and cover with cover slip, then observed under a light microscope (x100 magnification). Sperm cells moving in a straightforward unidirectional motionwere counted while sperm cells moving in circles, in backward direction or showing pendulating movement were excluded

Morphology

Morphological defects in a total of 400 sperm cells were determined by Wells and Awa (1970) method. Briefly, by making a drop of Wells and Awa stain and semen each on a warm slide,mixedand a smear of the mixture with another slide, thenair dried and viewed under a light microscope. The defects were classified according to Bloom (1973) method.

3.4.2 Testosterone assay

3.4.2.1 Protocol for Blood collection

2ml blood was collected at four weeks intervals from post kidding up to 12 weeks and on weekly basis thereafter to 18 weeks, through the left jugular vein into unheparinised tubes to obtain serum. The testosterone was measured in ng/ml.

3.4.3. Semen and Testosterone Analysis

Sperm characteristics and morphology were analyzed using standard procedures (Zemjanis, 1970 and Oyeyemi *et al.*, 2009). And the Testosterone assay by ELISA method

Microplate Enzyme Immunoassay (ELISA Method)

Testosterone Test Product used **-** Accu-Bind ELISA Microwells, Monobind Inc. Lake forest, CA92630 USA Testosterone Test System Product Code: 3725-300

Procedure

- Briefly, the duplicated microplate wells were cleaned for the serum sample
- Then 0.01ml (10µl) pipette into the microplate well and 0.05ml of the testosterone enzyme reagent added to the wells
- swirl the microplate gently for 20-30seconds to mix
- add 0.05ml of testosterone biotin reagent added to all the wells
- the microplate gently rocked for 20-30 seconds to mix, and then covered and incubated for 60 minutes at room temperature (27^{o}c)

- The content of the microplate was discarded by decanting and plate dried with absorbent paper
- 350ml of wash buffer was added, decant and repeated three times
- 0.01ml of the working substrate solution was added to all the wells
- incubated at room temperature for 15minutes
- then 0.05ml of stop solution was added to each well and gently mix for 15-20seconds,
- then the absorbance in each well was read at 450nm in a microplate reader.

Figure 3.4.1 Hormone assay using the ELISA Plate

SECTION THREE

3.5 Investigation of testicular Histology in male WAD goat from four to eighteen weeks post kidding.

3.5.1 Orchidectomy

Standard procedure for open castration following Intrascrotal injection of local anesthetics - lidocaine + adrenaline (20mg+0.0125mg/mL), was used (Deborah, 2015).

Orchidectomy was performed on four bucks per week from four to eighteen (4-18) weeks

3.5.2 Preservation of the tissues:

The epididymis and testis were separated and preserved in Bouin's fluid in labeled bottles for 24 hours.

3.5.3 Fixing of the tissues:

The tissue was fixed with 10% formalin and subjected to histological processing according to method employed by Junqueira and carneiro., (1980).

The tissues were immersed in rising concentration of ethanol (70%, 80%, 90% and absolute 100% two hours each) for thorough dehydration. And then treated three times with Xyline for clearing (two hours each) after which they were subjected to infiltration in molten wax three times (two hours each) and finally the tissues were embedded in paraffin wax, sectioned at 4µm(microns) thickness and stained using routine Hematoxylin and Eosin staining (H&E) method.

The Photomicrographs were obtained with Am-scope^{R} camera fitted to an Accoscope^{R} microscope. Various magnifications (X40, X100 and X400) were obtained for each section and observed under light microscope. Linear measurementsand counts were carried out using image analysis software TonpView^{R} 3.2 on the photomicrograph.

CHAPTER FOUR

RESULTS

SECTION ONE

4.1 Determination of changes in the body weight, linear body dimension and scrotal biometry(somatic parameters) in male WAD goat

The results of this study are presented in Tables 4.1.1 and Figures 4.1.1, 4.1.2 and 4.1.3. Table 4.1.1 shows thebirth weight, thebody linear measurement and.testicular dimension.

Results on the correlation analysis of the various parameters are shown in Figures 4.1.1, 4.1.2 and 4.1.3. The data demonstrate a statiscally significant correlation between Age and body weight R^2=0.917, P<0.05, Body weight and Scrotal length, R^2= 0.912, p<0.05, and Body weight and Scrotal circumference R^2= 0.779 p< 0.05 respectively.

Average birth weight 1.20±0.09kg was recorded for the kids and the body weight increases as they grow from 1.80±0.09 in the 4th week to 7.00±0.21 kg in the 18th week.The Average body gain increase gradually from the 4th week 0.73±0.03, 0.73±0.09, to the 12th week 1.19±0.97 kg, and decreased from 13th week 0.94±1.06, 0.85±8.86, 0.30±0.07 kg, increased slightly at 14th week (0.50±0.03), decreased from 15th week (0.08±9.94) and increased again in the 18th week (0.76±0.10)kg. The highest average growth rate occurred at the 12th week.

The Scrotal length increases gradually from 2.23±0.12 and in the 4th week to 5.00±0.09 and 6.10±0.08 cm in the 13th to 14th week and continued to increase to the 18th week 7.11±0.22 cm. The SC increased from 5.17±0.17 in the 4th week to 8.33±0.27 and 9.67±0.36 cm in the 13th to 14th weeks and also continued to increase to 14.12±1.00 cm in the 18th week of age

The Crown-rump length and Height at witheralso showed increase. The CRL increased from 31.67±0.55 in the 4th week to 47.00±1.73 cm in the 18th weeks, while the HAW

increased from 24.00±0.82 in the 4th week to 30.33±1.19 to 34.67±0.27cm in the 13th to 14th weeks of age and continue to increased thereafter to the 18th week.

CORRELATION REGRESSION MODELS

r is the correlation relationship between the two variables. Values range between -1, 0, +1. The closer the value is to either -1 or +1 the stronger the relationship.
The –ve sign means the variables exist in an inverse relationship, while the +ve sign means the variables exist in a direct relationship.

$\mathbf{R^2}$is the certainty of locating values along the slope of the model.

1. **AGE OF BUCK AND BIRTH WEIGHT**

The correlation of the age of buck and birth weight showed a correlation coefficient ***r*** of +0.754, indicating a high degree of correlation and a positive relationship between these parameters. The regression model generated was statistically significant at P<0.01 with the following model:

$$AGE = 345.344BW - 304.817,\ R^2 = 0.568,\ F(1,7) = 9.198,\ p<0.05$$

2. **AGE OF BUCK AND BODY WEIGHT**

The correlation of the age of buck and body weight showed a correlation coefficient ***r*** of +0.957, indicating a high degree of correlation and a positive relationship between these parameters. The regression model generated was statistically significant at P<0.01 with the following model:

$$AGE = 23.753BW - 6.785,\ R^2 = 0.917,\ F(1,7) = 77.044,\ p<0.01$$

3. **AGE OF BUCK AND CROWN RUMP LENGTH**

The correlation of the age of buck and crown rump length showed a correlation coefficient ***r*** of +0.904, indicating a high degree of correlation and a positive relationship between

these parameters. The regression model generated was statistically significant at P<0.01 with the following model:

$$AGE = 7.169\text{CRL} - 201.739,\ R^2 = 0.816,\ F(1,7) = 31.116,\ p<0.01$$

AGE OF BUCK AND HEIGHT AT WITHERS

The correlation of the age of buck and height at withers showed a correlation coefficient ***r*** of +0.906, indicating a high degree of correlation and a positive relationship between these parameters. The regression model generated was statistically significant at P<0.01 with the following model:

$$AGE = 3.790HAW - 27.052,\ R^2 = 0.821,\ F(1,7) = 32.182,\ p<0.01$$

AGE OF BUCK AND SCROTAL LENGTH

The correlation of the age of buck and scrotal length showed a correlation coefficient ***r*** of +0.917, indicating a high degree of correlation and a positive relationship between these parameters. The regression model generated was statistically significant at P<0.01 with the following model:

$$AGE = 22.636\text{SL} - 2.020,\ R^2 = 0.841,\ F(1,7) = 37.094,\ p<0.01$$

TABLE 4.1.1 BIOMETRY DATA AND TESTOSTERONE VALUES

Age(Wks)	MbwGR(%)	Mean No Castrated	Balance	HAW	CRL	SL	SC	TW
1	1.20±**0.09**							
4	**1.80±0.09**	**50.00**	**45**	**624.00±0.82[a]**	**31.67±0.55[a]**	**2.23±0.12**	**5.17±0.17**	**2.40±0.04[a]**
8	**2.53±0.18**	**40.56**	**164**	**026.33±0.50[a]**	**36.00±0.82[a]**	**3.13±0.10**	**6.07±0.06**	**5.80±0.12[a]**
12	**3.73±0.15**	**47.43**	**162**	**425.33±0.72[a]**	**43.00±1.25[b]**	**3.33±0.08**	**6.60±0.06**	**11.34±0.03[b]**
13	**4.67±1.21**	**25.20**	**4 2**	**030.33±1.19[a]**	**44.67±0.98[b]**	**5.00±0.09**	**8.33±0.27**	**15.00±0.10[b]**
14	**5.53±0.07**	**18.42**	**416**	**34.67±0.27[b]**	**45.33±0.60[b]**	**6.10±0.08**	**9.67±0.36**	**18.50±0.14[b]**
15	**5.83±0.14**	**5.43**	**412**	**35.33±0.55[b]**	**46.67±0.72[b]**	**6.27±0.41**	**11.77±0.19**	**21.60±0.10[c]**
16	**6.33±0.17**	**8.58**	**484**	**2.33±2.33[b]**	**47.33±0.27[b]**	**6.97±0.12**	**13.83±1.17**	**23.00±0.00[c]**
17	**6.24±0.11**	**-1.42**	**445**	**1.11±1.30[c]**	**47.73±0.45[b]**	**6.78±0.16**	**13.78±1.33**	**24.50±0.09**
18	**7.00±0.21**	**12.18**	**4-5**	**2.32±0.80[c]**	**47.00±1.73[b]**	**7.11±0.22**	**14.12±1.00**	**25.00±0.18[c]**

Key:

wks= weeks. Mbw = Mean Body weight (Kg). MGR= Mean growth rate (kg). TW = Testicular Weight
HAW= Heght at Wither.. CRL= Crown-Rump length. SL= Scrotal length. SC= Scrotal Circumference. TW= Testicular weight,

