POSTNATAL DEVELOPMENT OF THE REPRODUCTIVE TRACT OF RED SOKOTO BUCKS

BY

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CERTIFICATION

This thesis entitled "Postnatal development of the reproductive tract of Red Sokoto Bucks" by Benjamin Nwabueze Marire meets the regulations governing the award of the degree of Master of Science (M.Sc.) of Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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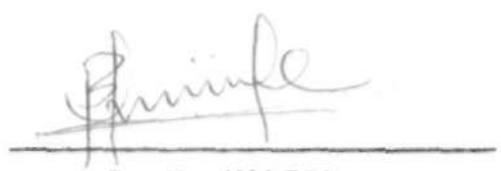
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I declare that this work is solely my effort and has not been presented to any Institution or Body for any award or honours.



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DEDICATION

I dedicate this thesis to my mother, Bessie Nebeke Marire, my late father, Samuel Ihenacho Marire and my senior brother, Henry Amobi Marire for their encouragements and support.

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ABSTRACT

Postnatal growth and development of the reproductive organs of Red Sokoto bucks were studied. The study was done in three sections. In section one, a survey was conducted to find the relationship between age, body weight, heart girth, withers height and scrotal circumference. It was found that scrotal circumference (Sc) increased with age, body weight (Bw), heart girth (Hg), withers height (Wh), testes weight (Tw) and testes volume (Tv). There were high correlations between Sc. and Bw. ($r=0.80$), Sc and Age ($r=0.85$), Sc and Tw ($r=0.97$), Sc and Age ($r=0.72$). These relationships indicate that scrotal circumference is a good predictor of testicular size and is closely correlated to body size.

In section two, growth and development of the reproductive organs in Red Sokoto bucks were studied using 21 bucks serially slaughtered in groups of 3 at 7, 30, 60, 90, 120, 150 and 180 days of age. The average daily gain by the bucks was 58.4 g for the entire period. There were high correlations between age, Bw, Hg, Sc, gonadal and accessory sex organ development. Scrotal circumference was related to testes weight by the equation: $Tw = 0.0028\ Sc^{3.514}$ ($r=0.99$). Spermatogenesis had commenced in all bucks by 90 - 100 days. Spermatozoa

were present in the testes and epididymis of all bucks at 120 days. All penile adhesions had disappeared by 180 days. Vesicular gland secretion were apparent from 90 days.

Gonadal sperm/spermatid count per buck averaged 1740.6, 2077.2 and 2247.7 x 10^6 cells at 120, 150 and 180 days respectively. Epididymal sperm reserves at the same ages were 223.0, 1002.7 and 1263.5 x 10^6 spermatozoa respectively.

In section three, pubertal age in Red Sokoto bucks was determined by monitoring urinary spermatozoa output (retrograde ejaculation) by standard methods involving urine collection and analysis for spermatozoa. Spermatozoa were first detected in urine at 150 days of age and 11.8 kg liveweight. No spermatozoon was found in urine of bucks of the same age but weighing less than 11.8 kg. There was no definite relationship between the number of spermatozoa voided in the urine and increase in the liveweight or age of the bucks from five to seven months.

It was concluded that Red Sokoto bucks could be used for breeding from 180 days of age with at least 12 kg liveweight. At this age and body weight, all components of the reproductive tracts were fully functional, and the bucks could be considered as having attained age of puberty. The Red Sokoto bucks should be separated from the female kids from 90 days of age to prevent accidental or unplanned breeding.

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ABBREVIATIONS

LW	=	Live weight
Hg	=	Heart girth
Wh	=	Wither height
Sc	=	Scrotal circumference
RTW	=	Right testis weight
LTW	=	Left testis weight
RTV	=	Right testis volume
LTV	=	Left testis volume
REW	=	Right epididymal weight
LEW	=	Left epididymal weight
PS	=	Preputial separation
PL	=	Penile length
PW	=	Penile weight
RSVW	=	Right seminal vesicle weight
LSVW	=	Left seminal vesicle weight
REL	=	Right epididymal length
LEL	=	Left epididymal length
STD	=	Seminiferous tubule diameter
ETD	=	Epididymal tubule diameter
RTSR	=	Right testis sperm reserve
LTSR	=	Left testis sperm reserve
RESR	=	Right epididymal sperm reserve
LESR	=	Left epididymal sperm reserve
LH	=	Luteinizing hormone
FSH	=	Follicle stimulating hormone

INTRODUCTION

The goat is the second most important livestock species in Nigeria in terms of numbers. In 1963/64, the population of goats in Nigeria was given as 21.1 million and that of sheep 7.2 million (F.A.O., 1966). But Devendra and Burns (1970) gave a population of 29.3 million goats in Nigeria, and reported that Nigeria ranked second only to India among the countries in the tropics and the subtropics. There are three recognised breeds of goats in Nigeria. The hardy, short-legged West African Dwarf breed, confined to the humid forest belts of the South, the large-size and long-legged Sahel breed and the Red Sokoto (Maradi) breed which are found in the semi-desert and Savannah zones of the country respectively (Adu *et al*., 1979). The Red Sokoto (Maradi) is the most numerous (17.3 million) and widely distributed breed of goat in Nigeria (Adu *et al*., 1979). It is one of the few well-defined breeds and is characterized by its uniformly dark red coat colour, short and horizontal ears and horns in both sexes.

The demand for meat from goats has increased because of inability of the cattle population to meet the increased demand for protein. In addition, the rapid rates of population growth, urbanization,

education and rising incomes are creating a growing demand for more and better food. This calls for concurrent increase in protein production.

Oyenuga (1969) shows that the total protein requirement of the nation is far less than the amount supplied. This situation is further worsened by population growth and endemic diseases among the livestock population, which quite often results in high neonatal losses.

The gestation length of the Red Sokoto goat is 5 months and the twinning rate is high. This means that this breed of goat may have potentials for fast multiplication, as two kiddings may be obtained in one year. Another good trait of this breed, is the early or fast attainment of slaughter weight. There is need therefore, to intensify research efforts on small ruminants with a view to increasing their numbers.

This research was undertaken in view of the limited information available on the reproductive development of Nigerian breeds of goats. Since the goat shows strongly developed sexual instincts at an early age, it seems desirable that a study of the reproductive system of the young buck be made in order to determine the rate of development and age at which sexual maturity is attained. This will help

in determining the age at which male kids should be weaned to prevent accidental breeding of young does which have not physically attained the breeding age. Dystocia due to relative foetal oversize often result in loss of kids during birth. Determination of the age at puberty in Red Sokoto bucks will further enhance the use of young bucks for breeding which should result in faster genetic progress through reduction in generation interval. It is therefore desirable that information on the reproductive tract development of the bucks be available as this would be useful in planning a breeding programme for the goats.

CHAPTER 1

REVIEW OF LITERATURE

1. INTRODUCTION

The literature review was in 3 parts: (1) A brief description of the male reproductive system; (2) Prenatal; and (3) Postnatal development of the reproductive tract. Under postnatal development, review was made of the testes, formation of spermatozoa, hormonal requirements for spermatogenesis, epididymis, ductus deferens and ampulla. Other reproductive organs reviewed include the vesicular gland, prostate gland, bulbo-urethral gland, the penis and prepuce. Review was also made of puberty, appearance of spermatozoa in ejaculates, endocrinology of puberty, factors affecting development of the reproductive organs and estimation of testicular size.

1-1 THE MALE REPRODUCTIVE SYSTEM

The male reproductive system consists of

i) two gonads, the testes which produce the male germ cells and male sex steroid hormones;

ii) a copulatory organ, the penis, by which semen is delivered into the vagina of the female;

iii) a long complicated set of tubes and tubules (epididymis and ductus deferens) which connect the testes with the pelvic urethra and so permit spermatozoa produced in the testes to be stored and conducted to the penis; and

iv) the accessory sex gland (vesicular gland, prostate gland, ampulla and bulbourethral gland) which provide a fluid vehicle for nourishing and transporting spermatozoa through the tract, propelled by the reflex contraction of the smooth muscles of their wall during coitus (Ham, 1965).

1.2 PRENATAL DEVELOPMENT

During embryonic development in mammals, the development of the reproductive organs starts in the gonadal ridge which lies medial to the embryonic kidney (mesonephros). The indifferent gonads of the embryo differentiate into testes after the migration of the primordial germ cells into the gonadal ridge (Ashdown and Hancock, 1975; Nalbandov, 1976).

It was formerly believed that in the male, the primordial germ cells developed from the sex cords of the testis (Ham, 1965). It has now been established however, that as in the female, the primordial germ cells are not formed in the gonad, but migrate from the yolk sac endoderm and enter the developing testes during the 5th week of gestation. They then become incorporated into the cords of epithelial-like cells that are commonly believed to represent down-growths of the surface epithelia. These are termed sex cords. They finally differentiate into cells that later give rise to the gametes (Abdel Raouf, 1960; Ham, 1965).

The differentiation of the primordial mammalian gonad into a testis or an ovary seems to be influenced by genetic as well as other stimuli. The gonad itself stimulates the development and differentiation of male and female organs of the genital system (Wartenberg, 1980). The development of a male or female organism is primarily determined at fertilization, and the "genetic sex" is required for a normal sexual differentiation of the gonads. The "gonadal sex" on the other hand, influences and regulates the differentiation of the "body sex"

(somatic sex), whereby the testis influences the development of the male genital system and male characteristics (Wartenberg, 1980).

Recent evidence indicates that it is not the Y chromosome *per se* that induces the primordial mammalian gonad to differentiate as a testis, but a cell inducer substance known as HY - antigen. The HY - antigen is a serologically detectable molecule whose presence on the cell surface is determined by genes situated in the pericentric region of the Y - chromosome. This HY - antigen is believed to influence the primordial gonads towards maleness as seen in the freemartin (Anderson, 1983). Evidently, sex determination of the male gonad would seem to depend on the presence of HY - antigen (Ohno, 1971, 1976, 1977; Watchel *el al*.,1975; Wolf, 1979). In turn, the sex differentiation of the male sex organs is under the influence of a masculinizing mechanism that emanates from the secretion of androgens. If these testicular hormones are absent, the Mullerian ducts and the urogenital sinus develop into female sex organs. The regression (involution) of the Mullerian ducts seems to be induced by the testes (Josso *et al*., 1977).

The differentiation of the sex organs was found to commence at about the 35th day of conception in sheep (Terrill, 1974). The primordial germ cells first become the gonocytes of the ram testes and eventually turn into spermatogonia from which spermatozoa are derived through the process of spermatogenesis (Ham, 1965).

It is probable that the placental gonadotrophin stimulates the growth of the testis early in fetal life and make it a functioning endocrine gland (Ham, 1965). The fetal androgen thus secreted by the interstitial cells of the developing fetal testes would initiate differentiation and development of the male reproductive tract and changes in the inguinal canal that permit the testes to descend through it more readily into the scrotum (Ashdown and Hancock, 1975).

1.3 POSTNATAL DEVELOPMENT

1.3.1 The testes

In rams and bulls, the testes enter the scrotum half way through fetal life (Ashdown and Hancock, 1975); so that the testes are already descended at birth (Terrill, 1974). After birth, each

component of the reproductive tract undergoes differentiation as it continues to grow in size relative to overall body weight (Nishikawa, 1959; Abdel Raouf, 1960). But functional competence is not achieved simultaneously in all components of the reproductive system.

The growth of goat testes from birth to 90 days is independent of birth weight and takes place at a definite and uniform rate (Yao and Eaton 1954). It is closely related to slaughter weight up to 114 days of age. After 90 days of age testicular growth is well correlated with birth weight until 120 days of age. Thereafter, the correlation ceases to exist (Phillip and Zeller, 1943; Yao and Eaton, 1954). The growth of the seminiferous tubule is closely related to the weight of the testis rather than to the age of the animal (Yao and Eaton, 1954). Spermatozoa appeared in the seminiferous tubule at the age of 92 days in male goats, much earlier than in rams, bulls and boars (Yao and Eaton, 1954). Yao and Eaton (1954) found that the entire process of spermatogenesis took approximately 22 days in the goat.

