SPERMATOGENESIS IN INDIGENOUS BULLS IN NIGERIA

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A

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THESIS APPROVAL

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This is to certify that I carried out the work reported in this thesis in the Theriogenology Section, Department of Veterinary Surgery and Medicine, Ahmadu Bello University under the supervision of Professors R. Zemjanis and S. M. Dennis.

The work of other investigators is acknowledged and referred to. No part of this thesis has been submitted elsewhere for a degree or diploma.



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DEDICATION

This Thesis is dedicated to my parents and brothers in Ghana, for their continuous encouragement and understanding.

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INTRODUCTION

In tropical countries animals play an important role as sources of protein. Protein intake per capita per day in Nigeria is low compared with the intake in developed countries. Daily intake per capita of animal protein in Nigeria has been estimated at 5 to 8 grams (F.A.O., 1971; Idusogie, 1971; Olayide et al., 1972). On the basis of the amount of protein in the national food supplies of 83 countries, Nigeria was among the lowest five (F.A.O., 1968). Inadequate supply is given as the main reason. The causes of inadequate supply include: low reproductive performance; poor and inadequate nutrition, and nomadic husbandry practices.

The low reproductive efficiency of indigenous cattle is considered to be due to nutrition, management, disease, and their interaction. Undernutrition delays sexual maturity, possibly as a result of decreased output of gonadotropic hormones by the anterior pituitary. Almost 90 per cent of the reported 8.5 million cattle in Nigeria are owned by nomadic Fulanis. Fulani are excellent cattlemen but their traditional nomadic

husbandry practices are not production-oriented.

There is little information on the reproductive performance of indigenous cattle, and the role of the bull in infertility has not been investigated in Nigeria. Available information suggests a seasonal breeding pattern in indigenous cattle breeds. With the increasing demand for animal protein, this investigation was undertaken to determine the role that the bull plays in lowered reproductive performance. The objectives of this study were to investigate spermatogenesis in indigenous bulls and relate it to seasons.

REVIEW OF LITERATURE

A. Reproductive Performance

1. Indigenous Cattle

a. Fertility Indices

Reproductive performance of indigenous cattle is low (Lamorde and Weinman, 1972; Wheat and Broadhurst, 1972; Akpokodje, 1974). Parameters commonly used to estimate breeding performance include: age at first calving, calving interval, 60 and 90-day non-return rate, and generation interval. Most information for nomadic herds has been based on surveys, and emphasis given to parameters other than per cent annual calf crop, calving interval, distribution of calvings, age at first calving, and service period. Data, therefore, had to be extrapolated whenever possible (Tables 1-4).

The available information indicates that the age of Bunaji (White Fulani) cattle at breeding centres in Northern Nigeria averaged 42 months at first calving, with a generation interval of 72 to 75 months (Wheat

Table 1: Annual calf crop of indigenous cattle in Nigeria

Breed	No. Animals	Calf Crop %
Bunaji	74	62.1*
White Fulani	29030	2.7**
Mixed, White Fulani	7566	34-49**
LIBC***	1395	67.2

*Based on records **Based on surveys

***LIBC = Livestock Improvement and Breeding Centre.

Ref: Lamorde and Weinman (1971); Johnson (1974); Nuru (1974); Zemjanis (1974a).

Table 2: Calving interval of indigenous cattle in Nigeria

Breed	No. Animals	Calving Interval (days)
Bunaji *	63	463
	50	388
Sokoto Gudali *	Not stated	496
		439
Azaouak-Rahaji *	Not stated	425
		537
White Fulani **	361	447
	145	459

Data obtained from LIBC herds* and Shika Experimental Station **, Ahmadu Bello University, Zaria.

Ref: Wheat and Broadhurst (1968, 1972); Zemjanis (1974a).

Table 3: Age of indigenous heifers at first calving in Nigeria*.

Breed	No. Heifers	Age at First Calving (months)
Sokoto Gudali	34	43.4
	75	40.8
Azaouak	Not stated	37.0
Bunaji	98	42.0
White Fulani	145	46.5
	-	45.4
Mixed	29030	54.72**

* Lamorde and Weinman (1971); Knudsen and Sohael (1970); Wheat (1972).

** Survey

Table 4: Reproductive performance of indigenous cattle in Nigeria*.