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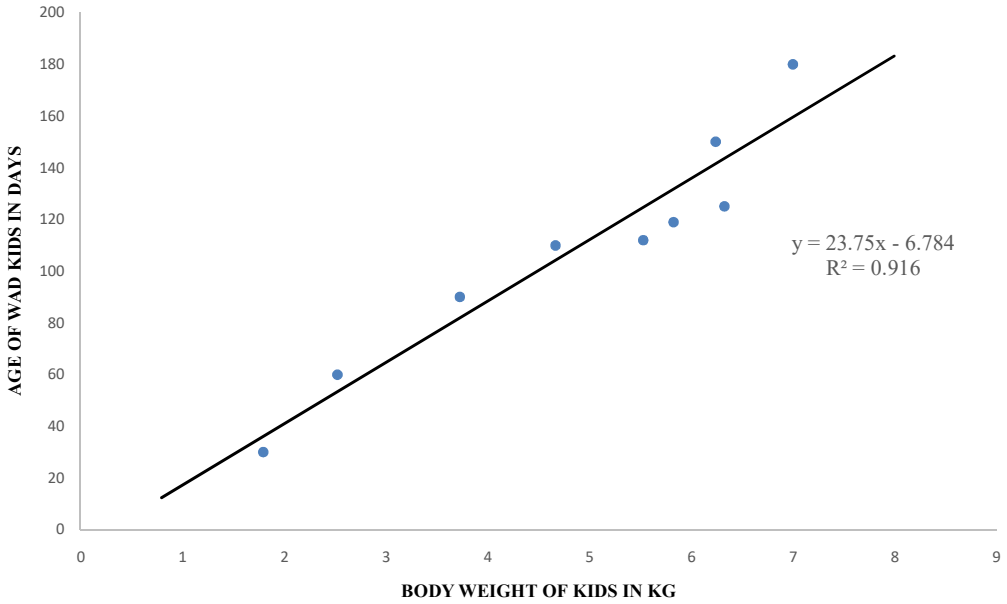


Figure 4.1.1: Correlation of Age and Body Weight of WAD kids

$AGE = 23.753BW - 6.785,\ r = +0.957,\ R^2 = 0.917,\ F(1,7) = 77.044,\ p<0.01$

33

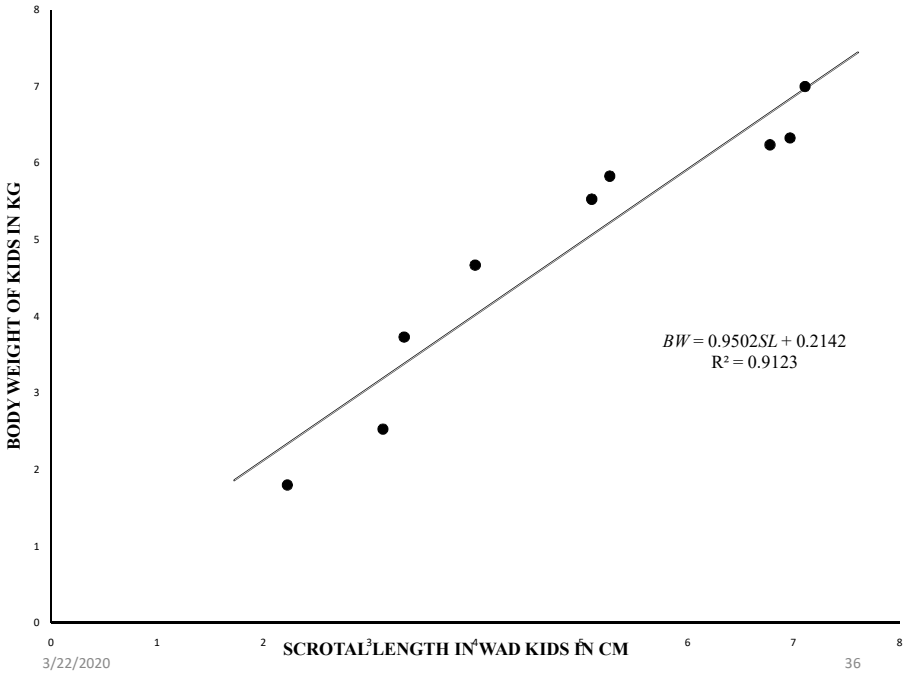


Figure 4.1.2 Body Weight and Scrotal Length in WAD kids

$BW = 0.95SL + 0.214$, $r = +0.955$, $R^2 = 0.912$, $F(1,7) = 72.814$, $p<0.01$

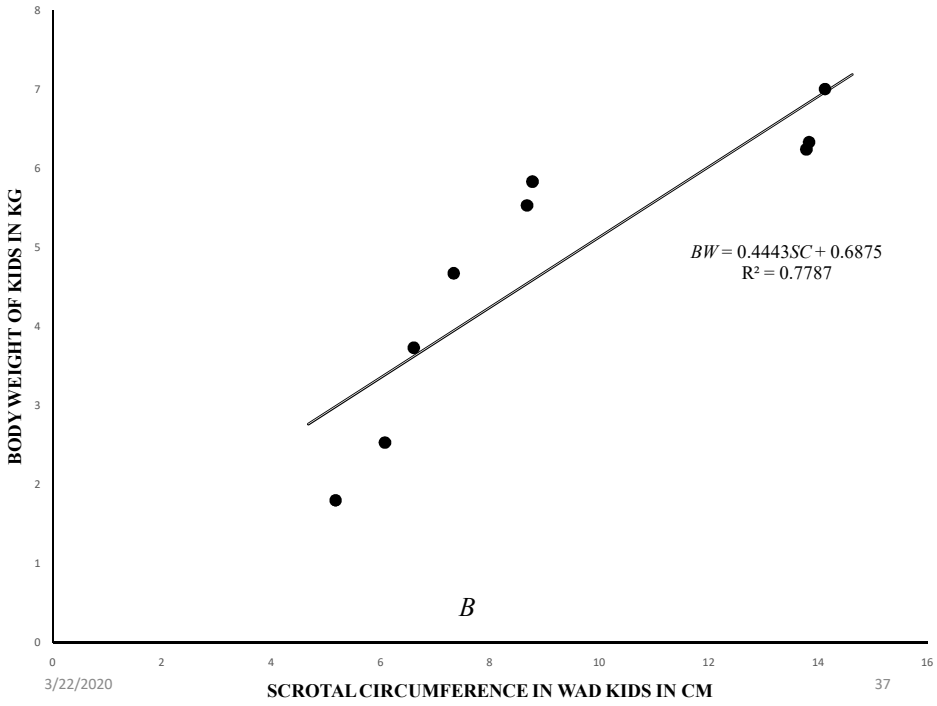


Figure 4.1.3 Body Weight and Scrotal Circumference in WAD kids

$W = 0.444SC + 0.688$, $r = +0.882$, $R^2 = 0.779$, $F(1,7) = 24.635$, $p<0.01$

SECTION TWO

4.2.0 Determinationof the time of first appearance of matured spermatozoa in the cauda epididymis and testosterone production in male WAD Kids

EPIDIDYMAL SPERM ANALYSIS

4.2.1Appearance of matured spermatozoa in the cauda epididymis

The results of this study are as presented in Tables 4.2.1, and 4.2.3and Plates 4.2.1.1 to 4.2.1.5 showingthe semen analysis, morphology, spermatozoa counts and the Testosterone production values of the male kids from four to eighteen weeks post kidding.The relationship between the age of the kids and testicular weight, from the 4th week (2.40±0.04 gm) to 13th to 14th weeks(15.00±0.10 to 18.50±0.14 gm) and thereafter which showed an increase in the weight of the testis as the kids advanced in age.

The mass activities was nil in the 4th to 12th week but became evident from 13th to 14th weeks with mass activity score + and 80% motility and increased thereafter. Spermatozoa motility was nil (4th- 12^{th}weeks), 80% (13^{th} to 14th weeks) and remained constant thereafter. The total spermatozoa count increased from 495 to 515 (4.95-5.15x10^{8}cells/ml) in the 13th to 14th weeks. Normal spermatozoa were nil (4th -13th weeks) became 97.58% in 14th week and decline thereafter. Abnormal spermatozoa were nil (4th -13th) weeks, became 2.42 to 6.17% in the 14th week and decreased from there to 4.73%. Plates 4.2.1.1 to 4.2.1.5 showed the morphology of the spermatozoa as observed under the microscope (x100 magnification) using Wells and Awa stain and Eosin-Nigrosine.

Table 4.2.1: **Semen Evaluation and Quality of the WAD goat bucks**

AGE (wks)	Mass activity	%Motility	HT	TH	BT	CT	CMP	NHRT	DH	SH	Total count	%Normal	%Abnormal
4	-	-	-	-	-	-	-	-	-	-	-	-	-
8	--	-	-	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	-	-	-	-
14	+	80	3	6	-	-	-	2	-	-	1	495	97.58	2.42
15	2+	80	4	5	-	1	-	3	1	-	-	502	97.22	2.70
16	3+	80	6	5	1	-	2	-	-	-	2	515	96.90	3.10
17	3+	80	12	7	-	-	-	2	-	-	4	405	93.83	6.17
18	3+	80	8	9	2	-	1	-	-	-	3	465	95.27	4.73

Means with different superscript within rows are statistically significant ($P<0.05$)

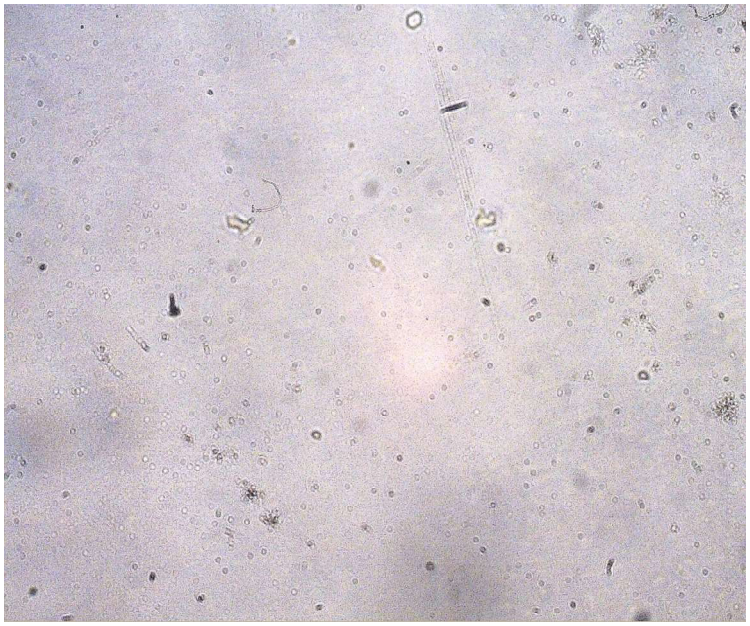
KEY:

- =No spermatozoa

+ = ejaculate with spermatozoa score

HT= Headless Tail, TH= Tailless Head, BT= Bent Tail, CT= Coiled Tail, CMP= Curved Mid Piece, NH= Narrow Head, RT=Rudimentary Tail, DH= Double Head, SH= Small Head,

4.2.1.0 Semen Analysis of the castrated WAD kids



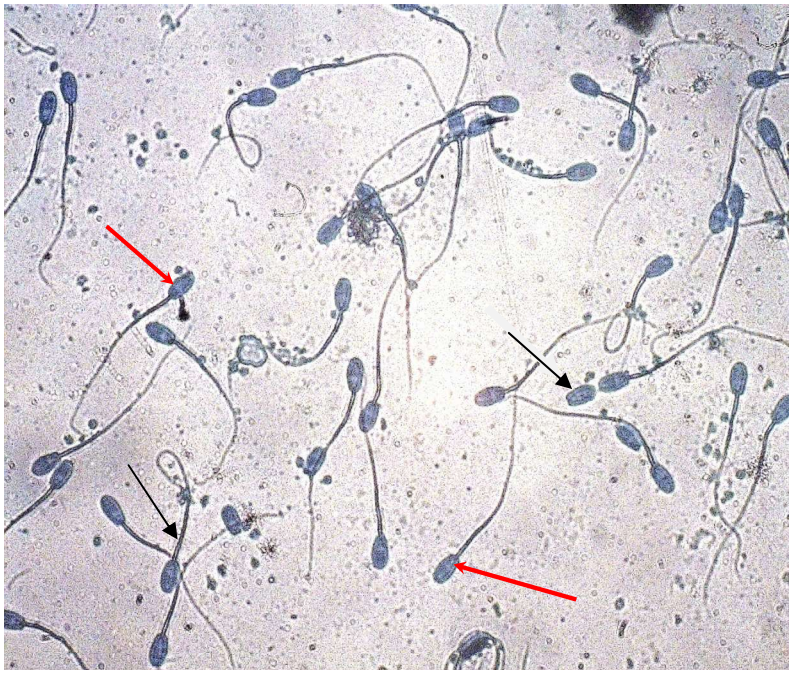
50

Plate 4.2.1.1 Slide with no evidence of spermatozoon (4-13wks)

showing artifacts

Stain: Eosin-nigrosin

Magnification: X100



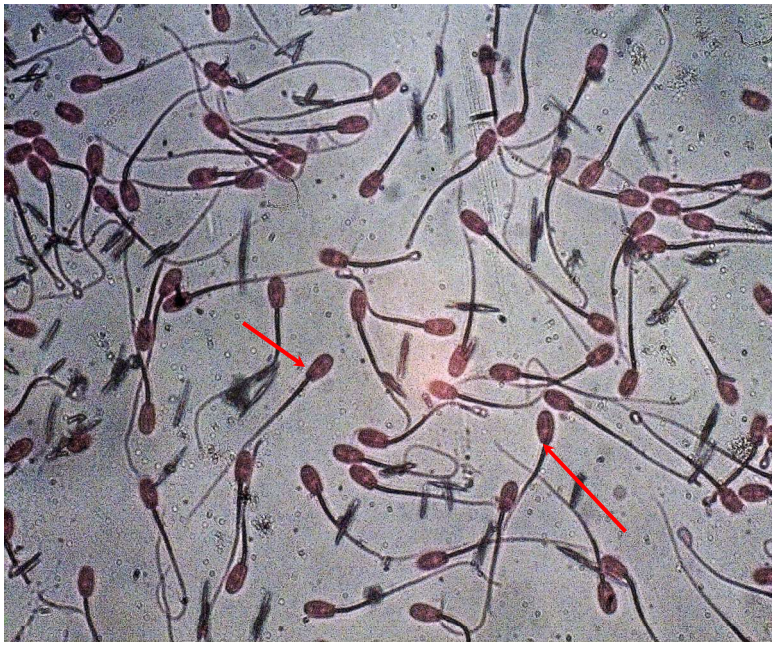
* 51

Plate 4.2.1.2 Slide showing spermatozoa at 14 wks (Normal cell-Red arrows;

Abnormal cells (black arrows).

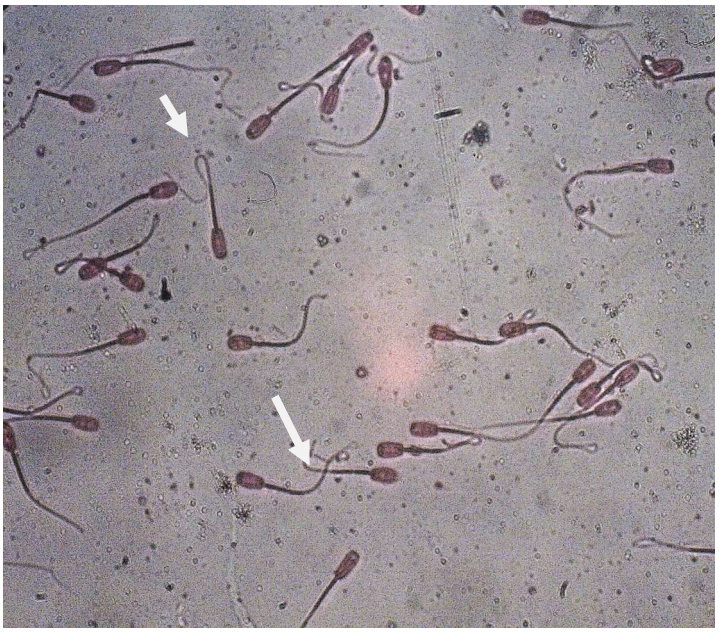
Stain: Wells and Awa

Magnification: X100



* 52

Plate 4.2.1.3 Slide showing spermatozoa at 15 weeks (Normal cell-Red arrows)
Stain: Wells and Awa
Magnification: X100



* 53

Plate 4.2.1.4. Slide showing spermatozoa at 16 wks (Abnormal cell- arrowed)
Stain: Wells and Awa
Magnification: X100

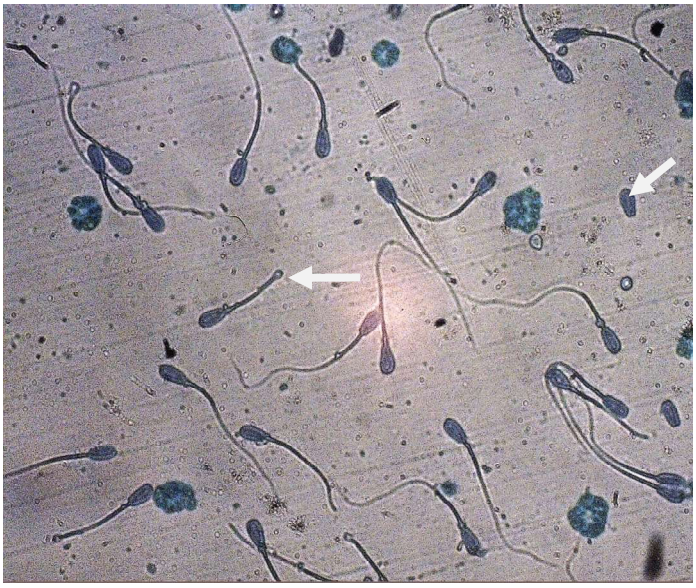


Plate 4.2.1.5. Slide showing spermatozoaat 17-18 wks (Abnormal cell-arrowed)
Stain: Wells and Awa
Magnification: X100

4.2.2 Histomorphometry of the seminiferous tubules of Testis of the WAD goat(µm).

BUCKS

AGE (wks)	Lumina Diameter	Germinal Epith.Height	Ductal diameter
4	20.79±0.70[a]	3.70±0.39[a]	16.68±0.50[a]
8	19.24±0.91[a]	5.12±0.83[a]	10.55±0.88[b]
12	23.41±1.42[a]	6.17±0.32[c]	6.31±0.12[c]
13	32.73±0.44[a]	6.25±0.25[c]	68.52±12.35[c]
14	78.59±9.18[b]	6.61±0.91	102.14±23.76[a]
15	78.70±1.05[b]	9.21±0.18[b]	104.55±0.39[b]
16	87.64±0.71[b]	8.84±0.39[b]	110.80±1.59[d]
17	93.89±0.77[a]	10.78±0.74[a]	112.16±0.95[a]
18	95.67±1.02[a]	13.32±0.69[a]	115.45±0.78[a]

Means with different superscripts across columns are stastistically significant (P<0.05)

4.2.3 Hormone analysis

The Serum testosterone values gradually increased from the 4th week (3.20±10ng/ml) fluctuated in the 8th week and significantly increased between 12th (6.12 ± 0.15ng/ml), and 13th week (10.20 ±0.68 ng/mL) then peaked at the 14th week of age to 11.25±1.75 ng/mL, thus indicating a lower production in the early age of the kids, increase to peak at 14th weeks, butdeclined thereafter.