The diameter of the seminiferous tubule ranges from about 40 microns in the 30 - 35 day old kid to 70 microns in the 90 day old buck, and by 114 days

the seminiferous tubule diameter was 132 microns (Yao and Eaton, 1954). At this latter age, many tubules had large lumen and contained numerous spermatozoa (Yao and Eaton, 1954). In the indigenous Yankasa rams, Osinowo et al., (1985), found that the seminiferous tubules of rams at 1.2 weeks were small in diameter (32.3u), had no lumen and contained a single layer of gonocytes. There was a 4-fold increase in tubular diameter between 1.2 and 13.9 weeks with formation of lumen and onset of spermatogenesis.

1.3.2 Formation of spermatozoa

Spermatozoa are formed in the testes by a process known as spermatogenesis, but undergo further maturation in the epididymis where they are stored until ejaculation takes place (McKerns, 1969; Johnson et al., 1970). Spermatozoa are formed within the seminiferous tubules from spermatogonia which lie on the basement membrane. The process involves cell division and differentiation, during which the number of chromosomes is halved and both nuclear and cytoplasmic components of the cell are reorganized (Bishop and Walton, 1960; Roosen Runge, 1962; Ortavant et al., 1969). The entire process of

spermatogenesis occurs in four phases in cattle: Phase I: Mitotic division of parent spermatogonia (SPG A) into dormant and active spermatogonia. The dormant spermatogonium ensures the continuity of the spermatogonia, while the active one divides four times to give more spermatogonia, which finally divide and give rise to sixteen primary spermatocytes. The duration of this phase is 15 - 17 days in cattle. Phase II: Mitotic division of the primary spermatocytes during which the number of chromosomes is halved. This process is referred to as meiosis I, and takes about 15 days to complete in cattle. The result is the production of secondary spermatocytes (White, 1974). Phase III: Division of the secondary spermatocytes into spermatids, a process known as meiosis II, which takes only a few hours to complete. Because of the rapid division of secondary spermatocytes into spermatids, it is difficult to find large numbers of secondary spermatocytes in sections of the testis. Phase IV: Metamorphosis of the spermatids into spermatozoa without further cellular division. This involves radical alteration in cellular form during which most of the cytoplasm (including ribonucleic acid,

water and glycogen) is lost (White, 1974).
The initial spermatid is a fairly large rounded c
cell, which later becomes an elongated cell. The
spermatozoan is a compact, elongated, motile cell
consisting essentially of a head and tail.

About 64 spermatozoa are produced from one o
original active spermatogonium and are finally
released from the adluminal compartments and pass
into the lumen of the seminiferous tubules
(White, 1974).

1.3.3 Hormonal requirements for spermatogenesis

Hypophysectomy in the rat, dog and ram causes a decrease in the weight of the testes and degeneration of the seminiferous epithelium. The process can be restored/reversed by giving gonadotrophin (White, 1974). There can be no doubt, therefore, that one or both of the gonadotrophins are concerned either directly or indirectly with the maintenance of the seminiferous epithelium and production of spermatozoa. In the rat, both FSH and LH stimulate spermatogenesis after hypophysectomy but the effect of LH may be due to androgen released from the interstitial cells since the injection of

high doses of testosterone has been shown to partially maintain spermatogenesis provided the germinal epithelium has not completely atrophied (White, 1974).

The site of action of hormones has been explained by in vitro cultures of the rat testicular tissue. It would appear that the formation of Type A spermatogonia requires testosterone, but development through the pachytene primary stage can occur without hormones. The division of pachytene spermatocyte to form a secondary spermatocyte, again requires testosterone and the final stages of the metamorphosis of spermatid to sperm require FSH (White, 1974).

1.3.4 The epididymis

The epididymis is responsible for the maturation, concentration, transport and storage of spermatozoa (Martin, 1969; Waites and Setchell, 1969; Orgebin-Crist, 1969 and White, 1973). The epididymal ducts also have both an absorptive and secretory function (White, 1974). Maturation changes in the epididymis include migration of the remnant of the cytoplasm, known as the cytoplasmic droplet, from the neck (i.e proximal part) until it is distally detached. Other maturation changes include; changes in membrane characteristics, increase in specific gravity and

fertilizing capacity. In some species, the spermatozoa also increase in potential for movement. Decrease in DNA, protein, phospholipid and negative charge, have also been reported, along with changes in metabolic pattern, and an increased susceptibility to cold shock (White, 1974). The lumen of the tubules at the head of the epididymis of a 7-day old goat was about 9 microns in diameter and empty (White, 1974). The lumen continued to increase in size until 110 days when some deeply stained mature spermatozoa appeared with some drops of secretions (White, 1974). Mature spermatozoa appeared in the tubules of the tail of the epididymis at the age of 114 days, by which age epididymal tubular diameter was 44 microns (Yao and Eaton, 1954).

1.3.5 Ductus deferens and ampulla

The ductus deferens transports sperm from the tail of the epididymis to the urethra by peristaltic movements which may occur during courtship and precoital stimulation. The final segments of the ductus deferens (the ampullae) are highly developed in the stallion, and unlike in other species, contribute ergothioneine to the ejaculate (White, 1974).

Yao and Eaton (1954) reported that there was no significant difference in the structure and dimensions of the ductus deferens between kids of different ages, from 60 days onwards. They found that the sizes at 60,70,80,90,100,110 and 120 days of age were 1.32, 1.23, 1.27, 1.32, 1.41, 1.14, and 1.41mm respectively. It is therefore evident that the ductus deferens does not present any trend of increase in diameter. Osinowo et al. (1985) found spermatozoa in the ductus deferens and ampullae of 2 out of 3 rams at 26.9 weeks old and in all rams by 38.8 weeks. This observation was however, not made in bucks by Yao and Eaton (1954).

1.3.6 The vesicular glands

The physical and chemical properties of semen are largely determined by the seminal plasma which constitutes its bulk, particularly in the boar and stallion (Mann, 1969). The seminal plasma contains some unusual organic compounds such as fructose, citric acid, sorbitol, inositol, glycerylphosphorylcholine and ergothioneine, which are not found elsewhere in the body (White, 1974). They serve as source of nutrients for the spermatozoa.

The vesicular glands in goats show many lobulated sacs enclosed in a sheath of fibromuscular tissue. At 60 days, many of the tubules were half open, while a few others had no lumen. It was not until 90 days that some tubules were filled with secretions, and after 120 days most of the tubules were wide open (Yao and Eaton, 1954; Abdel Raouf, 1960).

1.3.7 The prostate gland

This gland consists of lobules, and in the lobules partitions are formed by thick layers of loose fibro-elastic connective tissue with branching tubules that form many convoluted folds. The epithelium is comprised of a single layer of tall columnar cells and cuboidal basal cells. This pattern makes the epithelium appear pseudostratified. The epithelial cells increased in height from 25 microns in 60 day-old bucks to 32 microns in 105 day-old bucks. The tubules of the prostate gland in both young and old bucks were found to contain secretions, but the granular content of the secretion was increasing with age (Yao and Eaton, 1954). This gland therefore, starts secreting early in life, but the relative contribution of the prostate to the volume of the ejaculate is small in the larger domestic species, such as the bull, stallion, ram and boar (White, 1974).

1.3.8 Bulbourethral gland

This gland consists of numerous acini enclosed in a thin layer of fibrous connective tissue, which is surrounded by a thick layer of smooth and striated muscles. The epithelial cells are tall columnar with small nuclei at the basal end. The bulbourethral glands of the 70, 80 and 112-day old kids showed no conspicuous differences other than those of dimensions. This gland does not contribute much to the volume of the ejaculate in bull, boar, ram and stallion (White, 1974).

1.3.9 The penis

Johnstone (1948) and Wiodins and Terrill (1953) found that there was very little development of the penis in sheep before 10 weeks, and that development was complete at 20 weeks of age. Yao and Eaton (1954) reported that sections of the penis from 6 animals of different ages (90 to 120 days) showed no conspicuous differences except for size, ranging from 7 to 9mm in diameter. In the indigenous Yankasa rams, Osinowo et al (1985), found that the penis was 16cm long and weighed 5g at 1.2 weeks. Increase in penile length was virtually completed by 13.9 weeks, while penile weight increases continued till

38.8 weeks in rams. By 53 weeks the penile length and weight were 30.8cm and 38.2g respectively. These facts show that penile growth in rams is completed earlier in the temperate breed of sheep than in local breed. This could be as a result of better genetic composition, plane of nutrition and management in these exotic breed

1.3.10 Preputial separation

Before 90 days of age, the urethral process of most bucks was attached to the inner wall of the prepuce (Yao and Eaton 1954). Between 90 and 112 days of age, it showed varying degrees of detachment, mostly depending upon the birth weight and subsequent growth of the animals (Yao and Eaton, 1954). The urethral process in all the animals older than 112 days was free from the prepuce (Yao and Eaton, 1954). Wiggins and Terrill (1953) recorded that the urethral process of rams became free from the prepuce at the age of 91 days, although a number of the older lambs still had the process attached. Abdel Raouf (1960) found that separation between penis and penile sheath commenced from 70 days of age in rams. In the indigenous Yankasa rams, Osinowo et al (1985) showed that the separation of the penis from the penile sheath was very little in all rams up to 13.9 weeks of age,

but that partial separation was observed by 26.9 weeks and complete separation by 38.8 weeks. These findings show that preputial separation occurs at an earlier age in the exotic than local breeds of sheep and goats. This may be as a result of higher body weight of these animals compared to local sheep and goats of the same age group. The higher body weight could be due to superior genetic composition and better nutrition and management.

1.4 PUBERTY

1.4.1 Definitions

Several workers defined puberty based on different stages of sexual maturity. Thibault and Lavasseur (1974) defined puberty as the period of adolescence, when a male or female is first able to release gametes. Barber and Almquist (1975) and Oyedipe et al, (1981), defined puberty as the age at which the ejaculate first contains a minimum of 50 million spermatozoa with at least 10% motility. Puberty has also been defined as the age at which the reproductive organs become functional and reproduction may occur (Oyedipe et al, 1981). It is however, preferable to base the

definition of puberty on the age when the male and female can reproduce because this definition is more functional.

1.4.2 Appearance of spermatozoa in ejaculates

Spermatozoa are present in the seminiferous tubules and cauda epididymidis at 16 weeks in rams and 32 weeks in cattle. The ram ejaculate contains spermatozoa at 18 weeks, so the ram could be used for service from 24 weeks of age (Abdel Raouf, 1960). The bull on the other hand can mount and serve a heifer from 159 weeks of age (Abdel Raouf, 1960). This fact shows that rams attain puberty at 24 weeks of age. However, in the indigenous Yankasa rams, spermatozoa were first found in the ductus deferens and ampullae of 2 out of 3 rams at 26.9 weeks and in all rams by 38.8 weeks (Osinowo et al. 1985). Therefore the age of puberty in the latter breed is about 38.8 weeks.

1.4.3 Endocrinology of puberty

The physiology of puberty is governed by the gonadotrophins from the pituitary gland. Both LH and FSH are produced in the basophilic cells of the anterior pituitary gland. The biologic effects of LH and FSH

appear to be limited to stimulation of various physiologic processes within the gonads (Niswender et al. 1974). Most of the researches regarding the actions of LH and FSH on the testis has been performed in rats but similar mechanisms probably exist in domestic animals (Niswender et al., 1974). LH stimulates testosterone secretion from the interstitial cells of the testis. Prolactin may act synergistically with androgens to stimulate the male accessory glands such as the prostate, vesicular and preputial glands. FSH appears to stimulate Sertoli cells and/or the primary spermatocyte. Blom (1962), Frandson (1974) and Ashdown and Hancock (1975) reported that testosterone promotes the development and functioning of the accessory sex glands and the secondary sexual characteristics. The sex hormones also regulate spermatogenesis and sexual behaviour (Ham, 1965; White, 1974 and Nalbandov, 1976). These hormonal effects will eventually lead to attainment of puberty at the right age and body weight.