Parameter	Nomadic Cattle	LIBC** Govt.Herds	Optimum Performance
Age at first calving	60 mths	40 mths	26-28 mths
Calving interval	17-24 mths	16-18 mths	13 mths
Annual Calf Crop	40%	60%	85-90%
Calves produced in life-time	$2\frac{1}{2}$	4	8

* Zemjanis (1974a)

** Livestock Improvement and Breeding Centre.

and Broadhurst, 1968). Lamorde and Weinman (1972) reported the age of nomadic White Fulani cattle at first calving as 4½ years in Kano State and 7 years in Kaduna State. Analysis of data for Bunaji cattle at Birnin Kudu and Kabomo in Northern Nigeria, indicated an average age of 42 months at first calving and an average calving interval of 436 days (Wheat and Broadhurst, 1968). Akpokodje (1974) reported a life time calf crop of 0 to 15 calves with a pregnancy index of 0 to 300 days. For Bunaji cattle at Birnin Kudu and Kabomo, the generation interval was 72 and 75 months, respectively, compared with an interval of about 60 months for British breeds in the United States (Wheat and Broadhurst, 1968). Zemjanis (1974b), stated that optimum production cannot be obtained unless a cow calves with a calving interval not exceeding 13 or at the most, 14 months. He also summarised the available estimates for reproductive performance of indigenous cattle breeds in Nigeria (Table 4). Hafs et al. (1973) gave reproductive performance standards for good and average reproductive efficiency for dairy cattle in temperate zones (Table 5). By comparison it is apparent that the reproductive efficiency of indigenous cattle breeds in Nigeria is low.

Table 5: Temperate zone standards for comparing reproductive efficiency of indigenous cattle of Nigeria*.

Parameter	Average	Good
90-day non-return rate	65-70%	Above 75%
Services per conception	1.8 to 2.2	Below 1.5
Calving Interval	13.5-15 mths	12 to 13 mths
Annual Calf Crop	70 to 80%	Above 90%
Days open	120	100 or less

* Hafs et al., (1973).

b. Seasonal Reproductive Pattern

The available information indicates seasonal peaks in conception, as reflected by calving distribution. In the equatorial climate of southern Nigeria, Steinbach and Balogun (1971) reported that the highest calving rates occurred during June through September. Osori (1976) found that indigenous cows in the Savanna zone of Nigeria were seasonal breeders with peak activity during the rainy and pre-dry seasons.

In Tanzania, Wilson (1946) observed maximal conception during the hottest season of the year. Seasonal reproductive pattern has also been reported in

Kenya (Anderson, 1948) and in Niger (Pagot, 1975). Similar seasonal pattern has been reported from tropical and subtropical regions in South America (Caneiro, 1950), U.S.A. (Plasse et al., 1968), and India (Majeed et al., 1966).

2. Zebu Cattle in other Tropical Countries

According to Barthal (1975), Zebu-Azaouak cattle attain maturity rather late. Most cows calved for the first time at 3 to 5 years of age, between 4 and 7 years for the second time, and between 5 and 8 years for the third. The average calving rate of cows kept under natural conditions was twice in 36 months, representing a calving interval of 18 months. Nightingale (1969) reported low reproductive efficiency in indigenous cows of India. McDowell (1971) concluded that no Zebu breed approached the reproductive performance of European and American cattle.

Cross breeding the Zebu with the Shorthorn resulted in increased performance in Brazil (Loosli and Oyenuga,

1963; Dowling, 1972), U.S.A. (Dowling, 1972), and in tropical Australia (Barthal, 1975).

3. Bull

It is accepted that the most reliable indicator of reproductive performance of bulls is fertility of the serviced cows. Obviously a low reproductive performance may be influenced by factors in the females as well as in the males. The role of indigenous bulls in reproductive performance has not been investigated in Nigeria.

B. Spermatogenesis

1. Normal Spermatogenesis

The histological picture of spermiogenic epithelium in the bull has been described by various investigators (Ortavant, 1959; Albert, 1961; Faulkner,

1969b). Ortavant (1959) stated that spermatozoa were preceeded by four different cell types during spermatogenesis: spermatogonia (undifferentiated germ cells), primary and secondary spermatocytes, and spermatids (final primitive germinal cells). He observed that normal spermatogenesis proceeded in two phases--spermatocytogenesis and spermiogenesis. The former process begins with appearance of resting spermatogonia on the basement membrane and proceeds towards the lumen of the tubule. Resting type A spermatogonium divides mitotically into two; a resting spermatogonium to perpetuate future spermatogonia and an active type A spermatogonium. The active spermatogonium divides and forms intermediate spermatogonia, which, by division, form spermatogonia B. Spermatogonium B undergoes mitotic division to form two primary spermatocytes. The primary spermatocyte, a particularly large cell, moves away from the basement membrane towards the tubular lumen and divides by meiosis into two smaller, secondary spermatocytes. Subsequently, spermatids are produced by mitotic division, signifying the end of spermatogenesis and the beginning of spermiogenesis. During spermiogenesis,

spermatids undergo a series of complex cytological and morphological changes to give rise to spermatozoa.