Table 4.2.3 Testosterone production Values

Age(wks)	Testosterone level (T4ng/ml)
4	3.20±0.10
8	2.20±0.30
12	6.12±0.15
13	10.20±0.68
14	11.25±1.75
15	8.70±1.70
16	9.00±0.30

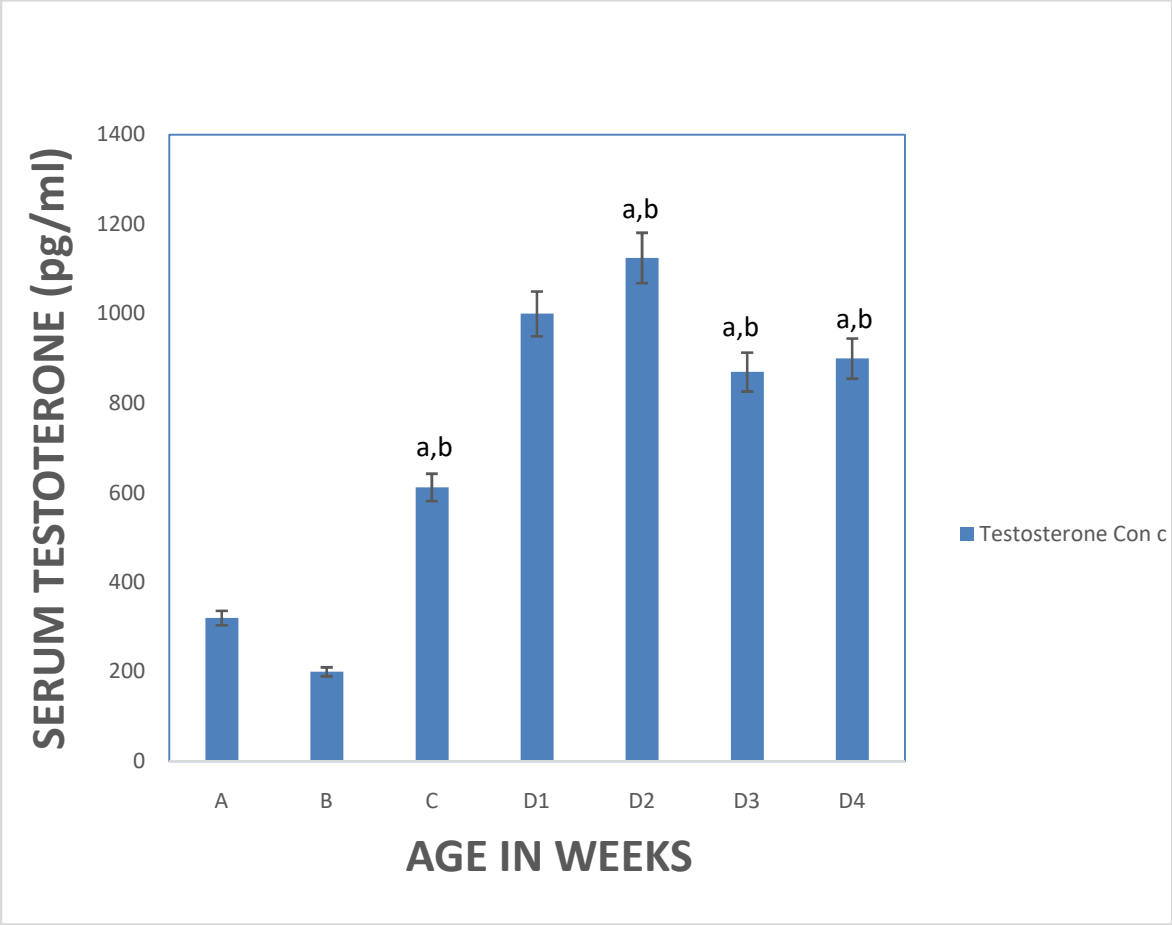


Figure 4.2.2.1 Serum Testosterone and Age of the kids from four to sixteen weeks post kidding

Data expressed as Mean ± SEMn=5

[a]p<0.05 (When compared with Age Group A)

[b]p<0.05 (When compared with Age Group B)

Keys:

A =4 weeks post kidding D3 = 15 weeks post kidding

B =8 weeks post kidding D4 = 16 weeks post kidding

C = 12 weeks post kidding

D1 = 13 weeks post kidding

D2 = 14weeks post kidding

SECTION THREE

4.3 Histological evaluation of the testis and epididymis

The histology of the Epididymis and the Testis of the kids were examined together with the histomorphometry of the seminiferous tubules (STs). It was observed that at the early age of the kids 4 to 13 weeks the ducts of the epididymis and the testis (Plates 4.3.1a and 4.3.1b arrowed) appear normal in morphology and do not contain spermatozoa, while the ducts from 14 weeks in Plates (4.3.1c to 4.3.1d and 4.3.2c to 4.3.2d) for the epididymis and the testis respectively, are large and contain copious amounts of spermatozoa. The appearance of the ducts of the epididymis and Seminiferous tubules in 13 weeks (Plates 4.3.1a and 4.3.1b and 4.3.2a and 4.3.2b) showed ducts with normal morphology without spermatozoa and theSertoli cells without discernible lumen and evidence of spermatogenesis. Whilefrom 14 weeks (plates 4.3.1 c to 4.3.1d and 4.3.2c to 4.3.2d),there weremoderate amounts of spermatogenic cells in the testis showing evidence of spermatogenesis,The ducts of the epididymis are also large and contain copious amount of spermatozoa.

The histomorphometry of the testis from four to eighteen weeks of age of the kids showed gradual increase in the Seminiferous tubules (ST) diameter (TD), germinal epithelial height, and the ST luminal diameter (LD), with significant increase ($p<0.05$) in diameter at14 weeks and 15 weeks (Table 4.2.2) there was no significant difference thereafter.

4.3.1.Histology of the epididymis of WAD kids

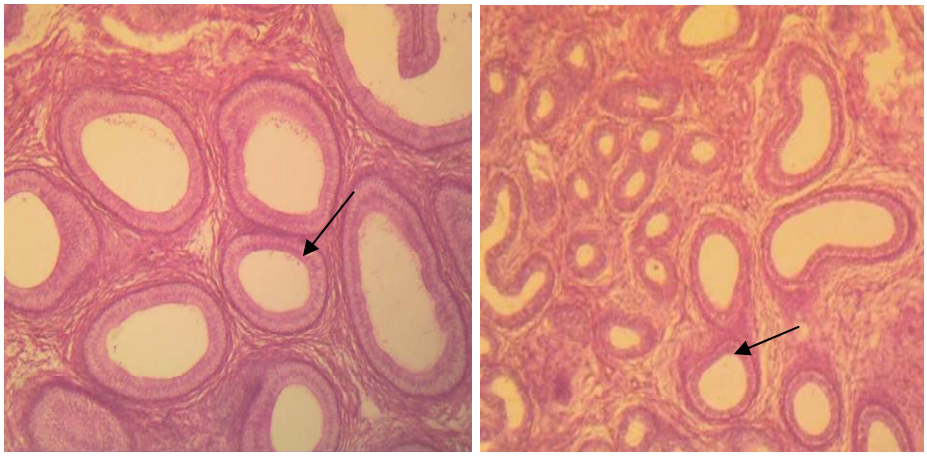


Plate 4.3.1a: Histology of the epididymis of WAD goat (at 4 and 8 weeks post kidding)

The ducts (arrowed) are variably-sized without clear evidence of spermatozoa(at 4 and 8weeks post kidding)

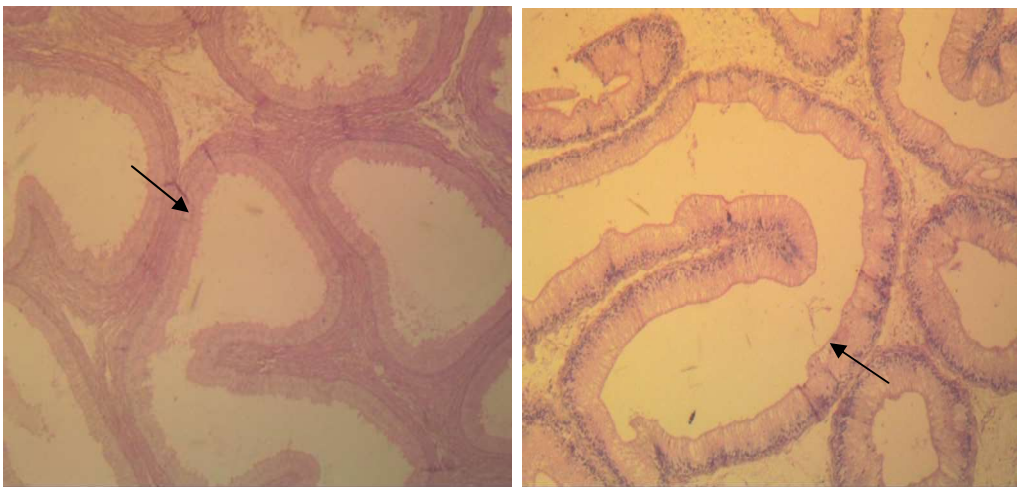


Plate 4.3.1b:Histology of the epididymis of WAD goat (12 and 13 weeks post kidding)

The ducts of the epididymis (arrowed) appear normal in morphology without clear evidence of spermatozoa at 12 and 13 weeks post kidding

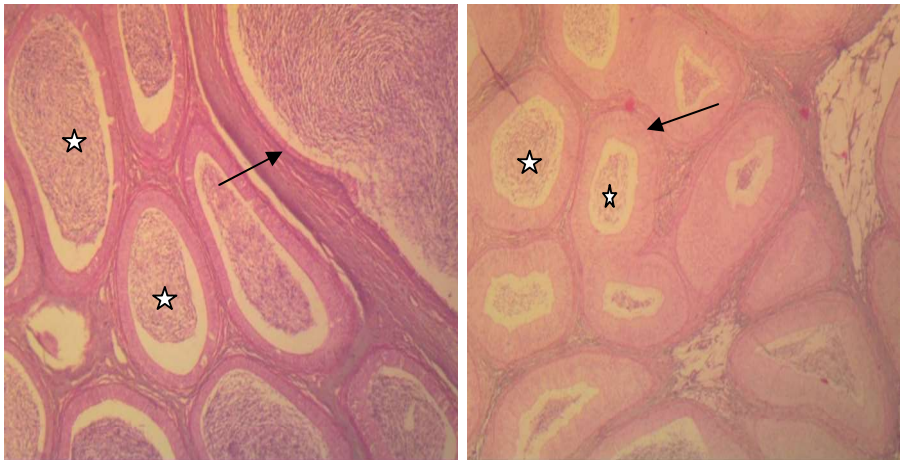


Plate 4.3.1c:Histology of the epididymis of WAD goat (14 and 15 weeks post kidding)

The ducts (arrowed) are large and contain copious amounts of spermatozoa (starred)at 14 and 15 weeks postkidding.