1.5 FACTORS AFFECTING DEVELOPMENT OF THE REPRODUCTIVE ORGANS

1.5.1 Age

It has been found that in bulls, age and testicular development have a curvilinear relationship (Hahn et al., 1969; Coulter and Foote, 1976; Elmore et al., 1976; Lunstra et al., 1978 and Osinowo et al., 1981). Work done by Coulter et al., (1975) showed that increase in scrotal circumference with age is up to a certain limit. Correlation between age and scrotal circumference in young Bunaji bulls was 0.88 (Osinowo et al., 1981).

In rams, Watson et al., (1956) reported a general increase in testicular weight and mean cross-sectional area of the seminiferous tubules, with increase in age. Testicular size increased steadily in young bulls and declined in the old bulls (Coulter, 1979; Coulter and Foote, 1979). It was found that further testicular development in bulls was very slow after puberty (Almquist et al., 1976). Holstein dairy bulls were found to reach their maximum scrotal circumference in 5 - 6 years (Hahn et al., 1969), after which the size was relatively stable. The testicular consistency was also found to be high in young bulls, decreasing as the animal grew, and remaining relatively constant in mature bulls

Coulter et al., 1975). Although spermatogenesis was found to have started by 13 months of age in Bunaji bulls, consistently large gonadal and epididymal sperm reserves were only found in bulls aged 17 months and above (Osinowo et al., 1981; Wildeus and Entwistle, 1983). Gonadal sperm/spermatid reserve increased from 1.507±0.779 billion in 13 - 16 months old bulls to 11.98±4.589 billion at 22 - 27 months. The corresponding epididymal sperm reserves increased from 0.06±0.051 billion to 5.798±1.641 billion (Osinowo et al., 1981).

1.5.2 Nutrition

Under-nourishment has been reported to delay growth and puberty in rams, boars, stallions and bulls, and age of selecting Holstein bulls for artificial insemination by many months (Foote and Trimberger, 1968; Leathem, 1975). Nutrition affects age at puberty. There is a correlation between body weight and testicular weight in males or age at the first oestrous in the dams. If nutrition is maintained at a normal level, puberty occurs when body weight reaches 60% of the adult body weight in sheep and 45% of the adult weight in cattle (Thibault and Levasseur, 1974). A similar relation does not exist in pigs. If growth is accelerated by

overfeeding, body weight at the time of puberty is higher than normal and the animal reaches maturity at a younger age. On the other hand, if growth is slowed down by underfeeding, puberty is delayed and body weight does not reach the level of that of normally fed animals (Thibault and Levasseur, 1974). Dietary protein deficiency results in a loss of testes mass, spermatogenic arrest and lowering of the secretory ability of the interstitial cells of Leydig (Tripathi et al., 1968). Lambs reared on a high plane of nutrition reach puberty earlier than those on a low plane (Ward, 1980). This is partly a reflection of the tendency to reach puberty only above a certain body weight, and partly of a direct effect of nutrition on the reproductive system. In rams, testis size, which is highly correlated with spermatogenic activity, responds to nutrition, and sperm production can be increased by "flushing" with high protein supplement for about 8 weeks before mating starts (Pryor, 1980). This is especially important both under natural mating conditions and when semen is to be collected for artificial insemination. Vitamin A deficiency was found to retard testes development in cat and ram (Leathem, 1975) and if combined with protein deficiency it could lead to testicular malformation and aspermia (Baronos et al., 1969).

Reports indicate that amino acids, carbohydrates, a few essential fatty acids and minerals are necessary for the production of the fluid medium, produced by the cellular environment of the testes, which is necessary for sperm transport (Leathem, 1975). The number of motile spermatozoa in the ejaculate of underfed animals was found to be 50% of normal, if the underfeeding was pre-pubertal (Flipse and Almquist, 1961). However, low protein intake has been found to produce more adverse effect on immature animals than mature ones (Leathem, 1975).

1.5.3 Body weight

Body weight is one of the factors affecting testicular traits in animal (Coulter and Foote, 1979; Osinowo, 1979; Osinowo et al., 1981). Watson et al., (1956) found in Merino rams that although testicular weight varied with age, it was more closely related to body weight. An increase in testicular weight was observed as the body weight increased, and a great increase in the cross-sectional area of the seminiferous tubules was recorded as body weight increased from 23-27kg in rams.

It has been reported that sexual maturity in ram lambs is more closely related to body weight than age (Terill, 1974). In growing bulls, about 64% of the variation in scrotal circumference was found to be due to changes in body weight (Coulter and Foote, 1977).

A curvilinear relationship was obtained between scrotal circumference and body weight in bulls (Coulter and Foote, 1977) and rams (Watson et al., 1956). There was the same relationship for testicular consistency and body weight for some breeds of cattle (Coulter et al., 1975).

1.5.4 Genetic factors

Age at sexual maturity in sheep varies from breed to breed (Terrill, 1974). This could mean that the rate of testicular development may depend on the genetic constitution of the breed. The rate of testicular development is found to be higher for fast-growing breeds like Hampshire and slow for slow-growing breeds like Merino (Chang and Rae, 1970).

Lunstra et al., (1978) found the scrotal circumference of various breeds of cattle to be almost the same (27.9±0.2cm) at puberty, but the age, body weight and testosterone content of the plasma at the time of puberty varied from breed to breed. In Nigeria however, Osinowo et al.,

(1981) reported a scrotal circumference of 19 - 24cm for Bunaji bul at puberty. The difference could be due to breed, level of nutrition and management practice.

Work on Angus and Holstein bulls by Coulter et al., (1975) showed that the Angus had a larger testes up to 3 years of age when they were surpassed by the Holstein. The Angus breed thus reached maximum testicular size at a younger age than the Holstein breed. The heritability estimate of scrotal circumference in bulls was reported to be about 0.67 (Coulter et al., 1976).

1.5.5. Seasonal effects

It has been shown that changes in season have profound effect on sexual activities and reproduction in general. Seasonal changes in the spermatogenic and androgenic activities of the testes occur in a wide range of mammals (Lincoln, 1976). This seasonality in sexual activity has been reported in all animals (Nalbandov, 1976). Weight and scrotal circumference measurements taken on some rams by Motimer and Lincoln(1982) during the non-breeding season showed a decrease in their testicular weight and size, with about one third decrease in weight recorded. Seasonal variation have been observed in the episodic secretion of LH and testosterone in rams,

with increase from the non-breeding to the breeding season (Lincoln, 1976; Pelletier et al., 1982). This shows that seasonal changes affect testicular development in the young animals but affect the weight of the testes in mature animals.

1.5.6 Hormonal effects

The sex differentiation of the male sex organs is guided under the influence of a masculinizing mechanism that emanates from the secretion of androgen. If these testicular hormones are absent, the Mullerian ducts and the urogenital sinus develop into female sex organs. If the testicular androgens are present, the Wolffian ducts and the urogenital sinus develop into male sex organs. The regression or involution of the Mullerian ducts seems to be affected by the testes (Josso et al., 1977).

It has been shown that the proliferation of gonocytes is stimulated by the pituitary gonadotrophin. The gonadotrophin releasing hormone from the hypothalamus stimulates the anterior pituitary to release luteinizing hormone (LH) and follicle stimulating hormone (FSH) (White, 1974). The LH stimulates Leydig cells to produce testosterone which in turn stimulates the germinal cells,

and maintains spermatogenesis (Gemzell and Roose, 1966). Androgen also helps in the development and maintenance of the accessory sex glands, stimulation of sexual behaviour and spermatogenesis (White, 1974).

The final differentiation of spermatids to spermatozoa requires FSH and probably testosterone. The FSH stimulates the testes and causes a significant increase in the diameter of the seminiferous tubules (White, 1974). Lunstra et al., (1978) found that testosterone production in bulls was related to growth which was in turn related to testicular development. Androgen stimulates protein anabolism causing increased nitrogen retention which accounts for the more rapid growth and greater ultimate weight of males in many animals (Frandson, 1974; Nalbandov, 1976). This may not be true in all cases due to genetic factors.

1.5.7 Effect of diseases

Epididymitis has been reported as one of the diseases affecting testicular development (Konig, 1964). It may result in testicular degeneration, which has been found to be the most frequent cause of infertility in rams and bulls (Konig, 1964; Smith et al., 1970).

Orchitis is another disease which may lead to degeneration of the testes. It is usually due to hematogenous metastasis of infection, and less frequently

through spread of infection from the genito-urinary passages (Konig, 1964; Jubb and Kennedy, 1970). Orchitis may be interstitial, intratubular or necrotic (Konig, 1964). Infections which lead to epididymitis and orchitis have been found to cause testicular degeneration in bulls (Kumi-Diaka, 1978). In rams epididymitis produced by Actinobacillus seminus hinders testicular development and result in a decrease in semen quality and quantity (Smith et al., 1970). Similarly, testicular hypoplasia affects testicular development but may not be observed until after puberty (Jubb and Kennedy, 1970). Some testicular disorders such as cryptorchidism (Wheat, 1961; Swift, 1968; Smith et al., 1970; Bishop, 1972; Kumi-Diaka et al., 1981) and testicular hypoplasia (Erickson, 1943; Laing and Young, 1956; Bishop, 1972; Lundgren, 1972) have been reported to be of genetic origin. Many infectious agents that interfere with the general well being of the animal may adversely affect the function of the testes depending on the duration and severity of infection.

1.6 ESTIMATION OF TESTICULAR SIZE

Testicular weight is an important trait which provides an accurate estimate of the amount of sperm-producing parenchyma in the testes (Coulter and

Foote, 1979). Due to the inability to measure testes weight directly in live animals, indirect methods have been used. These methods include measuring the testes length and diameter, the paired testes width and scrotal circumference (Willett and Ohms, 1957; Foote, 1969; Hahn et al., 1969; Almquist et al., 1976; Siedel and Foote, 1973; Elmore et al., 1976, Coulter and Foote, 1976, Lunstra et al., 1978; Daudu, 1984).

Linear measurements are made with callipers while the scrotal circumference is measured with flexible plasticized cloth or metal tape around the greatest diameter of the testes and scrotum (Foote, 1969; Hahn et al., 1969; Coulter and Foote, 1979). The method of measuring scrotal circumference was described by Elmore et al., (1976).

Scrotal circumference is well correlated with testicular development (Lino, 1972). It is easy to measure, highly repeatable and is highly correlated with testicular weight in rams and may be used for prediction of testicular weight and epididymal spermatozoa reserves (Hahn et al., 1969; Lino, 1972).

Work on Bunaji bulls by Osinowo et al., (1981) showed testicular size to be highly correlated to seminiferous tubule diamter and gonadal sperm reserve (r=0.81 to 0.85).

These traits were used as the indices of testicular development. These authors also found that scrotal circumference gave a good indication of testicular development as shown by the correlations between scrotal circumference and gonadal sperm/spermatid reserve (r=0.69), seminiferous tubule diameter (r=0.80), age (r=0.88), body weight (r=0.88) and testicular weight (r=0.94). Notter et al., (1981) found that a high correlation exists between scrotal circumference and testicular weight (r=0.93). In dairy bulls, relationship between scrotal circumference and testicular weight was close and linear (Hahn et al., 1969).

According to Lunstra et al., (1978), different cattle breeds in the temperate countries were found to have almost uniform scrotal circumference (27.9±0.2cm) at puberty, although there were variations in age and body weight. But work done by Osinowo et al., (1981) on Bunaji bulls in Nigeria showed that, between 12 and 24 months of age, the scrotal circumference of Bunaji bulls varied between 19.2±0.5 and 26.4±1.3cm. Several workers have observed that scrotal circumference is only a useful indicator of potential current sperm output and subsequent testicular development when used for young bulls (Hahn et al., 1969; Coulter and Foote, 1976; Elmore et al., 1976). Scrotal circumference

measurements, coupled with the standard breeding soundness examination gives the examiner an indication of a bull's sperm producing capacity and the semen quality at that time (Elmore et al., 1976; Osinowo, et al., 1977).

1.7 SUMMARY OF THE REVIEW

The development of the reproductive organs is correlated to age and body weight. The growth of the seminiferous tubule is closely related to the weight of the testis rather than age of the animal. Spermatogenesis commences at about 90 to 114 days of age in bucks, and spermatozoa may be found in the tail of epididymis from 114 days.