a. Spermatogonia

Knudsen (1954) and Ortavant (1959) identified three types of spermatogonia in the bull, ram and boar: type A, intermediate, and type B. Spermatogonia A are large cells(12μ) with little cytoplasm and are located close to the basement membrane. They have a large ellipsoid nucleus with very fine chromatin granules and a large, centrally located nucleolus. The finely dispersed chromatin granules give a "dust-like" appearance. Spermatogonia B are larger cells (23 μ), also located near the basement membrane, with a smaller spherical nucleus. The nucleus, in addition to fine granules, contains densely, staining chromatin masses, which tend to adhere to the nuclear membrane to give the nucleus a "crust-like" appearance.

b. Spermatocytes

Primary spermatocytes are larger than spermatogonia and are located next to spermatogonia towards the lumen of the seminiferous tubules. They have scanty cytoplasm and a nucleus, which undergoes changes during the different phases of meiosis (Tables6 and 7). During the leptotene phase of prophase, long slender chromosomes begin to arrange themselves in a boutique-like pattern, which becomes more apparent during the zygotene phase. The chromosomes become thicker and shorter during the pachytene phase. The diplotene phase is characterized by chiasma formation between homologous chromosomes. Finally, during diakinesis, the last stage of meiotic prophase, the chromosomes become greatly contracted, and each bivalent has a different arrangement. At the end of meiotic prophase, metaphase, anaphase, and telophase occur rapidly and each primary spermatocyte divides into two secondary spermatocytes (Roosen-Runge and Giesel, 1950). The interphase lasts only a few hours and each secondary spermatocyte divides into two spermatids. Secondary

spermatocytes have a spherical nucleus, containing 5-6 chromatin particles joined together by a network of filaments (Knudsen, 1954). They are smaller than primary spermatocytes, and are located on their luminal side.

Table 6: Meiotic prophase of primary spermatocytes in the bull*.

Different phases of Meiotic Prophase	Stages of the seminiferous epithelial cycle
Leptotene	2
Zygotene	3, 4, 5
Pachytene	6, 7, 8, 1
Diplotene	2, 3
Diakinase	4

* Ortavant, 1959.

Table 7: Classes of spermatogonia present during the different stages of the seminiferous epithelial cycle in the bull*

Stages of the seminiferous epithelial cycle	Classes of spermatogonia
8 - 1	A1
2	A2
3	Intermediate
6 - 7	B1
8	B2
1 - 2 - 3	Spermatocytes

* Ortavant, 1959.

c. Spermatids

Newly-formed spermatids are considerably smaller than spermatocytes and are characterized by a small spherical nucleus and an array of cytoplasmic organelles, such as Golgi zone, mitochondria, and centrioles. The Golgi zone appears as a spherical acrosomic system (Clermont, 1972). The spermatid

nucleus, which contains several chromatin granules, elongates and flattens dorso-ventrally, and a post-nuclear cap is formed in the posterior part. In the bull, the nucleus, at this stage, is spatula-shaped (Clermont, 1972). In the cytoplasm of young spermatids, the Golgi complex constitutes a zone of small vacuoles surrounded by flattened vesicles that assumes a U-shape (Ortavant, 1959; Clermont, 1972). Two or three granules soon gather to form a single acrosomic granule contained within an acrosomic vesicle. The Golgi complex then separates from the acrosomic granule, migrates towards the caudal part of the cell and finally, disintergrates. The acrosomic vesicle extends to form the acrosome, which covers approximately the proximal two-thirds of the nucleus. The tail sheath is differentiated from the cytoplasm and disappears during the final stages of bovine spermiogenesis (Knudsen, 1954).