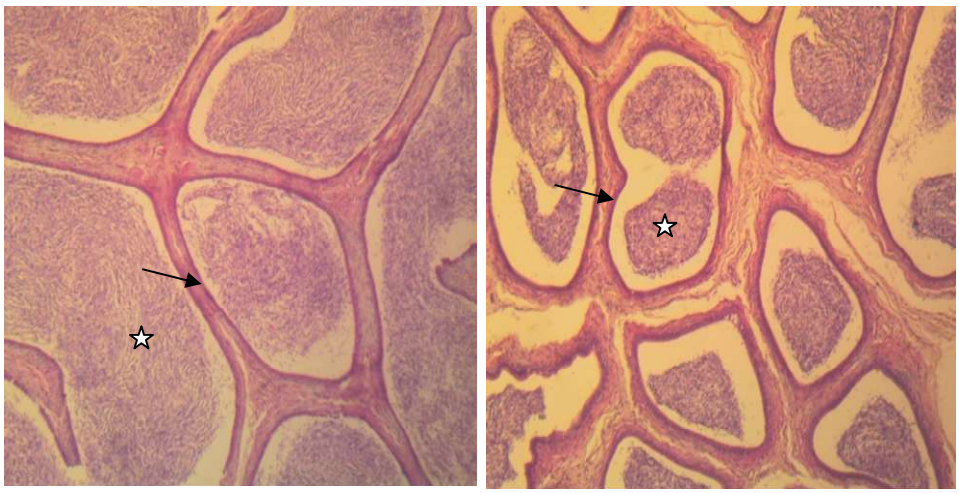


Plate 4.3.1d: Histology of the epididymis of WAD goat (16 to 18 weeks post kidding).

The ducts (arrowed) are large and contain copious amounts of spermatozoa (Star).

4.3.2 Histology of the testes of WAD kids

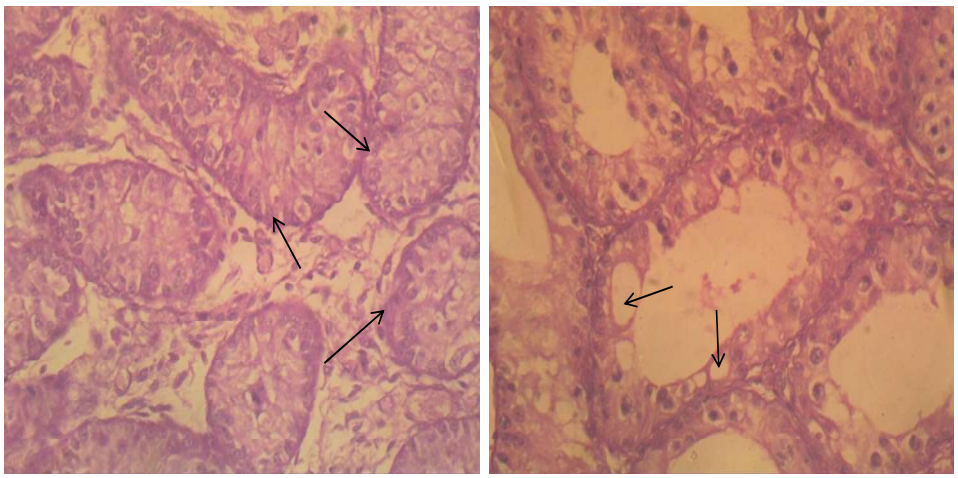


Plate 4.3.2aHistology of the testes of WAD goat (4 and 8 weeks post kidding)

Magnification: Left 100x, Right 400x

The STs are lined by mostly Sertoli cells (arrows). No discernible lumen. No clear evidence of spermatogenesis at 4 and 8 weeks post kidding

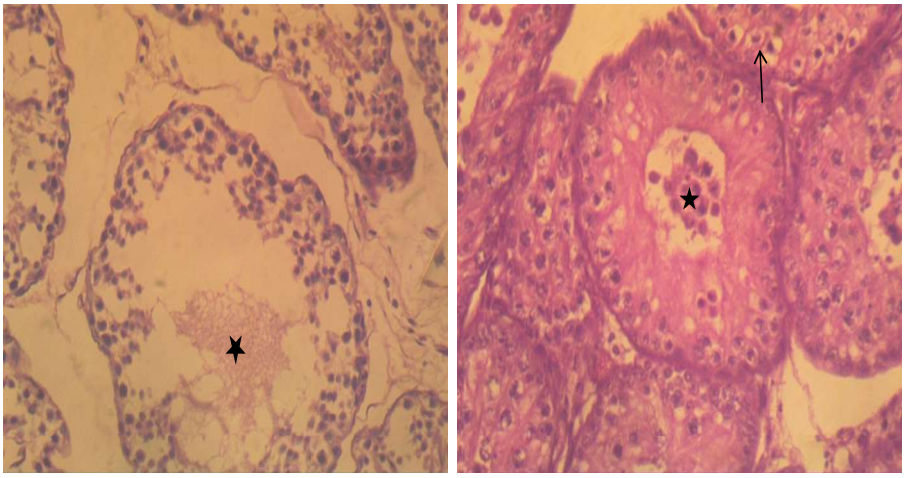


Plate 4.3.2b:Histology of the testes of WAD goat (12 and 13 weeks post kidding)

Magnification: Left 100x, Right 400x

The STs have irregular outlines and contain depleted amounts of spermatogenic cells. Few/depleted spermatocytes are present with residual bodies (star) in the lumen at 12 weeks post kidding.

At 13 weeks there are numerous small STs lined by mostly Sertoli cells (arrows) and a few spermatogonia. There is defoliation of cells into the newly budding lumens - canal (star).

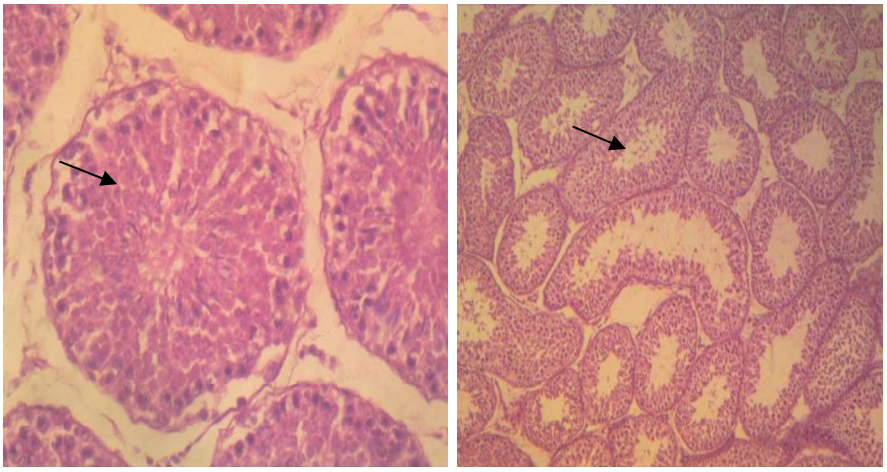


Plate 4.3.2cHistology of the testes of WAD goat (14 and 15 weeks post kidding)

Magnification: 400x

There are numerous closely-packed regular STs with moderate amounts of spermatogenic cells (arrowed). Spermatocytes predominate with evidence of spermatogenesis at 14 and 15 weeks post kidding.

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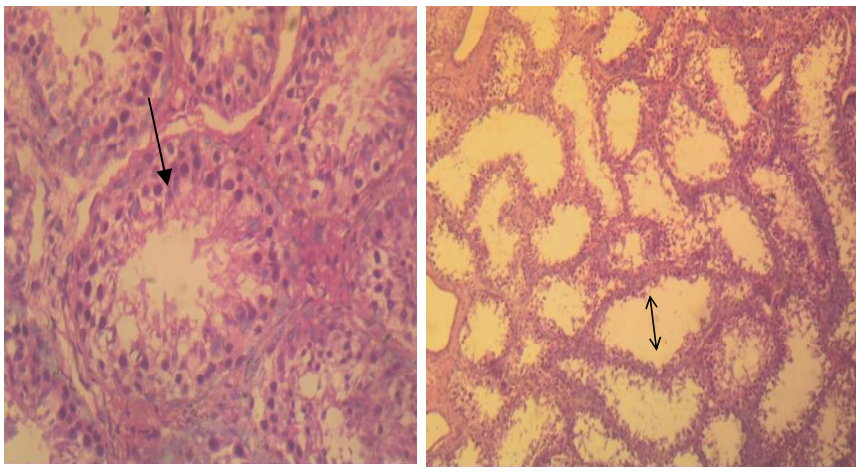

Plate 4.3.2d:Histology of the testes of WAD goat (16 to 18 weeks post kidding)

Magnification:: Left 100x, Right 400x

There are numerous closely-packed regular STs with moderate amounts of spermatogenic cells (arrowed). Spermatocytes predominate with evidence of spermatogenesis, there is marked depletion of the spermatogenic cells, thus giving the STs a widened lumen (arrowed)

CHAPTER FIVE

5.1 Discussion

Growth in animals can be divided into the pre-weaning average daily gain (ADG) and post-weaning average daily gain (Slippers *et al*., 2000). It has been observed that birth weight accounts for over 70% of the variability in survival of offspring in livestock to weaning (Anon, 2017). A high pre-weaning ADG is a reflection of the genetic potential of the kid, birth weight and mothering ability of the doe. In this study, the average birth weight of 1.20±0.09kg was observed. Lu and Potcoiba., (1988) had earlier observed birth weight of between 3 to 4.0kg in Boer kids, the difference could be due to breed, because Boer goats are large European dairy breeds (Warmington and Kirton, 1990). However, it is known that birth weight and the growth of kids are mostly under the influence of breed (Mourad, 1993), feeding (Haddad, 2005), sex (Kuchtik and Sedlackova, 2005) type of birth (Zhang *et al*., 2009) and season (Jimenez-badillo *et al*., 2009).

The birth weight and body weight showed a positive correlation (+0.754 and +0.957) with age. Earlier work by Tuah *et al.* (1989) with WAD goat in Ghana, observed pre-weaning growth rate between of 0.331 and 0.396kg, which is comparable with observation inthe kids at 14 to 15 weeks in this study.

In this study the average weekly weight gain of the kids was determined as the difference between the weights of kids from one week to another divided by the period (weeks). This increased progressively from birth, with appreciable increase at the twelfth week, but decreased thereafter. This may be due to physiological changes of the body in preparation for sexual maturity (Jeremy *et al*., 2002). This result is similar tofinding byCampbell, (1977) whoobservedaverage growth rates of male Boar goats (a bigger and exotic breed) of 291, 272, 245, and 250 g/day from birth to 100, 150, 210, and 270 days of age respectively. Eloy and Santa Rosa., (1998) had earlier observed that Saanen bucks can come into puberty and breed does as early as four months (16 weeks) of age, but equally

opined that waiting until it is a year old tofully attain sexual maturity before start using him for breeding is best.