The vesicular gland starts production of secretions from about 90 days by which age some of the tubules were filled with secretions. In temperate breed of sheep there was very little development of the penis before 10 weeks, but development was complete at 5 months of age. In rams indigenous to Nigeria, penile development was complete by 38.8 weeks of age. The urethral process of the penis shows varying degrees of attachment between 90 and 112 days of age depending on the birth weight and

subsequent growth of the bucks. But the urethral process was free from prepuce of all the animals older than 112 days. In Yankasa sheep indigenous to Nigeria, partial separation of penile process from prepuce occurred by 26.9 weeks, and complete separation was observed by 38.8 weeks. Penile development and preputial separation therefore occur earlier in certain breeds of sheep. Puberty is attained at 24 weeks of age in temperate breeds of rams, but by 38.8 weeks in Yankasa rams. Factors affecting reproductive organ development include age, nutrition, body weight, genetic composition, season, disease and hormonal effect.

CHAPTER 2

EXPERIMENTAL

SECTION A

RELATIONSHIP OF AGE AND BODY SIZE

TO SCROTAL CIRCUMFERENCE

1.1 INTRODUCTION

Scrotal circumference is highly correlated with testis weight (Hahn et al., 1969; Coulter and Foote, 1976), and with spermatozoa output in growing bulls (Boyd and VanDemark, 1957; Willett and Ohms, 1957; Almquist and Amann 1961; Amann and Almquist, 1962; Hahn et al., 1969). Testicular consistency is correlated with fertility (Hahn et al., 1969; Foote et al., 1970). These testicular traits are also highly heritable (Stemmler et al., 1973; Coulter et al., 1976). If these traits are to be considered for incorporation into management and breeding programmes it is desirable that their relationship to other traits be understood.

Among the reported causes of variation in testicular measurement in bulls are age, breed, bull stud (Coulter et al., 1975) and year and season of measurement (Coulter and Foote, 1976). The present study was to determine the relationships between age, body weight, heart girth, withers height and scrotal circumference in Red Sokoto bucks.

1.2 MATERIALS AND METHODS

For this work, two groups of Red Sokoto bucks were used. The first group of 34 bucks ranging in age from 12 - 72 weeks were sampled in Zaria abattoir. The ages were determined using the eruption time of the permanent teeth method (Clair, 1975). Measurements such as scrotal circumference, heart girth and withers height were taken before slaughter. For the scrotal circumference and heart girth measurements, the animals were made to stand with their heads upright. The scrotal circumference measurements were taken with a flexible tape. The testicles were pushed firmly down the scrotum. The flexible tape was then slipped over the scrotum around the greatest diameter which was recorded as the scrotal circumference of the animal. This method is in accordance with that described by Foote (1969) and Elmore et al., (1976).

The heart girth measurements were also taken with the flexible tape. This is the measurement of the girth of the area immediately behind the scapulae touching the highest bone on the back of the buck.

The withers height was recorded by using the flexible tape to measure the height from the fore-foot to the highest bone on the back of the buck immediately caudal to the scapula bone.

After slaughter the testes were removed, the epididymides dissected off and each of the testes weighed. The weighing was done on an electric weighing scale - Mettler P163. The testes volume was estimated by water displacement.

The second group of 40 bucks ranging in age between 6 and 56 weeks came from the Department of Small Ruminants, Nayional Animal Production Research Institute (N.A.P.R.I), Ahmadu Bello University, Zaria. They were reared under the semi-intensive husbandry management practice at the Institute. Parameters obtained or measured were; age, body weight, heart girth, withers height and scrotal circumference. The ages were obtained from records. Body weights were taken using hanging scale (Salter 235) with a jute bag attached to it. The heart girth, withers height and scrotal circumference were measured as described earlier. Data analysis was by standard statistical procedure (Steel and Torrie, 1960).

1.3 RESULTS

The results are presented in Table 1 - 4. In both groups of bucks the scrotal circumference (Sc) increased with testes weight (Tw), testes volume (Tv), age, body

weight (Bw), heart girth (Hg) and withers height (Wh) (Tables 1 and 3).

There were high correlations between Sc and Bw, Sc and Hg, Sc and Tw, Sc and Age, Bw and age, Hg and age, Wh and age in both groups of bucks (Tables 2 and 4).

The relationship between Tw and Sc is described by the equation Tw = -101.84 ± 10.37 (Sc) ($r = 0.95$, s.e.e. = 6.25, $P < 0.005$). Tv and Sc are best related by the equation Tv = -97.21 ± 9.96 (Sc) ($r = 0.96$, S.e.e. = 5.4, $P < 0.005$). Also Tw and Tv were found to be related as follows: Tw = 1.36 ± 0.95 (Tv) ($r = 0.99$, S.e.e = 1.76, $P < 0.005$).

The prediction equation for Sc was found to be $Sc = -0.0032X_1 + 0.016X_2 + 0.938X_3 - 0.594X_4 - 24.826$, where X_1 = age, X_2 = withers height, X_3 = heart girth and X_4 = body weight.

1.4 DISCUSSION

This study shows that scrotal circumference is highly correlated with the paired testes weight and volume in Red Sokoto bucks, and could therefore be a good estimator of testicular size. Other body parameters such as body weight, heart girth and withers height

are also correlated with the scrotal circumference and also the testes weight, with the correlation between the scrotal circumference and testes weight being the highest (r = 0.97).

The results are in agreement with findings in other species by several other workers. Lino (1972) reported that scrotal circumference is highly correlated with testicular development in rams. Scrotal circumference has high repeatability, is easy to measure, and is highly correlated with testicular weight in rams. Therefore, it may be used for prediction of testicular weight and epididymal spermatozoa reserves (Hahn et al., 1969; Lino, 1972). In Bunaji bulls, Osinowo et al. (1981) showed that scrotal circumference is highly correlated with testicular size and gonadal sperm reserve (r = 0.69). In rams Osinowo et al. (1985) also found that scrotal circumference is highly correlated with testes weight, seminiferous tubule diameter and gonadal and epididymal sperm reserves.

Since testicular size estimate from scrotal circumference measurements provides an accurate estimate of the amount of sperm producing parenchyma in the testes (Coulter and Foote, 1979), it could therefore be used in selecting bucks which would be expected to have higher gonadal and epididymal sperm reserves for breeding.

1.5 SUMMARY

The relationship between scrotal circumference and body size was investigated in 2 groups of bucks. Results showed that there were high correlations ($P < 0.005$), between scrotal circumference (Sc) and body weight ($r = 0.80-0.82$), Sc and heart girth ($r = 0.85-0.87$), Sc and testicular weight ($r = 0.97$), Sc and age ($r = 0.70-0.72$), body weight and age ($r = 0.70-0.98$), heart girth and age ($r = 0.89-0.94$) and withers height and age ($r = 0.80-0.90$).

These positive relationships show that scrotal circumference measurements can provide a good estimate of testicular size. Scrotal circumference has positive and high correlations with other body parameters. It can therefore be used in selecting bucks which would be expected to have higher gonadal and epididymal sperm reserves as well as other desirable traits for breeding.

Table 1: Changes in Scrotal circumference, heart girth, withers height, body weight, testicular weight and volume with age, for first group of 34 bucks.

Age (weeks)	No of bucks	Scrotal circum-ference (cm)	Body weight (kg)	Heart girth (cm)	Wither height (cm)	Testi-cular weight (gm)	Testi-cular volume (cc)
12-24	3	12.5±4.2	8.5±2.9	40.2±3.1	37.6±3.1	30.4±3.2	30.1±1.2
24-36	4	15.1±5.2	10.5±4.3	45.1±2.0	40.2±3.2	51.7±2.9	50.2±3.0
36-48	10	17.4±2.1	14.5±5.6	50.3±3.5	43.9±2.6	58.4±3.1	56.9±3.1
48-60	11	19.2±3.9	17.8±2.0	55.2±3.5	47.3±3.3	64.5±5.1	63.8±2.2
60-72	6	21.1±2.2	20.9±3.1	61.6±2.5	50.7±2.9	68.9±3.6	67.2±4.1

Table 2: Correlation Coefficient of the body parameters measured in the first group of 34 bucks.

	Age	Bw	Hg	Wh	Tw	Tv
BW	0.90	-	-	-	-	-
HG	0.89	0.98	-	-	-	-
WH	0.80	0.88	0.90	-	-	-
TW	0.88	0.96	0.89	0.89	-	-
TV	0.88	0.95	0.89	0.89	0.99	-
SC	0.72	0.80	0.85	0.71	0.97	0.97

Table 3: Changes in scrotal circumference, heart girth, liveweight and withers height with age for the second group of 40 bucks.

Age (weeks)	No of bucks	Scrotal circum-ference (cm)	Body weight (kg)	Heart girth (cm)	Withers height (cm)
6	9	8.5±4.5	5.4±1.6	39.6±7.0	39.4±3.0
17	5	16.7±1.1	8.9±1.7	49.0±5.6	41.4±6.3
18	9	17.7±2.3	11.3±2.3	53.2±2.4	48.5±5.5
24	2	18.7±1.4	17.0±0.5	61.0±0.5	57.5±2.0
30	6	21.6±1.6	23.8±2.0	67.1±1.4	63.9±4.6
36	3	20.4±1.2	31.5±2.2	73.0±1.1	65.0±1.3
48	4	22.0±2.1	36.0±2.4	76.7±0.2	66.5±4.3
56	2	22.3±1.2	38.5±2.0	79.5±1.4	66.0±0.8

Table 4: Correlation coefficient of the body parameters in the second group of 40 bucks.

	Age	Bw	Hg	Wh
Bw	0.98	-	-	-
Hg	0.94	0.96	-	-
Wh	0.90	0.91	0.92	-
Sc	0.70	0.82	0.87	0.77

SECTION B

POSTNATAL GROWTH AND DEVELOPMENT OF REPRODUCTIVE ORGANS IN RED SOKOTO BUCKS

2.1 INTRODUCTION

Postnatal growth and development of the reproductive tract of bucks have been less studied than those of other farm animals such as cattle and sheep. In cattle for instance, several workers have studied testicular growth and development (Hahn, et al., 1969; Coulter et al., 1975; Osinowo, et al., 1981; Oyedipe et al., 1981), and the effect of various factors on testicular development (Willett and Ohms, 1957; Lino, 1972). Extensive studies have also been conducted on the reproductive tract growth and development in sheep (Wiggins and Terrill, 1953; Daudu, 1984; Osinowo et al., 1985).

In goat breeding, optimal rate of genetic improvement can be realized through selection. This can be enhanced by a high reproduction rate, achieved for example through accelerated kidding schemes. Red Sokoto goats, the most numerous and widely distributed in Nigeria especially the Northern part, could respond suitably to accelerated kidding schemes. But their early sexual development has not been studied. In rams, Dyrmundsson (1973) showed that there is considerable variation between and within breeds in the rate of postnatal sexual development. This trend could be

obtainable in bucks, thus making it necessary to conduct studies for each breed under conditions in which it will be used. Body size, testicular sperm reserve and epididymal storage capacity of mature Yankasa rams have been studied (Daudu, 1984). The present study is on postnatal growth and sexual development in Red Sokoto bucks between 7 and 180 days of age with particular reference to onset of spermatogenesis, gonadal and accessory sex organ development and attainment of breeding capacity.

2.2 MATERIALS AND METHODS

2.2.1 Flock management and measurement of body parameters before and after slaughter.

A herd of 53 Red Sokoto does provided the male kids used for this study. The does were bred to bucks of the same breed. The joining ratio was 1 male to 8 females. Kidding occurred over a one month interval. At the end of kidding, 24 male kids were selected for the study.

The kids were left with their dams which were grazed on improved pasture for 6hr daily, together with an initial feeding of a 75% maize and 25% cotton seedcake concentrate supplement at the rate of 250g per animal per day.

In the last weeks of the experiment the concentrate supplement was changed to 75% wheat offal and 25% cotton seedcake. This change was due to scarcity of maize. Mineral salt licks and water were fed ad libitum. All the goats were routinely dewormed with Panacur and deticked with Delnave or Gamatox.

Three male kids per period were serially slaughtered at 7, 30, 60, 90, 120, 150 180 days of age. Before slaughter, ther liveweight, heart girth, withers height and scrotal circumference of the bucks were determined as in the previous section. Their ages owere obtained from records.