d. Spermatozoa

Mature bovine spermatozoa are composed of a head,

neck, midpiece, and tail (Blom and Birch-Andersen, 1960). The dorso-ventrally flattened head consists almost entirely of the nucleus. The proximal part of the nucleus is protected by the acrosomic cap (Clermont, 1972). The neck, which connects the head of the spermatozoon to the midpiece, is composed of basal granules and bundles of fibrils. The tail is long (40 to 50 μ) and thin and is differentiated into three parts; mid piece, mainpiece, and endpiece (White, 1972). The midpiece is the thickened region between the head and mainpiece and is 10 to 15 μ long. The mainpiece is the longest part of the tail (about 30 μ) and provides most of the propellant mechanism. The endpiece is the short terminal portion (about 3 μ) not surrounded by a sheath (Blom and Birch-Andersen, 1960; Fawcett, 1961; Wu and Newstead, 1966).

e. Sertoli Cell

Sertoli cells are large elongated cells, located at the basement membrane of the seminiferous tubule. The nucleus is irregular in shape, the nuclear membrane

has deep indentations, the nucleolus is prominent, and the cytoplasm is scanty. The cells have multiple long processes which surround spermatocytes and spermatids. Sertoli cells are believed to provide protection, offer support, and to serve as nurse cells for developing elongated spermatids until the latter become transformed into mature spermatozoa. They are also called sustentacular cells, nurse cells, foot cells, and trophocytes. Small groups of elongated spermatids may be seen with their heads directed towards the periphery of the tubule and attached to a Sertoli cell (Ortavant, 1969).

f. Seminiferous Epithelium Cycle

During the process of spermatogenesis specific cellular associations arise from the basement membrane and are directed towards the tubular lumen. These cellular associations are called stages of the cycle of the seminiferous epithelium. The seminiferous epithelium cycle is defined as the series of changes

occurring between two successive appearances of the same cellular associations (Ortavant, 1959; Faulkner, 1969a).

The spermatogenic cycle represents the time interval required from the first division of resting spermatogonia to the release of spermatozoa into the lumen. The length of the spermatogenic cycle in the bull is estimated to be 52 to 55 days (Dawson, 1958; Orgebin et al., 1958). Maturation of spermatozoa in the bovine epididymis is estimated to require 10 days (Orgebin et al., 1958).

2. Abnormal Spermatogenesis

Inability of spermatogenic epithelium to differentiate normally may be congenital or primary, or acquired or secondary. The principal primary disturbance is testicular hypoplasia. Secondary disturbances are associated with testicular pathological conditions such as degeneration, atrophy, and inflammation (Lagerlof, 1934, 1939). In such cases, the

spermatogenic epithelium is intrinsically capable of differentiating normally, but is prevented from doing so by some external damaging factors.

Fertility is the normal functioning of testes, accessory glands, and ducts to deliver spermatozoa of normal quantity and quality (Roberts, 1971). Male infertility and sterility is usually characterized by normal sexual desire and ability to copulate and ejaculate but with an abnormally high percentage of fertilization failure or early embryonic deaths, to complete failure, respectively. Careful examination of semen reveals reduced capacity to incapacity to fertilise to be associated with either normal or abnormal semen. Defects of spermatozoa or early zygotes may be congenital, or acquired.

a. Congenital

1) Testicular Hypoplasia

Varying degrees of hypoplasia or underdevelopment of testes may occur. Knudsen (1961) defined testicular

hypoplasia as defective or incomplete development of the seminiferous epithelium. It can be either uni-or bilateral, and is usually not observed until after puberty (Konig, 1964; McEntee, 1970; Roberts, 1971). Testicular hypoplasia is generally unrelated to general health and body development (Moore, 1948; Donaldson, 1963). Libido is strong and coitus is performed normally (Lagerlof, 1938; Christensen, 1965). Clinical signs and manifestations of infertility are not spectacular (Konig, 1964). Grossly, affected testes vary from being smaller and softer than normal to near normal in size and consistency, and the cut surfaces tend to bulge (Lagerlof, 1938; Konig, 1964; Humphrey and Ladds, 1975). Histologically, hypoplastic tubules are characterised by partial to complete lack of germinal elements, predominance of Sertoli cells, or failure of spermatogenesis depending upon severity (Lagerlof, 1938; Kodagali et al., 1971; Humphrey and Ladds, 1975). Testicular hypoplasia is classified as mild, severe, and extreme, based on deficiency of few, most or all functional tubules, respectively (Lagerlof, 1938; Laing and Young, 1956; Konig, 1959). Giant cells may be present in the affected tubules and also hyperplasia

of interstitial cells (Lagerlof, 1938, 1957; Laing and Young, 1956).