In this study there was a positive correlation (r) and strong relationship between the SL and SC and the age of male WAD kids, with the SL significantly stronger +0.917 ($P<0.05$).This suggests that SL could be a better determinant of age at puberty in male WAD kids. This agrees with the earlier studyon Red Sokoto goat that showed testicular length and circumference are significantly correlated with body weight (Ashwood, 2009), testicular weight and sperm reserve (Marire *et al*., 1991). Bratte *et al*. (1999) and Ashwood, (2009) concluded that testicular length and circumference are indicators of breeding soundness in animals. The findings in this study agree with these reports.Trejo *et al.* (1988), in young Saanen and British Alpine goats have further observed a close relationship between body weight, SC and testosterone concentration, which peaked at sexual maturity. The finding in this study is indicative of begining of onset of reproductive process (onset of puberty).

The present study has also showed a positive correlations (+0.904, and+0.906) between the CRL and HAW with age. This finding indicates that linear body measurements increase with age and agrees with earlier report (Ashwood, 2009).Information in male WAD goat in this respect is scarce, however works have been carried out on fetal measurement of Crown-Rump Length (CRL) and Height at Withers (HAW) by Waziri *et al.* (2012) in Sahel goat.

Testicular parameters including testicular weight (TW) are important factors in assessing sexual maturity in animals. They indicate the level of sexual activity, semen production and the changes in the daily sperm production potential (Leal *etal*., 2004).The finding in this study, confirms a relationship, between the testicular weight increases, and semen quality. This is expected though, within reasonable limit, since normal increase in testicular weight suggests more testicular tissue indicating enhanced testicular functions including spermatogenesis (Melo *et al*., 2010).For instance in this study, kids (4 to 12 weeks) with low testicular weight (2.40±0.04 to 11.34±0.65gm) had no clear evidence of spermatozoa (azoospermia) in the cauda epididymis. From 14 weeks however, mass activity and motility could be scored with semen milked from the cauda epididymis..

The observation in this report showed a lower age at sexual maturity to when compared to values byRaji.(2016). who studied male WAD goat under extensive management. The difference could be due to birth weight of the kids, plane of nutrition, management and the environment.

Observation in this study further show that as the total spermatozoa count increases from age 14 to 18 weeks, the abnormal sperm cells increase and the proportion of normal cells decreases. The increase in abnormal sperm cells at this stage may indicate infertility in the buckand therefore may not serve breeding purpose, as earlier observed by Eloy and Santa Rosa., (1998) in buck at 4 months and opinedthat the buck be allowed to attain 1 year of age before it is use for breeding. Ball and Peter.,(2004) suggest that increase abnormal sperm cells may be due to increase in tissue metabolism, exposure to toxic metabolites and increased rate of spermatogenesis occurring at this stage.

Also in this study the production of testosterone increased gradually but declined at 8 (2.20±0.30) week, and increased significantly between 12 (6.12±0.15) and 13 (10.20±0.68) week then peaked at 14 weeks (11.25±1.75 πg/ml)but thereafter declined till week 18.

Earlier work done by Katongole and Gombe, (1985)onadult indigenous goats in Uganda recorded a range of 500and 1,200pcg/ml (5.00 and 12.00 πg/ml). This agreed with findings in kids that were between 12 and 14 weeks in this study, suggesting that male kids within this age range has reached the beginning of reproductive process (onset of puberty)..

Some fluctuations in testosterone level also occurred with age. These were prominent before and after 14 weeks and they may be due to Leydig cell regulation of the seminiferous tubules preparatory to spermatogenesis (Ball and Peters, 2004) and other conditions such as plane of nutrition, environmental condition etc. Similar observation was recorded by Jeremy *et al*. (2002) in Cynomolgus macaques (*Macaca fascicularis)* thatfluctuation in testosterone production often occurs during the peripubertal period.It has also been associated with episodic release of LH from the pituitary in adult male ram and bull (Katongole *et al*., 1974), as a result of increased seminiferous tubules size and

proliferation of germ cells characterizing spermatogenesis occurring at this stage (Melo *et al*., 2010).

The histology of the epididymis and testis in this study showed a gradual development of the ducts and seminiferous tubules from 4 weeks having no spermatozoa to 14 weeks when spermatozoa appeared.Histomorphometry showed a similar pattern in STs of the testis with respect to lumina diameter, germinal epithelial height, and ductal diameter. The peak in ST lumina diameter and the ductal diameter at 14 weeks appears to be in preparation for spermatogenic activity occurring at this stage. The current observation with testicular histomorphometry seems to be in agreement with the finding with testosterone values in this study which may have stimulated proliferation of germ cells, thereby initiating onset of sexual maturity (Melo *et al.*, 2010). Kamal and Devi., (2017) and Raji., (2016) observed a significant increase in diameter in the 4 and 6 months (16 and 24 weeks) old male Assam and WAD goats respectively, but the present finding showed earlier onset of puberty in male WAD kids. However factors such as birth weight, breed, management, nutrition or environment (Haddad, (2005) could be responsible for these differences.

5.2 Conclusion

Marked changes in somatic parameters, testosterone concentration, epididymal semen characteristics, testicular and epididymal histology were indicative of the onset of reproductive process which occurred between weeks 13 and 14 post-kidding in West African Dwarf bucks raised under intensive management. This period may therefore be recommended as the earliest time for harvesting of semen for breeding purposes.

Contributions to Knowledge

This study has been able to contribute to the body of scientific knowledge in the following areas:

The study has confirmed that:

1. The initiation of sexual maturity, defined as the presence of mature and viable spermatozoa in the caudal epididymis at between 13 and 14 weeks post kidding in male WAD goats intensively raised.

2. The lumina diameter of the seminiferous tubule and ductal diameter of epididymis, as correlates of sexual maturity to have increased from 32.73±0.44 to 78.59±9.18 µm and 68.52±12.35 to 102.14±23.76 µm, respectively at 13 to 14 weeks post kidding in male WAD goat intensively raised are clear indicators of the physiological parameters controlling onset of reproductive functions in bucks.

3. The study has confirmed that testosterone profile is correlate of sexual maturity, of between 10.02±0.68 πg/ml and 11.25±1,75 πg/ml during the 13 to 14 weeks post kidding in male WAD goats intensively raised.

Recommendation

At the ages of 13 to 14 weeks post kidding WAD buck could be used for mating. At this age the livestock farmers should separate the buck from the mother doe, and the female siblings early after weaning to avoid inbreeding in the herd.

The body weight of 5.53±0.07 kg, scrotal length 6.10±0.08 cm, testosterone production 11.25±1.75 πg/ml, as observed in this study could be use as determinants for selection of sexually matured buck to get maximum breeding result.

Livestock farmers can as from now be better advised about the time their buck could economically be put into productive use on their farm.

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APPENDICES

Appendix 1

Semen Analysis from the castrated testis of WAD kid

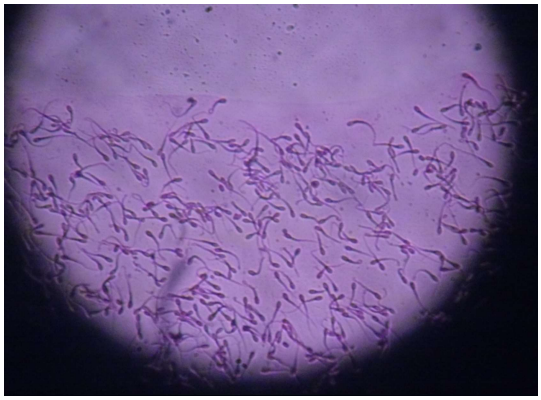

Plate. Showing the Morphology of D2 Group (14 weeks) Spermatozoa (Wells and Awa Stain-WAS)

Semen Analysis from the castrated testis of WAD kid

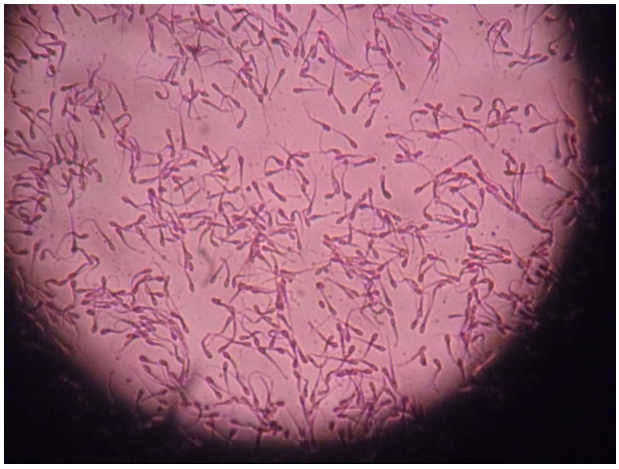

Plate. Showing the Live/dead ratio of D2 group (weeks) Spermatozoa (Eosin- Nigrosin Stain-ENS)

Appendix 2

TABLES:- SHOWING THE WEEKLY WEIGHT AND BODY MEASUREMENT.