Immediately after slaughter, the testes, epididymis, vesicular glands and penis were dissected out and weighed with an electrical balance. Testicular volume was measured by water displacement method, using a run-off beaker. The epididymal length was measured with a ruler by stretching the epididymis on a table. The caput, corpus and cauda portions of each epididymis were then separated and weighed individually.

Degree of preputial separation was measured by pushing out the penis from the penile sheath and measuring the protrusion with a ruler. The penile length was measured by estimating the whole length from the external urethral orifice to the root of the penis. This was done

after obliterating the sigmoid flexure and stretching out the full length of the penis. The penis was then weighed.

2.2.2 Histological procedures

Thin slices (0.5-1cm) from the testis, epididymis, ductus deferens, vesicular gland and ampulla were taken and fixed in Bouin's solution for histological studies. Samples were fixed in the Bouin's solution for 72hrs, and then processed for histological study using standard techniques (Osinowo et al., 1981). Paraffin wax sections (3 - 5 microns thick) were stained with hematoxylin and eosin (H & E) and periodic acid schiff (PAS) stains.

Slides were first examined with a light microscope under low power (x65), and detailed studies done under high dry (x400) and oil immersion (x1000) objectives. Seminiferous tubule and epididymal duct diameters were each calculated as the mean of 20 round tubules measured on slides of testicular and epididymal sections, using graticules.

2.2.3 Sperm reserve determination

a) Gonadal sperm reserve

The tunica albuginea of each testis was removed with a scalpel blade and the testis parenchyma homogenized in 50ml of formal saline using an Atomix blender (M.S.E) at full speed for about 2 minutes. Each homogenate was then rinsed out of the blender into a measuring cyclinder with an additional 20ml of formal saline. The final homogenate volume was then recorded. Five mls. of the latter was pipetted out into a conical flask and diluted with 80ml of formal saline. This was then stored overnight at $5^{o}C$ to allow separation of sperm and spermatids from testicular tissues. After storage, a suitable dilution of the homogenate was taken and the sperm/spermatid numbers were determined, using a haemocytometer. The sperm/spermatid counts were taken in quadruplicates from which the mean sperm count was determined.

b) Epididymal sperm reserve

Each epididymal part (caput, corpus or cauda) was minced with a sharp scissors in 20ml of formal saline in a conical flask. This was stored overnight at $5^{o}C$

to allow separation of spermatozoa and spermatids from other tissues. The minced samples were filtered through a wire-gauze to remove epididymal tissue, and the filtrate volume was measured. The samples were then diluted with suitable amounts of formal saline and the sperm concentration estimated in quadruplicates using a hemocytometer. These methods for estimating gonadal and epididymal sperm reserves were in accordance with that used by Osinowo *et al.* (1981).

Data analysis was by standard statistical procedures (Steel and Torrie, 1960). Correlation coefficents were obtained from both linear ($Y = a + bx$) and geometric ($Y = ax^b$) regressions where Y, a, b and x are dependent variable, constant, regression coefficient and independent variable respectively.

2.3 RESULTS

Mean values of body size and reproductive traits of the Red Sokoto bucks from 7 to 180 days of age are presented in Table 1. Correlation coefficents between traits, derived from linear and goemetric regressions are presented in Table 2.

2.3.1 Growth and body size

Average daily gain over the entire period was 58.4g. The growth curve was best described by the equation: $Lw = 0.5104\ A^{0.5833}$ ($r = 0.94$, s.e.e. = 0.23), where Lw is liveweight (Kg) and A is age (days).

2.3.2 Testicular growth and development

Scrotal circumference (Sc, cm), testes weight (Tw, g) and seminiferous tubule diameter were highly correlated to each other, as well as to age and liveweight (Table 2). The relationship between testes weight (Tw) and scrotal circumference (Sc) was best described by the equation: $Tw = 0.0028\ Sc^{3.514}$ ($r = 0.99$, s.e.e = 0.14). Both age and liveweight were best related to testes weight by the equations: $Tw = 0.00105A^{1.478}$, ($r = 87$, s.e.e. = 0.91) and $Tw = 0.091\ Lw^{2.66}$ ($r = 0.98$, s.e.e. = 0.38), respectively.

Between 7 and 120 days of age, testes weight increased about 64.3 fold while scrotal circumference increased 2.1 fold. At the same time the weight of the epididymis and penis increased about 16.5 and 5.6-fold, respectively.

The seminiferous tubules at 7 days were small, averaging 3.6 ± 0.04 microns in diameter (Table 3), with no lumen and containing only a single layer of spermatogenic cells (Fig. 1).

Intertubular space was largest between 7 and 30 days of age. There was a 3.6 fold increase in seminiferous tubule diameter between 7 and 120 days. At 90 days, lumina appeared in some of the seminferous tubules in one out of three bucks, and by 120 days, lumina were seen in all seminiferous tubules in all the bucks. Concurrently the intertubular spaces had also reduced significantly (Fig. 2).

Spermatogenesis had commenced in one out of three bucks by 90 days, and in all the bucks by 120 days (Table 3 and Fig. 3). The same buck which commenced spermatogenesis at 90 days had some testicular spermatozoa and also had the highest liveweight (8.6kg) and the largest testes (31.3g) within its age group. Testicular spermatozoa were present in all bucks by 120 days of age (Table 3).

Gonadal sperm/spermatid count averaged 6.3×10^6 at 90 days, increasing to 2247.7×10^6 cells by 180 days. The number of spermatozoa per gram of epididymal and testicular tissue is shown in Table 5. The caput, corpus and cauda epididymides had relative weights of 1:0.42:1.13 respectively, while their corresponding ratio for sperm reserve/g of tissue was 1:1.1:4.4.

2.3.3 Accessory sex organs

There was a 3.7 fold increase in epididymal tubule diameter between 7 and 120 days. Epididymal spermatozoa were present in all bucks by 120 days of age, during which the epididymal tubule diameter averaged 26.12±0.62 microns (Table 4). Epididymal growth was closely correlated to testicular growth (Table 2). The mean epididymal sperm reserve was $223.0x10^6$ at 120 days, increasing to $1263.5x10^6$ cells by 180 days (Table 1). Figures 4 and 5 show how spermatozoa had accummulated in the tubules of epididymides at 120 and 180 days respectively.

The paired vesicular glands weighed 0.2g at 7 days, increasing to 6.6g at 180 days of age. Vesicular gland growth was highly correlated to age, liveweight, scrotal circumference, and to the weights of testis, epididymis and penis (Table 2). By 90 days, some secretions were observed in about 70% of the open ducts of the vesicular glands (Fig. 6). By 150 days of age, all the ducts contained some secretions (Fig. 7).

The ductus deferens epithelium contained two layers of cells in all age groups. There were outer and inner layers of tall and low columnar epithelial cells. This pattern made the epithelium appear pseudostratified.

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The epithelial cells began to produce some secretions from 90 days of age. There was no increase in size of the ductus deferens with age.

The ampulla was similar to the ductus deferens except that the epithelial folds were more convoluted. In addition, there was no significant change in size of the ampulla with age, except that the glands started producing some secretions from 90 days of age. By 120 days of age, the ampulla was highly active and produced a lot of secretions.

2.3.4 Penile growth and development

The rate of increase in penile length decreased drastically after 120 days, but the penile weight increase still continued till about 180 days. The separation of the penis from the penile sheath was insignificant in all bucks before 90 days of age. Complete separation was observed by 180 days.

2.4 DISCUSSION

The results of this study show that the development of the reproductive organs in Red Sokoto bucks was more closely correlated to body weight than age, with heavier

bucks showing more advanced development than lighter ones of the same age group. This finding compares well with the previous work done by Watson et al. (1956), which indicated that although testicular weight varied with age in Merino rams, it was more closely related to body weight. In addition, Terrill (1974) reported that sexual maturity in ram lambs is more closely related to body weight than age. In this study, it was found that spermatogenesis had commenced by 90 days in one out of three bucks which had the highest body weight (8.6kg) and testicular weight (31.3g) within its age group. By 120 days however, spermatozoa were found in the caput, corpus and cauda epididymides of all bucks. In the indigenous Yankasa rams, Osinowo et al (1985) found that testicular spermatozoa were present in one out of three rams which had the highest liveweight (17kg) and largest testes (100.8g) within the same age group of 98 days. There is no previously reported work on the indigenous bucks for comparison. However, it is evident from the present work that liveweight influences sexual development and attainment of puberty. Since the heavier bucks had gonadal spermatozoa at 90 days of age, it is recommended that such bucks be weaned by this age to prevent indiscriminate and unplanned breeding. Puberty, defined as the age when the male is first able to release

spermatozoa, was attained in this study between 120 and 180 days, at a body weight range of 10-12kg. This contrasts with the results of Ragab et al. (1966) in Rahmani rams which attained puberty at 177 - 456 days and 26 - 41kg body weight. Yankasa rams in Nigeria attained puberty between 189 and 273 days at a body weight range of 18 - 26kg (Osinowo et al., 1985). Yao and Eaton (1954) reported that puberty was attained in an American breed of goat between 114 and 135 days of age at a body weight range of 18 - 20kg. The report by Yao and Eaton is in conformity with the present study. It appears therefore that the variation in age and body weight at which puberty occurs seems to be due to breed differences, plane of nutrition and management practice.

Penile adhesions disappeared between 150 and 180 days of age in bucks in this study. Yao and Eaton (1954) reported that urethral process in all bucks older than 112 days was free from the prepuce. In contrast, Wiggins and Terrill (1953) reported that urethral process of rams become free from the prepuce at the age of 91 days, although a number of the older lambs still had the process attached. Osinowo et al. (1985) showed that separation of penis from the penile sheath was completed by 271.6 days. The age of complete preputial separation therefore seems to be linked with the genetic composition of the animal as well as plane of nutrition.

In general, development and growth of the body, gonad and accessory sex organs were highly correlated. The high correlation between scrotal circumference and the other traits studied is in conformity with what has been reported in the ram by other investigators (Osinowo *et al*., 1985). This correlation is an indication that scrotal circumference can be a good indicator of sexual development in the buck, as has been reported in the ram. In the present study, body weight was found to influence age at puberty in kids.

The cauda epididymidis weighed highest and contained the highest number of spermatozoa/g of tissue. This pattern, together with the relative sizes of different parts of the epididymis has also been observed in indigenous rams by Osinowo *et al* (1985). In either case, the cauda epididymidis appeared to be a storage site.

The onset of spermatogenesis preceded the complete breakdown of penile adhesions and large accummulation of epididymal sperm reserves, which are necessary adjuncts for successful mating. Some accessory sex organs started production of secretions by 90 days, but full secretory activity was not attained until about 150 - 180 days. In this regard, full functional capacity by all parts of the reproductive tract was not attained in all the bucks until about 180 days in this study. It is therefore

recommended that Red Sokoto bucks be considered for breeding from 180 days of age if they weight at least 12kg.

2.5 SUMMARY

Postnatal growth and development of the reproductive organs in 21 Red Sokoto bucks were studied. The animals were serially slaughtered at 7, 30, 60, 90, 120, 150 and 180 days of age. Dimensions and weights of the testes, epididymides, vesicular glands and penis were recorded and preputial separation noted. Histological sections were prepared and studied for each age group. Gonadal/epididymal sperm reserves were also studied.

The average daily gain by the bucks was 58.4g for the entire period. There were high correlations between age, liveweight, heart girth, scrotal circumference gonadal and accessory sex organ development. Scrotal circumference (Sc) was related to testes weight (Tw) by the equation: $Tw = 0.0028\ Sc^{3.5}t^{14}$ ($r = 0.99$). Spermatogenesis had commenced in all bucks by 90 - 180 days. Spermatozoa were present in the testes and epididymides of all bucks at 120 days. All penile adhesions had disappeared by 180 days. Vesicular glands started producing secretions from 90 days and by 150 days, they were full of secretions.

Gonadal sperm/spermatid count per buck averaged $1740.6x10^6$, $2077.2x10^6$ and $2247.7x10^6$ cells at 120, 150 and 180 days respectively. Epididymal sperm reserves at the same ages were $223.0x10^6$, $1002.7x10^6$ and $1263.5x10^6$ spermatozoa respectively.