Lagerlof (1939) classified testicular hypoplasia into three:

1. A small proportion of tubules hypoplastic; germinative cells several layers thick; some spermatocytes with hydropic degeneration and formation of large vacuoles, and spermatidic giant cells present; number of spermatozoa small; and tubular diameter varying from 130 to 310 μ;
2. Approximately two-thirds of the tubules hypoplastic with only one layer of cells, resembling Sertoli cells; some tubules have spermatogonia and others, spermatocytes in various stages of development; numerous spermatidic giant cells present; and tubular diameter varying from 110 to 250 μ; and
3. Only a single layer of cells in the seminiferous tubules that resemble Sertoli cells; no spermatozoa; basement membrane of normal thickness; and the tubular diameter varies from 100 to 250 μ.

Differentiation between testicular hypoplasia and degeneration is often difficult because of the variable histological manifestations of hypoplasia (Bishop, 1970; McEntee, 1970; Humphrey and Ladds, 1975). On the basis of numerous tubular measurements, Konig (1964) prepared a scale for hypoplasia based on tubular diameter. Blom and Christensen (1972) reported that hypoplastic testes were usually half the size of normal testes.

Testicular hypoplasia, according to most investigators, is hereditary (Lagerlof, 1934; Kenney, 1971; Ball et al., 1968). In Swedish Highland cattle, it is reported to be due to an autosomal recessive gene with incomplete penetrance (Eriksson, 1943). Laing and Young (1956) and Lundgren (1972) described inheritance of the condition in other cattle. Knudsen (1954) cytogenetically examined hypoplastic testes of bulls and reported that spermatogenesis, in such testes, was characterised by multipolar spindle formation in the spermatocytes. Cohrs (1967) suggested that hypoplasia may result from exogenous factors acting during gestation. To date, no cause, other than hereditary factors, has been reported for testicular hypoplasia. Hypoplastic testes are predisposed to degeneration.

2) Cryptorchidism

In addition to testicular hypoplasia, cryptorchidism is probably the best known bovine genital defect (Blom and Christensen, 1972). In the bull, as in other species, the undescended testes may be located in the abdominal cavity or inguinal canal, with the latter being more common (Humphrey and Ladds, 1975). Grossly, a cryptorchid testis is smaller and softer than normal and is suspended by the mesorchium. Histologically, there usually is extreme hypoplasia (Cohrs, 1967).

Bovine cryptorchidism is considered to be inherited but the mode of inheritance is uncertain (Wheat, 1961; Bishop, 1972). Wheat (1961) reported that it was probably due to a recessive gene.

3) Sperm Defects

Spermatozoan defects, possibly genetic, have been described in bulls (Roberts, 1971).

1. Abnormal acrosomes or knobbed spermatozoa (Donald and Hancock, 1953; Blom and Birch-Andersen, 1965).
2. Coiled or returned tails and narrow heads (Swanson and Boyd, 1962).
3. Dag defect or strongly coiled, folded or split tails (Blom, 1966).
4. Cockscrew defect (Blom, 1959).
5. Pseudo-droplet defect or rounded or elongated thickened areas in the midpiece (Blom, 1968).
6. Lack of intact cells (Hancock and Rollinson, 1949; Jones, 1962).
7. Eversion of the galea capitis and crater-shaped depressions in the nucleus (Aamdel, 1951; Bane and Nicander, 1965).
8. Abaxial tails and swollen midpieces (Aughey and Renton, 1968).

Acrosomal defects or knobbed spermatozoa are related to defective spermiogenesis involving the Golgi apparatus. Defective acrosomes render spermatozoa incapable of penetrating and fertilizing ova. The defect may be seen in spermatids (Donald and Hancock, 1953; Blom and Birch-Andersen, 1965; Saacke et al.,

1968; Roberts, 1971). In Friesian cattle, it is apparently due to an autosomal, recessive sex-linked gene (Donald and Hancock, 1953).

Chromosomal aberrations such as translocations and inversions may occur at meiosis (Knudsen, 1954, 1958; Gustavsson, 1969). An apparently normal semen picture may accompany these defects.

Cytogenetic disturbances in spermatogenesis cause abnormalities in primary spermatocytes by chromosomes failing to separate at anaphase, and extra-centrosomal divisions resulting in giant cell formation (Knudsen, 1958).