2.1 WEEK 1:

Groups (n=4)	Weight (kg)	CR (cm)	HAW (cm)	SL (cm)	SC (cm)
A	0.63±0.43	0.83±0.17	2.67±0.33	0.17±0.17	0.33±0.17
B	0.17±O.17	0.00±0.00	0.70±0.07	0.33±0.17	0.43±0.07
C	0.17±0.07	1.67±0.33	0.00±0.00	0.13±0.13	0.00±0.00
D1	0.17±0.03	1.67±0.33	0.17±0.17	0.00±0.00	0.00±0.00
D2	0.20±0.00	0.33±0.33	1.00±1.00	0.00±0.00	0.33±0.17
D3	0.10±0.00	2.00±0.00	0.67±0.33	0.00±0.00	0.33±0.17
D4	0.00±0.00	1.67±0.33	1.67±0.33	0.23±0.19	2.33±1.45

2. 2: WEEK 2

Groups **(n=4)**	**Weight (kg)**	**CR (cm)**	**HAW (cm)**	**SL (cm)**	**SC (cm)**
A	0.23±0.07	1.67±0.33	1.33±0.33	0.47±0.27	0.13±0.03
B	0.07±0.03	1.67±0.33	1.33±0.67	0.33±0.16	1.33±0.17
C	0.17±0.03	1.67±0.33	0.07±0.07	0.00±0.00	0.40±0.10
D1	0.17±0.03	2.00±0.00	0.67±0.67	0.17±0.17	0.83±0.33
D2	0.47±0.27	1.33±0.33	0.33±0.33	0.23±0.15	0.50±0.26
D3	0.10±0.10	1.33±0.33	1.67±0.33	0.40±0.10	0.20±0.10
D4	0.10±0.06	1.33±0.33	0.67±0.33	0.17±0.17	0.17±0.12

2 3: WEEK 3

Groups (n=4)	Weight (kg)	CR (cm)	HAW (cm)	SL (cm)	SC (cm)
A	0.37±0.07	1.33±0.33	0.00±1.00	0.13±0.03	0.33±0.07
B	0.23±0.07	1.67±0.33	0.07±0.07	0.67±0.67	0.33±0.33
C	0.27±0.03	1.67±0.33	1.33±0.33	0.67±0.17	0.17±0.17
D1	0.27±0.03	1.67±0.33	1.00±0.00	0.43±0.07	0.03±0.03
D2	0.23±0.07	1.33±0.33	0.33±0.33	0.03±0.03	0.13±0.13
D3	0.23±0.03	1.67±0.33	0.33±0.67	0.17±0.03	0.27±0.13
D4	0.17±0.03	1.67±0.33	1.00±0.00	0.00±0.00	0.47±0.29

2. 4: WEEK 4

Groups (n=4)	Weight (kg)	CR (cm)	HAW (cm)	SL (cm)	SC (cm)
A	0.27±0.07	0.17±0.17	2.00±0.00	0.23±0.13	0.07±0.07
B	0.27±0.37	2.67±0.33	0.00±0.00	0.30±0.10	0.43±0.07
C	0.30±0.10	1.67±0.33	2.00±0.00	0.33±0.33	0.67±0.17
D1	0.17±0.03	1.67±0.33	1.67±0.33	0.33±0.33	0.40±0.10
D2	0.17±0.03	1.00±1.00	0.67±0.67	0.03±0.03	0.00±0.00
D3	0.20±0.00	1.33±0.66	2.00±0.00	0.17±0.03	0.03±0.03
D4	0.20±0.00	1.33±0.66	1.67±0.33	0.17±0.17	0.17±0.17

2. 5: WEEK 5

Groups (n=4)	Weight (kg)	CR (cm)	HAW (cm)	SL (cm)	SC (cm)
A	0.30±0.00	0.83±0.17	1.67±0.33	0.13±0.03	0.33±0.03
B	0.03±0.03	0.80±0.20	0.67±0.33	0.27±0.07	0.07±0.07
C	0.23±0.13	1.00±0.00	0.00±0.00	0.33±0.33	0.33±0.33
D1	0.10±0.00	0.83±0.17	0.17±0.17	0.33±0.33	0.07±0.07
D2	0.07±0.03	1.00±0.00	0.67±0.33	0.70±0.30	0.27±0.13
D3	0.23±0.03	1.67±0.33	0.67±0.67	0.17±0.03	0.00±0.00
D4	0.17±0.03	2.00±0.00	0.33±0.33	0.00±0.00	0.03±0.03

2. 6: WEEK 6

Groups (n=4)	Weight (kg)	CR (cm)	HAW (cm)	SL (cm)	SC (cm)
B	0.27±0.03	0.80±0.20	0.83±0.17	0.00±0.00	0.43±0.03
C	0.30±0.10	1.67±0.33	1.33±0.33	0.00±0.00	0.07±0.07
D1	0.17±0.03	1.50±0.50	1.33±0.33	0.33±0.33	0.33±0.33
D2	0.30±0.10	0.67±0.33	0.33±0.33	0.13±0.07	0.23±0.03
D3	0.17±0.03	0.67±0.67	0.33±0.33	0.27±0.13	0.20±0.10
D4	0.23±0.09	0.00	-0.33±0.33	0.00	0.53±0.24

2. 7: WEEK 7

Groups (n=4)	Weight (kg)	CR (cm)	HAW (cm)	SL (cm)	SC (cm)
B	0.23±0.07	2.33±0.67	1.33±0.33	0.00±0.00	0.33±0.33
C	0.20±0.00	1.00±0.00	0.10±0.10	0.67±0.17	0.50±0.00
D1	0.47±0.27	1.00±0.00	0.17±0.17	0.50±0.00	0.40±0.10
D2	0.23±0.03	1.00±0.00	0.00±0.00	0.17±0.17	0.43±0.03
D3	0.13±0.03	1.67±0.33	1.33±0.33	0.30±0.10	0.77±0.27
D4	0.20±0.06	1.33±0.67	1.00±0.00	0.67±0.67	0.33±0.09

2 8: WEEK 8

Groups (n=4)	Weight (kg)	CR (cm)	HAW (cm)	SL (cm)	SC (cm)
B	0.37±0.03	1.67±0.33	0.07±0.07	0.17±0.03	0.10±0.00
C	0.27±0.03	2.33±0.67	1.33±0.33	0.07±0.07	0.83±0.17
D1	0.53±0.23	2.67±0.33	1.33±0.33	0.17±0.17	0.83±0.17
D2	0.27±0.07	0.67±0.67	1.00±0.00	0.07±0.03	0.20±0.00
D3	0.23±0.03	0.00±0.00	1.33±0.33	0.07±0.03	0.13±0.07
D4	0.17±0.03	0.67±0.67	0.67±0.33	1.33±0.13	0.27±0.15

2. 9: WEEK 9

Groups (n=4)	Weight (kg)	CR (cm)	HAW (cm)	SL (cm)	SC (cm)
C	0.37±0.03	1.00±0.00	1.33±0.33	0.00±0.00	0.10±0.10
D1	0.20±0.00	1.00±0.00	0.83±0.16	0.07±0.07	0.03±0.03
D2	-1.03±0.67	1.00±0.00	1.00±0.00	0.20±0.00	0.37±0.07
D3	0.17±0.07	0.33±0.33	0.00±0.00	0.20±0.00	0.57±0.07
D4	0.17±0.03	0.33±0.33	0.00±0.00	0.70±0.30	0.50±0.40

2. 10: WEEK 10

Groups (n=4)	Weight (kg)	CR (cm)	HAW (cm)	SL (cm)	SC (cm)
C	0.20±0.00	3.00±0.00	0.33±0.33	0.00±0.00	0.07±0.07
D1	0.30±0.00	2.67±0.33	0.00±0.00	0.33±0.33	0.03±0.03
D2	1.53±0.57	0.67±0.33	0.00±0.00	0.20±0.00	0.30±0.00
D3	0.17±0.03	2.67±1.33	0.00±0.00	0.20±0.00	0.37±0.07
D4	0.27±0.03	2.67±1.33	0.67±0.33	0.40±0.10	0.07±0.07

2. 11: WEEK 11

Groups (n=4)	Weight (kg)	CR (cm)	HAW (cm)	SL (cm)	SC (cm)
C	0.07±0.07	0.10±0.10	0.83±0.17	0.30±0.10	0.07±0.07
D1	0.13±0.03	0.10±0.10	1.00±0.00	0.20±0.00	0.03±0.03
D2	0.30±0.00	2.00±1.00	0.33±0.33	0.20±0.10	0.20±0.00
D3	0.23±0.07	0.67±0.67	0.67±0.33	0.20±0.10	0.47±0.13
D4	0.20±0.00	1.67±0.67	1.67±0.33	0.43±0.07	0.43±0.23

2. 12; WEEK 12

Groups (n=4)	Weight (kg)	CR (cm)	HAW (cm)	SL (cm)	SC (cm)
C	0.13±0.06	1.33±o.33	0.83±0.17	0.07±0.07	0.67±0.17
D1	0.03±0.06	0.83±0.17	0.83±0.17	0.07±0.07	0.50±0.00
D2	0.30±0.10	1.33±0.33	0.33±0.33	0.37±0.03	1.00±0.00
D3	0.13±0.12	1.67±0.33	1.67±0.33	0.33±0.07	0.40±0.00
D4	0.00±0.00	1.33±0.33	1.67±0.67	0.00±0.00	0.23±0.15

2. 13: WEEK 13

Groups (n=4)	Weight (kg)	CR (cm)	HAW (cm)	SL (cm)	SC (cm)
D1	0.37±0.03	0.83±0.17	0.17±0.17	0.03±0.03	0.00±0.00
D2	0.33±0.17	1.67±0.33	0.67±0.33	0.13±0.03	0.50±0.00
D3	0.13±0.13	0.67±0.67	0.67±0.67	0.07±0.03	0.27±0.07
D4	0.30±0.06	1.00±0.58	1.33±1.33	0.67±0.33	1.37±0.41

2. 14: WEEK 14

Groups (n=4)	Weight (kg)	CR (cm)	HAW (cm)	SL (cm)	SC (cm)
D2	0.23±0.07	2.67±0.67	0.67±0.67	0.17±0.03	0.33±0.17
D3	0.20±0.10	3.67±0.33	2.00±0.00	0.13±0.07	0.27±0.07
D4	0.23±0.03	1.67±0.88	2.00±1.16	0.17±0.17	2.13±1.44

2. 15: WEEK 15

Groups (n=4)	Weight (kg)	CR (cm)	HAW (cm)	SL (cm)	SC (cm)
D2	0.30±0.00	3.00±1.00	2.00±1.00	0.26±0.03	0.67±0.33
D3	0.30±0.10	0.33±0.33	0.67±0.33	0.23±0.06	0.40±0.10
D4	0.33±0.12	2.33±0.33	2.00±1.15	0.50±0.00	0.50±0.29

2. 16: WEEK 16

Groups (n=4)	Weight (kg)	CR (cm)	HAW (cm)	SL (cm)	SC (cm)
D4	0.33±0.03	1.33±0.67	0.67±0.33	0.17±0.17	0.27±0.07

Data expressed as Mean ± SEM

n=4

CR – CRUMP-RUMP LENGTH, HAW- HEIGHT AT WITHER, SL – SCROTAL LENGTH, SC – SCROTAL CIRCUMFERENCE, A – 4 Weeks, B – 8 Weeks, C- 12 Weeks. D1 – 13 Weeks, D2 – 14 Weeks, D3 – 15 Weeks, D4 – 16 Weeks, E – 17 Weeks, F – 18 Weeks.