It is therefore concluded that Red Sokoto bucks can be used for breeding from about 180 days of and 12kg liveweight. By this age and body weight, all components of the reproductive tracts are fully functional, as evidenced by the data obtained in the present study.

Table 1: Means of body measurements and reproductive organs at different ages from 7 days to 180 days in Red Sokoto bucks.

TRAITS	AGE OF BUCKS IN DAYS 7	30	60	90	120	150	180
Live weight (kg)	1.9	3.5	4.0	6.0	10.0	10.7	12.0
Heart girth (cm)	28.5	35.3	37.7	42.3	50.3	50.3	52.0
Withers height (cm)	29.3	33.7	35.3	40.2	43.7	47.5	49.0
S. Circumference (cm)	5.1	6.3	7.0	10.2	15.7	17.3	18.0
Right Testicular weight(gm)	0.4	1.0	1.2	6.8	26.1	34.4	34.4
Left testicular weight (gm)	0.4	1.0	1.2	6.8	26.0	33.9	34.4
Right testicular volume(ml)	0.4	1.0	1.1	7.0	25.7	33.6	34.7
Left testicular volume (ml)	0.5	1.0	1.1	6.7	25.3	34.0	34.5
Right Epididymal weight(gm)	0.2	0.4	0.8	1.5	3.5	4.6	5.0
Left Epididymal weight (gm)	0.2	0.4	0.8	1.5	3.7	4.8	5.0
Preputial separation (cm)	0.0	0.0	0.0	0.5	2.3	3.2	3.3
Penile length (cm)	10.9	15.6	18.1	19.6	21.0	22.1	23.0
Penile weight (gm)	1.4	3.3	4.2	6.6	9.5	10.0	11.7
R. Seminal V. weight (gm)	0.1	0.4	0.7	1.0	2.0	2.7	3.3
L. seminal vesicle wt. (gm)	0.1	0.3	0.7	1.1	2.0	2.6	3.3
R. Epididymal length (cm)	3.2	4.3	5.1	6.4	10.0	10.7	10.8
L. Epididymal length (cm)	3.2	4.3	5.3	6.6	9.8	10.7	10.7
Right testicular sperm reserve $x10^6$	-	-	-	4.2	911.6	988.1	1116.9
Left testicular sperm reserve $x10^6$	-	-	-	2.1	829.0	1089.1	1130.8
Right epididymal sperm reserve $x10^6$	-	-	-	-	127.2	434.4	497.6
Left epididymal sperm reserve $x10^6$	-	-	-	-	95.8	568.3	765.9
Seminiferous tubule diameter (microns)	3.6	3.7	3.7	6.3	16.5	17.3	20.6
Epididymal tubule diameter (microns)	5.5	5.5	6.5	19.8	26.1	18.0	28.3

S = Scrotal

R = Right
L = Left

Table 2. Correlations between age, liveweight and body/reproductive traits in Red Sokoto bucks.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	Age	1	0.94	0.92	0.89	0.87	0.87	0.87	0.87	0.86	0.93	0.92	0.72	0.91	0.94	0.91	0.90	0.90	0.92	0.80	0.85	0.63	0.62	0.51	0.46
2	Lw	0.96	1	0.98	0.96	0.98	0.98	0.98	0.98	0.97	0.99	0.98	0.88	0.91	0.97	0.96	0.95	0.98	0.99	0.92	0.92	0.77	0.77	0.62	0.58
3	Hg	0.91	0.96	1	0.97	0.96	0.96	0.96	0.96	0.95	0.98	0.97	0.87	0.91	0.99	0.95	0.95	0.98	0.98	0.87	0.88	0.91	0.69	0.68	0.67
4	Wh	0.91	0.94	0.97	1	0.96	0.96	0.95	0.96	0.95	0.94	0.96	0.89	0.87	0.96	0.91	0.91	0.96	0.96	0.87	0.88	0.93	0.70	0.64	0.76
5	Sc	0.93	0.99	0.95	0.94	1	0.99	0.99	0.99	0.99	0.97	0.98	0.94	0.85	0.95	0.94	0.94	0.99	0.99	0.95	0.93	0.82	0.81	0.65	0.88
6	RTW	0.88	0.96	0.89	0.90	0.91	1	0.99	0.99	0.99	0.98	0.98	0.94	0.86	0.95	0.94	0.94	0.99	0.99	0.95	0.93	0.81	0.79	0.64	0.86
7	LTW	0.88	0.96	0.89	0.89	0.91	0.99	1	0.99	0.99	0.97	0.98	0.94	0.85	0.95	0.94	0.94	0.99	0.99	0.95	0.93	0.81	0.80	0.64	0.56
8	RTW	0.88	0.95	0.89	0.89	0.97	0.99	0.99	1	0.99	0.97	0.98	0.94	0.85	0.95	0.93	0.93	0.99	0.98	0.95	0.84	0.81	0.80	0.63	0.66
9	LTV	0.88	0.95	0.88	0.87	0.97	0.99	0.99	0.99	1	0.97	0.97	0.95	0.84	0.94	0.93	0.93	0.99	0.98	0.95	0.93	0.82	0.81	0.64	0.67
10	REW	0.92	0.97	0.91	0.89	0.98	0.99	0.99	0.99	0.99	1	0.99	0.88	0.92	0.98	0.98	0.97	0.98	0.99	0.89	0.89	0.87	.76	0.59	0.63
11	LEW	0.90	0.96	0.89	0.87	0.97	0.98	0.99	0.99	0.99	0.99	1	0.89	0.90	0.97	0.97	0.97	0.99	0.99	0.90	0.89	0.9	.77	0.61	0.64
12	PS	0.89	0.96	0.89	0.90	0.98	0.99	0.99	0.99	0.99	0.98	0.98	1	0.71	0.82	0.83	0.83	0.93	0.91	0.93	0.84	0.9	0.90	0.74	0.67
13	PL	0.86	0.88	0.91	0.88	0.87	0.78	0.78	0.78	0.79	0.82	0.81	0.78	1	0.93	0.91	0.89	0.88	0.88	0.72	0.76	1	0.62	0.52	0.47
14	PW	0.89	0.94	0.98	0.97	0.95	0.89	0.89	0.89	0.87	0.91	0.88	0.88	0.87	1	0.97	0.96	0.96	0.96	0.84	0.85	.	.64	0.55	0.49
15	RSVW	0.90	0.91	0.86	0.84	0.91	0.90	0.91	0.91	0.90	0.95	0.94	0.91	0.74	0.89	1	0.99	0.94	0.95	0.85	0.84	0.7	0.69	0.54	0.48
16	LSVW	0.91	0.91	0.87	0.86	0.92	0.91	0.91	0.91	0.91	0.95	0.94	0.91	0.76	0.90	0.99	1	0.94	0.94	0.85	0.86	0.71	0.69	0.53	0.48
17	REL	0.92	0.98	0.96	0.94	0.99	0.97	0.97	0.97	0.96	0.97	0.97	0.96	0.87	0.95	0.90	0.90	1	0.99	0.93	0.91	0.80	0.79	0.65	0.58
18	LEL	0.93	0.99	0.97	0.95	0.99	0.96	0.96	0.96	0.95	0.97	0.96	0.96	0.88	0.94	0.90	0.91	0.99	1	0.92	0.91	0.80	0.79	0.64	0.57
19	STD	0.94	0.96	0.86	0.87	0.94	0.93	0.93	0.93	0.93	0.93	0.92	0.94	0.74	0.86	0.90	0.90	0.92	0.92	1	0.94	0.85	0.83	0.66	0.60
20	ETD	0.94	0.94	0.89	0.88	0.93	0.88	0.88	0.88	0.88	0.90	0.89	0.83	0.79	0.87	0.85	0.86	0.92	0.93	0.93	1	0.7	.72	0.56	0.55
21	RTSR	0.79	0.85	0.73	0.74	0.86	0.88	0.89	0.88	0.89	0.87	0.88	0.91	0.67	0.70	0.79	0.79	0.84	0.86	0.86	0.77	1	0.96	0.63	0.57
22	LTSR	0.78	0.85	0.71	0.70	0.85	0.87	0.88	0.88	0.89	0.86	0.88	0.90	0.70	0.66	0.75	0.74	0.83	0.85	0.7	0.77	0.9	1	0.76	0.72
23	RESR	0.68	0.71	0.61	0.66	0.69	0.72	0.71	0.71	0.71	0.69	0.69	0.73	0.59	0.61	0.58	0.57	0.70	0.70	0.69	0.61	0.63	0.76	1	0.98
24	LESR	0.63	0.65	0.53	0.57	0.62	0.64	0.64	0.64	0.63	0.63	0.63	0.67	0.53	0.54	0.54	0.53	0.62	0.62	0.63	0.55	0.57	0.72	0.98	1

Correlation coefficients are simple below and geometric above the diagonal.

Table 3: Testicular Histology (Seminiferous tubules) showing the effect of age on lumen formation, number of germinal layers in the Seminiferous tubules, appearance of primary spermatocytes and spermatids Seminiferous tubule diameter and onset of spermatogenesis.

Animal Tag No.	Age (days)	% tubule with lumen	No. of germinal layers	Appearance of primary spermatocytes	Appearance of spermatids	Seminiferous tubule diameter (U)	% Spermato-genesis
3610 3612 3607	7	-	1	-	-	3.58±0.04	-
577 578 579	30	-	1	-	-	3.79±0.11	-
581 583 580	60	-	1	-	-	3.71±0.07	-
585 586 1033	90	+80	1-2	+	+	6.25±0.21	+80
571 573 1009	120	+++100	4-6	+++	+++	16.49±61.0	+++100
565 581A 1007	150	+++100	5-6	+++	+++	17.34±0.78	+++100
558 559 562	180	+++100	5-6	+++	+++	20.64±0.63	+++100

\+ In one out of 3 bucks
+++ In all the 3 bucks

Table 4: Measurements taken from sections of epididymides showing the effects of age on lumen size and percentage tubules containing spermatozoa.

Animal No.	Age (days)	Lumen size (microns)	% Tubule containing spermatozoa
3610 3612 3607	7	5.49±0.23	-
577 578 579	30	5.21±0.1	-
581 583 580	60	6.50±0.75	-
585 586 1033	90	19.77±0.55	-
571 573 1009	120	26.13±0.62	90% +++
565 581A 1007	150	27.96±0.67	100% +++
558 559 562	180	28.28±0.67	100% +++

+++ = In all the 3 bucks.

Table 5: Number of spermatozoa per gram of epididymal and testicular tissue.

Tissue	Age	Mean wt. of tissue (gm)	Mean sperm reserve $x10^6$	Mean No. of sperms per gram of tissue $x10^6$
Caput EP	120	1.38	23.9	17.3
Corpus EP		0.69	15.1	21.9
Cauda EP		1.72	72.6	42.2
Testis		52.10	1740.6	33.4
Caput EP	150	2.0	61.7	30.9
Corpus EP		0.67	25.8	38.5
Cauda EP		2.0	415.4	207.7
Testis		63.3	2077.2	30.4
Caput EP	180	1.90	106.5	56.1
Corpus EP		0.85	32.0	37.6
Cauda EP		2.20	492.8	224.0
Testis		68.8	2299.7	33.4

EP = Epididymidis

Seminiferous tubules of a 7-day old buck showing absence of lumen, one cell layer on the epithelium and high proportion of intertubular space.

Mag. x 200.