4) Segmental Aplasia

Segmental aplasia of the mesonephric or Wolffian duct has been well-described in bulls (Blom and Christensen,1951, 1972; Konig, 1964; Roberts, 1971). Majority of cases are unilateral and the body, tail, entire epididymis, and even portion of the vas deferens, may be missing. The seminal vesicles on the same side may be hypoplastic or missing. Unilaterally affected

bulls are fertile. Spermiostasis with spermatocoele and/or spermatic granuloma may develop proximal to the missing segment and the back pressure may result in testicular degeneration (Kenney, 1971). Segmental aplasia is considered to be due to an autosomal recessive (Konig *et al.*, 1972).

Spermiostasis resulting in spermatocoeles and in time, spermatic granulomas resembling an infectious granuloma, may develop from rudimentary, blind mesonephric tubules (ductuli aberrantes), and may or may not be associated with a local immune reaction (Kenney, 1971; Roberts, 1971; Blom and Christensen, 1972). Spermiostasis involves the head of the epididymis and rarely other portions. The associated spermatocoeles and spermatic granulomas develop slowly. Even a small area of spermiostasis within a testis or epididymis, may under certain circumstances (trauma, infections) increase in size and cause occlusion of the epididymal duct (Blom and Christensen, 1972). Spermiostasis is not common in bulls (Roberts, 1971).

b. Acquired

Testicular conditions due to acquired causes are more common than congenital or genetic causes and include testicular degeneration, orchitis, fibrosis, and calcification (Cohrs, 1967; McEntee, 1970). The seminiferous epithelium is highly sensitive to any adverse influence with resultant effects on spermatogenesis.

1) Testicular Degeneration

There are numerous cases in which the seminiferous tubules lose their power, either gradually or suddenly, to produce physiological spermatozoa in fertile bulls, and for reasons other than infection or inflammation (McEntee, 1970; Roberts, 1971; Humphrey and Ladds, 1975). Such cases are designated as testicular degeneration. The fertility of an affected bull will depend upon the severity of degeneration and the stage of the process (Lagerlof, 1938). The condition becomes

irreversible when it proceeds beyond physiological limits, that is, when the testis becomes atrophic.

The clinical picture varies with time. Grossly, the testis has poor consistency, may be smaller than normal, the tunica albuginea may be thickened, and the cut surfaces may not bulge (McEntee, 1970). The ejaculate has a lower concentration and reduced motility, and is characterised by increased sperm abnormalities (Lagerlof, 1938). Combining the semen and testicular changes, Lagerlof (1938), clinically classified bovine testicular degeneration into three:

1. Bulls with considerably reduced fertility but with no morphologically demonstrable change in the genitalia;
2. Bulls of low fertility but with normal appearing genitalia; and
3. Sterile bulls with small atropic testes.

Degenerative changes in the germinal epithelium have been described (Lagerlof, 1938; Knudsen, 1954; Konig 1964; McEntee, 1970; Humphrey and Ladds, 1975). Knudsen (1964) recognised three degrees of cellular reaction in testicular degeneration:

1. Mild changes with cytoplasmic vacuolation and centrosomal degeneration;
2. moderate changes with complete centrosomal and nuclear, spindle fibre degeneration; and
3. severe changes with lack of spindle formation and appearance of characteristic restitution nuclei (result of intranuclear chromosomal division).

Commonly observed histopathological changes with increasing severity were: cytoplasmic vacuolation, germinal cell desquamation, hydropic degeneration, pyknosis of spermatocytic nuclei, karyolysis, giant cells, spermiostasis, calcification of inspissated tubular contents, tubular atrophy, wave-like thickening of the basement membrane, fibrosis, and interstitial cell hyperplasia. In extreme cases, the seminiferous epithelium becomes completely denuded with only Sertoli cells remaining (Lagerlof, 1938; Knudsen, 1954; McEntee, 1970; Barker, 1956).

Spermatogonia - A cells are reduced or completely disappear in severe cases of testicular degeneration (Knudsen, 1954; Humphrey and Ladds, 1975). Spermatogonia -

B cells appear not to be affected even in severe cases. The initial degenerative change v sible is cytoplasmic vacuolation in primary spermatocytes (Knudsen, 1954). Primary spermatocytes may have contracted bivalents which spread throughout the cell, often in grape-like formations (Konig, 1964). Changes in size and structure were the most commonly observed changes in secondary spermatocytes. When the spermatogonia were so damaged that they lost their proper orientation to the basement membrane, degeneration became irreversible (Humphrey and Ladds, 1975).