Appendix 3.1

Correlations

		Age of the Buck	Birth Weight	Body Weight	Crown Rump Length	Height at Withers	Scrotal Length	Scrotal Circumference	STDiameter	Germinal Epithelial Height	ST Luminal Width
Age of the Buck	Pearson Correlation	1	.754*	.957**	.904**	.906**	.917**	.874**	.609	.439	-.023
	Sig. (2-tailed)		.019	.000	.001	.001	.000	.002	.109	.276	.958
	N	9	9	9	9	9	9	9	8	8	8
Birth Weight	Pearson Correlation	.754*	1	.684*	.671*	.625	.557	.472	.798*	.629	.177
	Sig. (2-tailed)	.019		.042	.048	.072	.119	.199	.018	.095	.675
	N	9	9	9	9	9	9	9	8	8	8
Body Weight	Pearson Correlation	.957**	.684*	1	.945**	.876**	.955**	.882**	.593	.486	.000
	Sig. (2-tailed)	.000	.042		.000	.002	.000	.002	.121	.222	1.000
	N	9	9	9	9	9	9	9	8	8	8
Crown Rump Length	Pearson Correlation	.904**	.671*	.945**	1	.729*	.848**	.755*	.656	.540	-.093
	Sig. (2-tailed)	.001	.048	.000		.026	.004	.019	.077	.167	.827
	N	9	9	9	9	9	9	9	8	8	8
Height at Withers	Pearson Correlation	.906**	.625	.876**	.729*	1	.950**	.965**	.281	.084	.111
	Sig. (2-tailed)	.001	.072	.002	.026		.000	.000	.501	.842	.794

	N	9	9	9	9	9	9	9	8	8	8
	Pearson Correlation	.917**	.557	.955**	.848**	.950**	1	.975**	.345	.226	.037
	N	9	9	9	9	9	9	9	8	8	8
Scrotal Circumference	Pearson Correlation	.874**	.472	.882**	.755*	.965**	.975**	1	.199	-.011	.099
	Sig. (2-tailed)	.002	.199	.002	.019	.000	.000		.637	.979	.815
	N	9	9	9	9	9	9	9	8	8	8
ST Diameter	Pearson Correlation	.609	.798*	.593	.656	.281	.345	.199	1	.654	.374
	Sig. (2-tailed)	.109	.018	.121	.077	.501	.403	.637		.079	.362
	N	8	8	8	8	8	8	8	8	8	8
Germinal Epithelial Height	Pearson Correlation	.439	.629	.486	.540	.084	.226	-.011	.654	1	-.314
	Sig. (2-tailed)	.276	.095	.222	.167	.842	.591	.979	.079		.449
	N	8	8	8	8	8	8	8	8	8	8
ST Luminal Width	Pearson Correlation	-.023	.177	.000	-.093	.111	.037	.099	.374	-.314	1
	Sig. (2-tailed)	.958	.675	1.000	.827	.794	.931	.815	.362	.449	
	N	8	8	8	8	8	8	8	8	8	8

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Appendix 3.2 Data analysis

Descriptives

testo	N	Mean	Std.Deviation	Std.Error	**95% Confidence**...	
					Lower Bound	Upper Bound
1.00	4	.3300	.01000	.00577	.3052	.3548
2.00	4	2.3200	.04000	.02309	2.2206	2.4194
3.00	4	.5950	.02500	.01443	.5329	.6571
4.00	4	.3350	.02500	.01443	.2729	.3971
5.00	4	1.1400	.09000	.05196	.9164	1.3636
6.00	4	.8900	.17000	.09815	.4677	1.3123
7.00	4	.9200	.08000	.04619	.7213	1.1187
8.00	4	.	.	.	.	
9.00	4	.	.	.		
Total	36	.6705	.62513	.10882	.4488	.8921

Descriptives

testo	95% Confidence...		
	Upper Bound	Minimum	Maximu
1.00	.3548	.32	.34
2.00	2.4194	2.28	2.36
3.00	.6571	.57	.62
4.00	.3971	.31	.36
5.00	1.3636	1.05	1.23
6.00	1.3123	.72	1.06
7.00	1.1187	.84	1.00
8.00			
9.00			
Total	.8921	.14	2.36

birthweight			
1.00	1.3535	1.00	1.20
2.00	1.3484	1.00	1.20
3.00	1.4202	1.00	1.20
4.00	1.5535	1.20	1.40
5.00	1.7968	1.10	1.50
6.00	1.4484	1.10	1.30
7.00	1.3484	1.00	1.20
8.00	1.3535	1.00	1.20
9.00	1.3484	1.00	1.20
Total	1.2066	1.00	1.50

Descriptive

	N	Mean	Std. Deviation	Std. Error	95% Confidence...	
					Lower Bound	Upper Bound
weekweightone						
1.00	4	.6333	.75056	2.4978	.43333	1.2311
2.00	4	.1667	.28868	.8838	.16667	-.5504
3.00	4	.1667	.11547	.4535	.06667	-.1202
4.00	4	.0667	.05774	.2101	.03333	-.0768
5.00	4	.2000	.00000	.2000	.00000	.2000
6.00	4	.1000	.00000	.1000	.00000	.1000
7.00	4	.0000	.00000	.0000	.00000	.0000
8.00	4	.0667	.05774	.2101	.03333	-.0768
9.00	4	.1667	.05774	.3101	.03333	.0232
Total	36	.1727	.26014	.2650	.0452	.0805

	95% Confidence…		
	Upper Bound	Minimum	Maximum
weekweightone	2.4978	.20	1.50
1.00	.8838	.00	.50
2.00	.4535	.10	.30
3.00	.2101	.00	.10
4.00	.2000	.20	.20
5.00	.1000	.10	.10
6.00	.2101	.00	.10
7.00	.3101	.10	.20
8.00	.2650	.00	1.50
9.00			
Total			
CR			
1.00	1.5504	.50	1.00
2.00	.0000	.00	.00
3.00	3.1009	1.00	2.00
4.00	3.1009	1.00	2.00
5.00	1.7676	.00	1.00
6.00	2.0000	2.00	2.00
7.00	3.1009	1.00	2.00
8.00	1.8807	.20	1.00
9.00	1.5504	.50	1.00
Total	1.3490	.00	2.00

Descriptive

	N	Mean	Std. Deviation	Std. Error	95% Confidence… Lower Bound	Upper Bound
SL						
1.00	4	.1667	.28868	.16667	-.5504	.8838
2.00	4	.3333	.28868	.16667	-.3838	1.0504
3.00	4	.1333	.23094	.13333	-.4404	.7070
4.00	4	.0000	.00000	.00000	.0000	.0000
5.00	4	.0000	.00000	.00000	.0000	.0000
6.00	4	.0000	.00000	.00000	.0000	.0000
7.00	4	.2333	.32146	.18559	-.5652	1.0319
8.00	0	.	.	.	.	.
9.00	0	.	.		.	.
Total	28	..1238	.21887	.04776	.0242	.2234

SC						
1.00	4	.3333	.28868	.16667	-.3838	1.0504
2.00	4	4333	.11547	.06667	.1465	.7202
3.00	4	.0000	.00000	.00000	.0000	.0000
4.00	4	.0000	.00000	.00000	.0000	.0000
5.00	4	.3333	.28868	.16667	-.3838	1.0504
6.00	4	.3333	.28868	.16667	-.3838	1.0504
7.00	4	2.3333	2.51661	1.45297	-3.9183	8.5849
8.00	0	.	.	.	.	.
9.00	0	.	.	.	.	.
Total	28	.5381	1.11825	.24402	.0291	1.0471

Total	95% Gonfidence	Upper Bound	
		Minimum	Maximum
		.	
SL			
1.00	.8838	.00	.50
2.00	1.0504	.00	.50
3.00	.7070	.00	.40
4.00	.0000	.00	.00
5.00	.0000	.00	.00
6.00	.0000	.00	.00
7.00	1.0319	.00	.60
8.00	. . .		
9.00	. . .		
Total	.2234	.00	.60

SC			
1.00	1.0504	.00	.50
2.00	.7202	.30	.50
3.00	.0000	.00	.00
4.00	.0000	.00	.00
5.00	1.0504	.00	.50
6.00	1.0504	.00	.50
7.00	8.5849	.00	5.00
8.00	. . .		
9.00	. . .		
Total	1.0471	.00	5.00
sc2			
1.00	.3800	.00	1.00
2.00	.2768	.10	.20
3.00	2.0504	1.00	1.50
4.00	.8303	.20	.50
5.00	2.2676	.50	1.50
6.00	1.6384	.10	1.00
7.00	.6303	.10	.40
8.00	.6838	.00	.40
9.00	. . .		
Total	.7352	.00	1.50

			.		95% Confidence…	
SI2	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound
1.00	4	.4667	.46188	.26667	-.6807	1.6140
2.00	4	.3333	.28868	.16667	-.3838	1.0504
3.00	4	.0000	.00000	.00000	.0000	.0000
4.00	4	.1667	.28868	.16667	-.5504	.8838
5.00	4	.2333	.25166	.14530	-.3918	.8585
6.00	4	.4000	.17321	.10000	-.0303	.8303
7.00	4	.1667	.28868	.16667	-.5504	.8838
8.00	4		.		.	.
9.00	4	.	.		3800	1247
Total		2524	28039	.06119		

Sc2							
	1.00	4	.1333	.05774	.03333	.0101	.2768
	2.00	4	.16667	1.3333	.28868	.6162	2.0504
	3.00	4	.10000	.4000	.17321	-.0303	.8303
	4.00	4	.8333	57735	.33333	-.6009	2.2676
	5.00	4	.5000	.45826	.26458	-.6384	1.6384
	6.00	4	.2000	.17321	.10000	-.2303	.6303
	7.00	4	.1667	.20817	.12019	-.3504	.6838
	8.00	0	.	. .		.	.
	9.00	0	.	. .		.	.
Total		28	5.5095	.49589	10821	.2838	.7352

	95% Upper bound	**Minimum**	**Maximum**
sl3			
1.00	.2768	.10	.20
2.00	3.5351	.00	2.00
3.00	1.3838	.50	1.00
4.00	.7202	.30	.50
5.00	.1768	.00	.10
6.00	.3101	.10	.20
7.00	.0000	.00	.00
8.00	.	.	.
9.00	.	.	.
Total	.5125	..00	. 2.00
sc3	.	.	.
1.00	6202	.20	.40
2.00	1.7676	.00	1.00
3.00	.8838	.00	.50
4.00	.1768	.00	.10
5.00	.7070	.00	.40
6.00	.8404	.00	.40
7.00	1.7170	.00	1.00
8.00	.	.	.
	.	.	.
9.00	.3906	.00	1.00
Total			