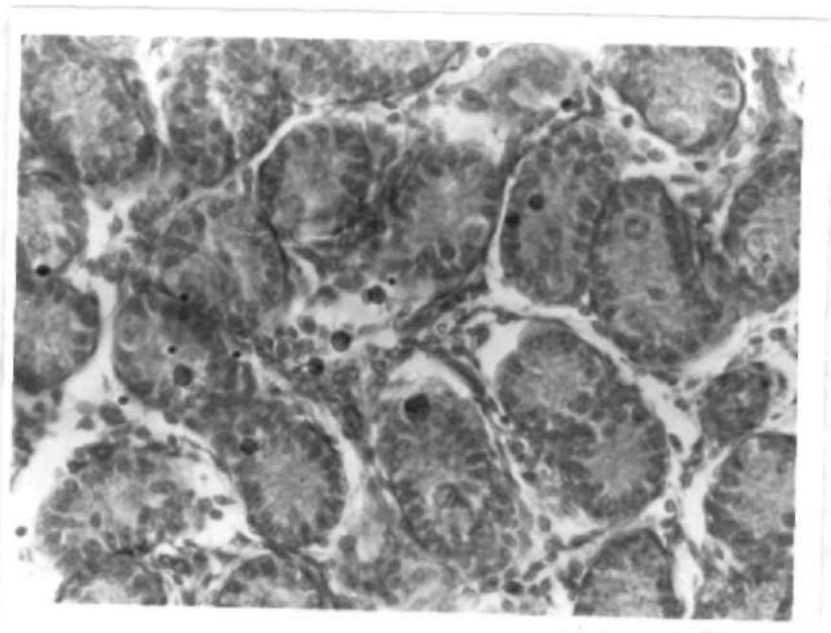


Fig. 1

Seminiferous tubules develop lumen at 90 days of age. The proportion of inter-tubular spaces has reduced significantly. Spermatogenesis has begun with a lot of primary spermatocytes in concentric layers along the walls of seminiferous tubule.

Mag. x 200.

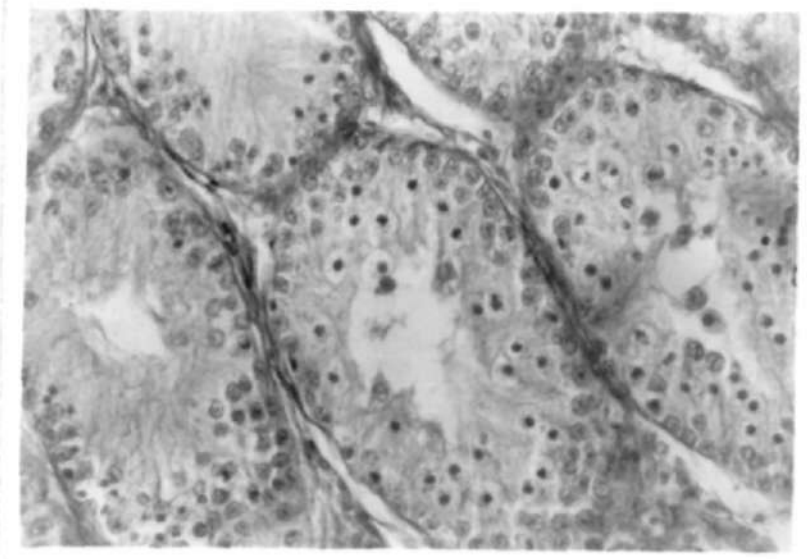


Fig. 2.

150-day old seminiferous tubules with full spermatogenic activity, showing 4 - 6 layers of germinal cells. There are primary spermatocytes, round and elongated spermatids.

Mag. x 200

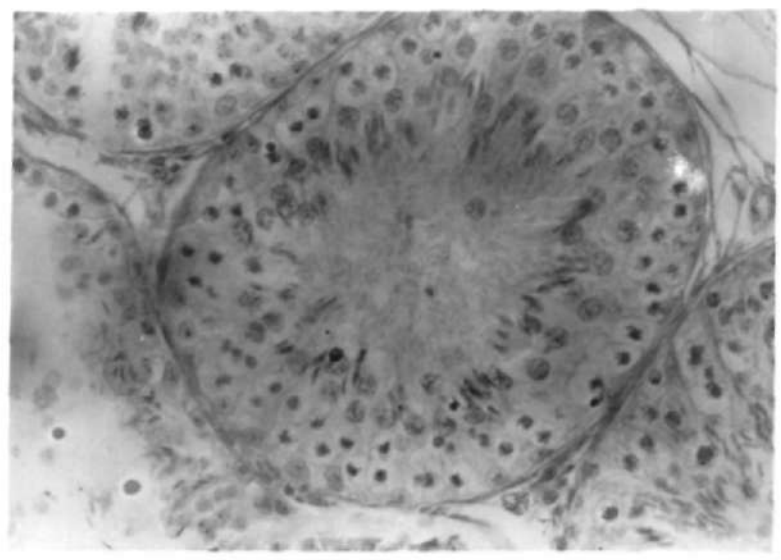


Fig. 3.

Epididymal tubules of 120-day old buck showing spermatozoa which had accummulated within the lumen of the epididymis. The figure also shows sterocilia along the lumen wall of the epididymis.

Mag. x 200.

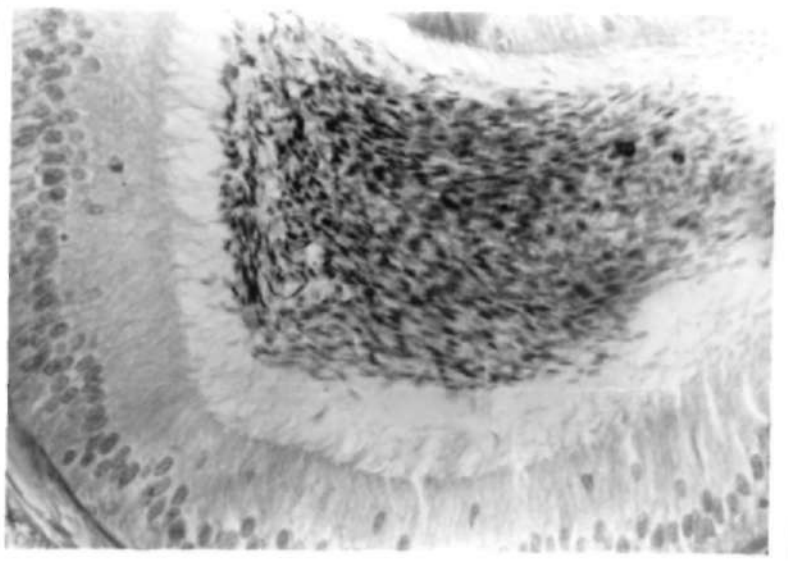


Fig. 4.

180-day old buck with high density of spermatozoa accummulated in the epididymal lumen. The luminal wall has well developed sterocilia.

Mag. x 200.

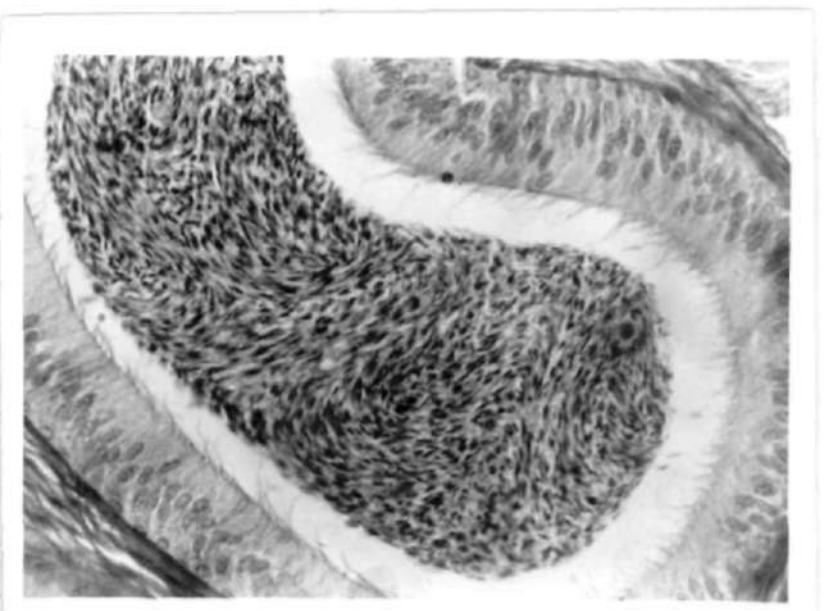
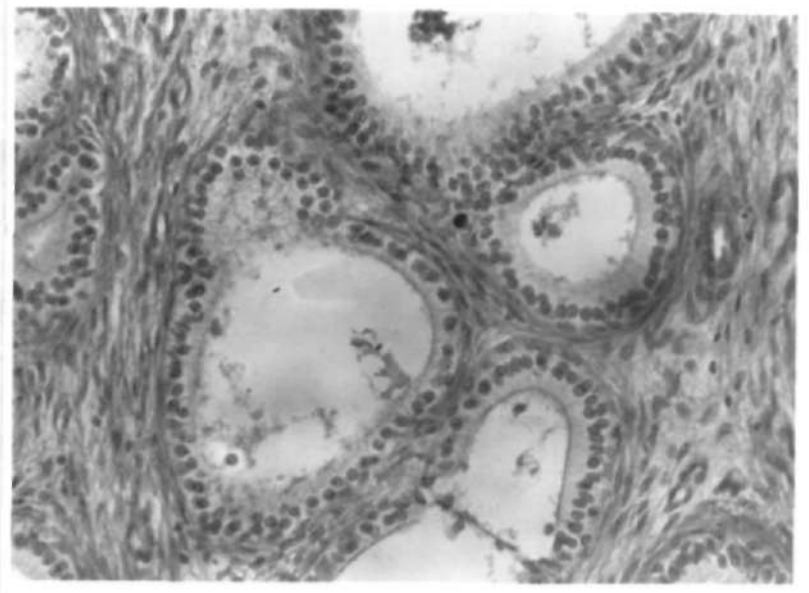


Fig. 5.

Vesicular gland of a 90-day old buck showing some of the ducts with vesicular gland secretions.

Mag. x 200.



150-day old vesicular gland. The ducts are large and well developed and contain a lot of vesicular gland secretions.

Mag. x 200.

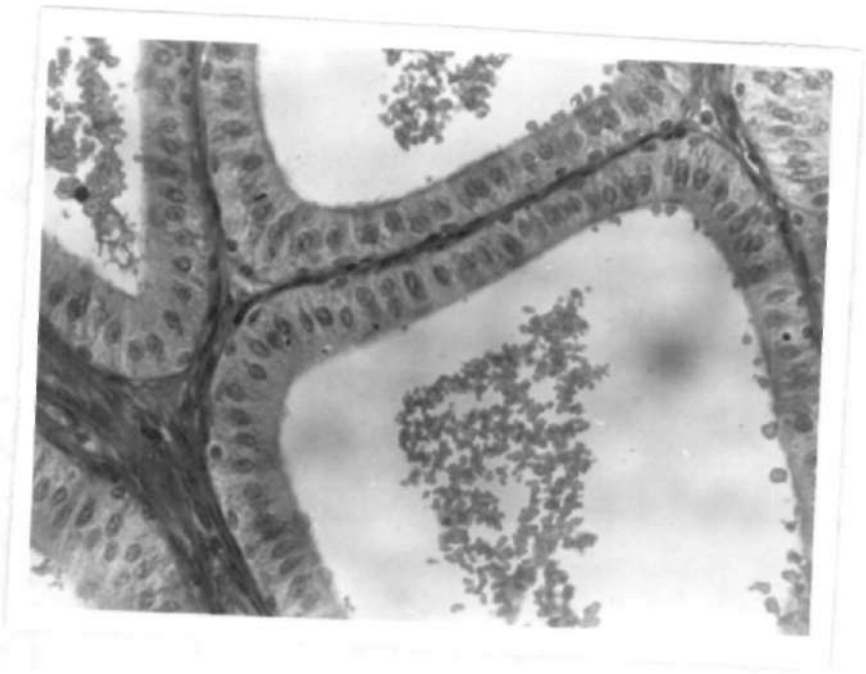


Fig. 7.

SECTION C

DETERMINATION OF PUBERTAL AGE BY RETROGRADE EJACULATION IN RED SOKOTO BUCKS.

3.1 INTRODUCTION

It has been shown radiographically that reflux of semen into the bladder occurs in rams during electrical stimulation, and that spermatozoa can be recovered from the urine of sexually rested rams (Havell et al., 1969).