1) Aetiology of Testicular Degenerations

The causes of testicular degeneration are numerous and complex. Lagerlof (1939) listed "fever, chronic generalized diseases, intoxication of both endogenous and exogenous nature, mental influence, disturbances in nutrition and conditions of inanition" as potential causes. The causes may be summarized (Lagerlof, 1934, 1936; Roberts, 1971; Humphrey and Ladds, 1975).

a) Thermal - includes high ambient temperature, prolonged pyrexia due to infection, scrotal dermatitis, scrotal wounds and infection, cryptorchidism, inguinal hernia, and frostbite.

b) Nutritional - Usually caused by underfeeding or starvation, drought with vitamin A deficiency accompanied by protein - carbohydrate deficiency. Chronic diseases associated with inanition and debility include severe parasitism such as helminths and ticks, chronic arthritis, worn teeth, or any disease interfering with the intake or passage of food through the intestines (Davies et al., 1957).

c) Trauma, Stress or Disease - Includes adverse shipping conditions, fatigue, fractured ribs and contusions from fighting, severe arthritis, and liver abscesses.

d) Localized Infections - Orchitis and epididymitis are common causes of testicular degeneration and include Brucella abortus, Corynebacterium pyogenes, Actinomyces bovis, "epi-vag" (IBR-IPV), G-UP virus (Bouters, 1964), lumpy skin disease, Nocardia sp., Chlamydia sp. (Storz et al., 1968),

and Besnoitia besnoiti (Pols, 1960). Sperm granuloma may result in testicular degeneration.

e) Systemic Disease - Testicular degeneration usually results from accompanying pyrexia (for example, pneumonia, shipping fever, and IBR-IPV) or by debility and emaciation (foot and mouth disease, actinomycosis, actinobacillosis, paratuberculosis, and pyelonephritis).

f) Toxins - A number have been incriminated McEntee, 1970).

g) Age - Progressive testicular degeneration occurs frequently with age (Collins et al., 1962; Hahn et al., 1969; McEntee, 1970). The age effect is influenced by disease, genetic and management factors.

h) Vascular Lesions - Degenerative changes can be caused by any interference with testicular circulation such as torsion, clamping by an emasculatome, biopsy, and vascular hyaline degeneration in older bulls (McEntee, 1970; Faulkner, 1959).

i) Irradiation - Injuries to spermatogonia, spermatocytes, and spermatids; spermatocytes are the most

sensitive (Murphree and Parish, 1956; Welch and Murphree, 1965).

j) Hormonal - Moore (1948) considered endocrine failure to be a basic cause of degeneration.

k) Neoplasms - Seldom observed except in old bulls and are usually benign interstitial cell tumours (Dunn and McEntee, 1964).

n) Auto-immunization - Significance under natural conditions is unknown (Roberts, 1971).

m) Genetic - Although genetic factors have been found to influence acquired testicular degeneration in certain bulls, the question of increased resistance to degeneration remains to be clarified (Bane, 1954; McEntee, 1970).

Lagerlof (1934, 1936) was the first to demonstrate the effect of heat on testes by inducing degenerative changes in the bull by interfering with the heat regulating mechanism by increasing the intrascrotal temperature. He called attention to the practical importance of high ambient temperatures on fertility of bulls. Brown (1960) and Elliot (1968) reported decreased fertility in bulls of temperate zones during months of highest ambient temperature, and attributed

the effect to heat - so-called "summer" infertility. Testicular degeneration is common in temperate zone breeds in tropical climates (Donaldson, 1963).

Seasonally breeding animals such as wild ruminants are reported to undergo physiological testicular atrophy between breeding periods (Faulkner, 1969a). This is a normal reproductive pattern.

2) Orchitis

Orchitis or inflammation of the testes causes morbid changes, which result in secondary degeneration of the seminiferous epithelium and often destruction of the tubules (Konig, 1964).

Orchitis often produces changes that are palpable during clinical examination (Lagerlof, 1938). Konig (1964) classified bovine orchitis into intertubular or interstitial, intratubular, and necrotic. Grossly, interstitial orchitis may not be recognised, intratubular orchitis is characterised by firmer consistency and by solitary or multiple white foci upon sectioning, and necrotic orchitis by yellowish, often laminated,

calcification in the parenchyma (Konig, 1964). Histologically, Blom and Christensen (1972) observed central necrosis with calcification, neutrophils, lymphocytes, plasma cells, giant cells, and cell debris.