Koefoed-Johnsen (1964) and Lino et al., (1967) showed that bulls and rams eliminate some spermatozoa through micturition and masturbation. However, the number of sperm voided in the urine may be a small percentage of the total production. Simone and Young (1931), Kennelly and Foote (1964) and Koefoed-Johnsen (1964) concluded that most unejaculated spermatozoa are resorbed in the excurrent duct system.

Puberty has been defined as the age when the male is first capable of releasing spermatozoa (Osinowo et al., 1985). Several methods have been used to determine the time of release of first spermatozoa. These include electroejaculation, epididymal sperm reserve determination and histological examination of testis and epididymis. Since masturbation and spontaneous ejaculation are known to occur in domestic animals such as bulls, rams and bucks (Amann, 1970) it appears that puberty can be

determined by continuous urine collection and examination of the latter for spermatozoa. This study was designed to determine puberty in Red Sokoto bucks using the retrograde ejaculation method.

3.2 MATERIALS AND METHODS

Two groups of Red Sokoto bucks were used in this study. The first group comprised 9 male kids ranging in age from 3 - 6 months. The ages were obtained from birth records. The animals were from the main breeding flock of the National Animal Production Research Institute (N.A.P.R.I), Shika, Zaria, and were managed under a semi-intensive system. They were grazed for 6hr daily, and were fed about 200g of a 75% maize or wheat offal; 25% cottonseed cake concentrate supplement per head/day.

Each buck was put in a metabolic cage for 24 hr beginning at 7.00 a.m. on the collection days. The urine collected at the end of the 24 hr period was centrifuged at 4,000 rpm for 15 minutes and the sediment was examined for spermatozoa under the light microscope, at x400 magnification. Urine was collected from each buck twice a ~~week~~ for 4 weeks, and examined for spermatozoa. The ages and body weights of bucks which voided spermatozoa in urine were recorded.

The second group comprised 4 bucks aged 3 months. The animals were also from N.A.P.R.I, and the ages were obtained from birth records. Twenty-four-hour urine samples were collected, three times a week from each animal, and examined as for the first group. This was done repeatedly until they all attained the age of seven months.

For both trials, total sperm count was done using a haemocytometer, and the sperm concentration (c) was calculated using the formula: C=50,000xNxV where N = number of spermatozoa counted, V=volume of the sediment; and 50,000 was a constant factor.

3.3 RESULTS

Results of this experiment are presented in Tables 1 and 2. In the first group of bucks, spermatozoa were first detected at the age of 151 days, at a body weight of 12.0 kg (Table 1). In the second group of bucks, spermatozoa were detected at the age of 150 days at a body weight of 11.8 - 12.5 kg (Table 2). In both groups, bucks of the same age, weighing less than 11.8 kg, had no spermatozoa in their urine samples.

3.4 DISCUSSION

The results of this study show that spermatozoa first appear in the urine of Red Sokoto bucks about 150 days of age at a minimum liveweight of 11.8 kg.

In section two of this chapter, it was shown that the accummulation of epididymal spermatozoa started at 4 months, and by the 5th month mumbered more than 1 billion. The heaviest bucks had the highest gonadal and epididymal sperm reserves. The results of the present study further emphasize the effect of body weight on age at puberty.

Puberty, defined as the age at which spermatozoa is detected in urine was attained at the age of 150 days. Bucks weighing less than 11.8 kg did not reach puberty until about 6 months of age.

According to Hans-Joachim De Haás and Horst (1979) goats attained puberty at the age of about 6 months, depending on body weight, breed and management. These authors also reported that body weight, much more than age, influences reproduction. The present finding is in agreement with these observations.

There was no consistency in the number of spermatozoa voided in the urine with increase in age or body weight. Lino et al. (1967) reported that the number of spermatozoa

voided in the urine represented only a small percentage of the total production, and did not depend on liveweight or age. They further commented that sexually rested animals may masturbate more often than those in use.

This method (retrograde ejaculation), offers a fairly good means of determining pubertal age and liveweight at which bucks build up sufficieht epididymal sperm reserves.

3.5 SUMMARY

Pubertal age in Red Sokoto bucks was determined by monitoring urinary spermatozoa output (retrograde ejaculation). A high concentration of spermatozoa were first detected in urine at five months of age in bucks weighing 11.8 kg. No spermatozoa were found in urine of bucks of the same age but weighing less. There was no definite relationship (correlation) between the number of spermatozoa voided in urine and increase in liveweight or age from five to seven months. Retrograde ejaculation method only offers a means of determining the age and liveweight at puberty in bucks.

Table 1: Age and body weight at which spermatozoa appeared in urine of 9 Red Sokoto bucks of varying ages.

Buck No.	Age (days)	Weight of buck (kg)	Mean 24 hr urine vol. (ml)	Total sperm count
1	90	6.8	165±3.0	0
2	91	6.2	145±4.0	0
3	92	7.8	112±6.0	0
4	123	8.5	120±6.2	0
5	123	11.0	180±2.0	0
6	150	10.5	186±4.0	0
7	151	12.0	190±5.0	520,000
8	152	12.5	175±6.0	360,000
9	183	14.0	200±10	900,000

Table 2: Age and body weight at which spermatozoa appeared in urine of 4 Red Sokoto bucks of the same age group from 90 - 210 days of age.

Buck No.	Age (days)	Weight of buck (kg)	Mean urine volume (ml)	Total sperm count
1	90	8.0	120±2.1	0
2	"	7.7	112±3.5	0
3	"	6.8	105±6.2	0
4	"	6.0	95±9.1	0
1	120	11.0	135±3.2	0
2	"	9.2	140±3.0	0
3	"	8.0	139±2.7	0
4	"	7.2	120±2.6	0
1	150	12.5	185±3.1	180,000
2	"	11.8	165±2.3	110,000
3	"	10.5	140±6.4	0
4	"	9.8	135±7.1	0
1	180	14.0	180±2.0	240,000
2	"	12.8	175±4.2	120,000
3	"	11.9	155±3.1	165,000
4	"	11.6	145±2.9	100,000
1	210	15.1	185±2.6	250,000
2	"	13.6	165±3.4	300,000
3	"	13.0	190±3.7	110,000
4	"	12.8	175±5.2	150,000

CHAPTER 3

GENERAL DISCUSSION AND CONCLUSION

1. GENERAL DISCUSSION

The results of this study showed that the development of the reproductive organs was more cclosely correlated to body weight than age, with heavier bucks showing more advanced development than lighter ones of the same age group. This finding compares well with the previous work done by Watson et al. (1956), which indicated that although testicular weight varied with age in Merino rams, it was more closely related to body weight. In addition, Terrill (1974) reported that sexual maturity in ram lambs was more closely related to body weight than age.

The study also showed that scrotal circumference was highly correlated with the paired testes weight and volume in Red Sokoto bucks, and could therefore be a good estimator of testicular size. Other body parameters such as body weight, heart girth and withers height are also correlated with the scrotal circumference and also the testes weight, with the correlation between the scrotal circumference and testes weight being the highest ($r = 0.97$).

The results were in agreement with findings in other species by several other workers. Lino (1972) reported that scrotal circumference was highly correlated with

testicular development in rams. Scrotal circumference has high repeatability, is easy to measure, and is highly correlated with testicular weight in rams. Therefore it may be used for prediction of testicular weight and epididymal spermatozoa reserves (Hahn et al., 1967; Lino, 1972).

Since testicular size estimate from scrotal circumference measurements provides an accurate estimate of the amount of sperm producing parenchyma in the testes (Coulter and Foote, 1979), it could therefore be used in selecting bucks which would be expected to have higher gonadal and epididymal sperm reserves for breeding work.

In this study also, it was found that spermatogenesis had commenced by 90 days in one out of three bucks which had the highest body weight (8.6)kg) and testicular weight (31.3 g) within its age group. By 120 days however, spermatozoa were found in the caput, corpus and cauda epididymis of all bucks. In the indigenous Yankasa rams, Osinowo et al. (1985) found that testicular spermatozoa were present in one out of three rams which had the highest liveweight (17 kg) and largest testes (100.8 g) within the same age group of 98 days. There are no previously reported work on the indigenous bucks for comparison.

However, it is evident from the present work that liveweight influences sexual development and attainment of puberty.

Since the heavier bucks had gonadal spermatozoa at 90 days of age, it is recommended that bucks be weaned by this age to prevent indiscriminate and unplanned breeding. Puberty, defined as the age when the male is first able to release spermatozoa, was attained in this study between 120 and 180 days, at a body weight range of 10 - 12 kg. This contrasts with the results of Ragab et al., (1966) in Rahmani rams which attained puberty at 177 - 456 days and 26 - 41 kg body weight. Yankasa rams in Nigeria attained puberty between 189 and 273 days at a body weight range of 18 - 26 kg (Osinowo et al., 1985). Yao and Eaton (1954) reported that puberty was attained in goats between 114 and 135 days of age at a body weight range of 18 - 20 kg. The report by Yao and Eaton is in conformity with the present study except for the higher body weight at puberty in their study. So the variation in age and body weight at which puberty occurs seems to be due to breed differences, plane of nutrition and management practice.

Penile adhesions completely disappeared between 150 and 180 days of age in bucks used in this study. Yao and Eaton (1954) reported that the urethral process in all bucks older than 112 days was free from the prepuce. In contrast, Wiggins and Terrill (1953) reported that the urethral process in rams become free from the prepuce at the age of 91 days, although a number of the older lambs still had the process attached. Osinowo et al., (1985) showed that separation of penis from the penile sheath in the Yankasa ram was complete by 271.6 days. The age of complete preputial separation therefore seems to be linked with the genetic composition of the animals as well as plane of nutrition.

In general, development and growth of the body, gonad and accessory sex organs were highly correlated. The high correlation between scrotal circumference and the other traits studied is in conformity with what has been reported in the ram by other investigators (Daudu, 1984; Osinowo, et al. 1985). This correlation is an indication that scrotal circumference can be a good indicator of sexual development in the buck, as has been reported in the ram. In the present study, body weight was found to influence age at puberty in kids.

The cauda epididymidis weighed higher then the caput or corpus, and contained the highest number of spermatozoa per gram of tissue. This pattern together with the relative sizes of different parts of the epididymis has also been observed in Yankasa rams by Osinowo et al., (1985). In either case, the cauda epididymidis appeared to be a storage site.

The onset of spermatogenesis preceded the complete breakdown of penile adhesions and large accummulation of epididymal sperm reserve which are necessary adjuncts for successful mating. Some accessory sex organs started production of secretions by 90 days, but full secretory activity was not attained until about 150 - 180 days. In this regard, full functional capacity by all parts of the reproductive tract was not attained in all the bucks until about 180 days in this study.

The results of the retrograde ejaculation experiments show that the age at which spermatozoa appeared in urine of Red Sokoto bucks depend on liveweight. The earliest age at which spermatozoa were detected in buck urine was 150 days at a minimum liveweight of 11.8 kg.

From earlier studies, in slaughtered bucks, the accummulation of epididymal spermatozoa started at 120 days, and by 150 days, the reserve was more than

1 billion spermatozoa. The heaviest bucks had the highest gonadal and epididymal sperm reserves. These two results therefore appear to emphasize the effect of body weight on sperm production.

From the retrograde ejaculation tests, puberty defined as the age at which spermatozoa is first detected in urine, was attained at the age of 150 days, though it was delayed in bucks weighing less than 11.8 kg till about 180 days. This finding is in agreement with the anatomical studies.

According to Hahs and Horst (1976), goats attained puberty at the age of about 6 months, depending on body weight, breed and breeding intensity. These authors also reported that weight much more than age, influences puberty. The present finding is in agreement with these reported observations.

It was observed that there was no consistency in the number of spermatozoa voided in the urine with increase in age or body weight. Lino (1972) reported that the number of spermatozoa voided in the urine represented only a small percentage of the total production, and did not depend on the liveweight or age. Retrograde ejaculation test, offers a fairly accurate means of determining the age and liveweight at puberty.

CONCLUSIONS

It is concluded from this study that reproductive development in Red Sokoto bucks is more closely related to liveweight than age, and can be predicted from scrotal circumference measurements on the live bucks. Full functional capacity of the reproductive tract in this breed is attained by 180 days of age and at about 12 kg liveweight. Red Sokoto bucks may be used for breeding from that age.

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