(1) Aetiology of Orchitis

Infection and trauma are reported as the major causes of bovine orchitis (Lagerlof, 1938; McEntee, 1970; Humphrey and Ladds, 1975). Many infectious agents have been isolated from inflamed testes or from their semen: Br. abortus, C. pyogenes, A. bovis, Nocardia sp., Diplococcus sp., Mycobacterium bovis, Chlamydia sp., epi-vag (IBR-IPV), and G-UP virus (Williams, 1932; Bierberdorf, 1953; Bouters, 1964; Kimball et al., 1954; Konig, 1964; Storz et al., 1968; Roberts, 1971).

Pathological changes in bacterial orchitis are usually non-specific except brucellosis. Lesions of brucella orchitis are suggestive and the degree of infection is usually reflected in the semen quality with changes in colour and volume (Williams, 1932; Moore,1948).

3) Epididymitis

Epididymitis, or inflammation of the epididymis, occurs in bulls and is caused by or may be secondary to the causes of orchitis. Epididymitis is more common than orchitis and has a variable course (Konig, 1964). Epididymitis arises principally by ascending infection from the uro-genital tract, less frequently by haematogenous spread, and seldom by trauma (Galloway, 1961). Epididymitis most commonly involves the duct and tail of the epididymis but may involve the body and head.

The infectious causes of bovine epididymitis include: Br. abortus, C. pyogenes, Chlamydia sp. and epi-vag (IBR-IPV) (Williams, 1932; Mare and Van Rensburg, 1961; Storz et al., 1968; Roberts, 1971). Although epi-vag and IBR-IPV are apparently serologically identical, the severity of the clinical manifestations are not. The role of IBR-IPV virus in the pathogenesis of epi-vag is still controversial (Humphrey and Ladds, 1975). The difference may be one of strain virulence.

The acute stage of epididymitis with oedematous enlargement may be followed by abscess formation,

sometimes with perforation, periorchitis, and peritonitis (Konig, 1964; McEntee, 1970). Histologically, affected epididymal ducts contain fibrin, neutrophils, damaged spermatozoa and epithelium, macrophages, and giant cells (Konig, 1964). Galloway (1961) observed that chronic epididymitis, which usually involved the ducts, followed the acute phase or arose insidiously.

Associated lesions with epididymitis are abscess formation, tunic vaginalis adhesions, oedema, varicocoele, spermatocoele, and spermatic granuloma. Spermatic granuloma (response to interstitial extravasation of spermatozoa) may be a sequel to spermatocoele (Blom and Birch-Andersen, 1960), inflammation, and possibly, trauma (McEntee, 1970). It may also develop secondary to congenital duct occlusion (McEntee, 1970).

4) Seminal Vesiculitis

Seminal vesiculitis is the most common condition affecting the bovine seminal vesicles. The incidence ranges from 0.8 to 4.6%, is higher in young beef bulls,

and is apparently influenced by management and level of feeding (Ball et al., 1968; Roberts, 1971).

Seminal vesiculitis may be ascending or descending from infection from the prepuce or epididymitis or orchitis, respectively. It is caused by a variety of infectious agents: C. pyogenes (Galloway, 1964; Blom and Christensen, 1965; McEntee, 1970); Br. abortus (Williams, 1932; Roberts, 1971); Streptococcus spp; Escherichia coli (Roberts, 1971); Actinobacillos actinoides (Jones et al., 1964); Mycoplasma bovigenitalium (Blom and Erno, 1967; Roberts, 1971); Chlamydia sp. (Storz et al., 1968); epi-vag (Mare and Van Rensburg, 1961); and G-UP virus (Bouters, 1964).

Infection may be spread in young bulls by homosexuality (Ball et al., 1968).

5) Tunica Vaginalis

Galloway (1961) observed that adhesions between the parietal and visceral layers of the tunica vaginalis are common. He reported that severe, extensive fibrous adhesions, considered the result of trauma, in

the absence of other lesions, may interfere with testicular motility within the scrotum. Testicular lesions associated with such extensive adhesions have been reported (Lancaster, 1956). Periorchitis may occur as an extension from orchitis, epididymitis or peritonitis, or from exogenous trauma. Hydrocoele, pyocoele, chylocoele, and haematocoele involving the tunica vaginalis may occur (McEntee, 1970). Testicular herniation, as a sequel to rupture of the tunica albuginea, has been reported (Blom and Christensen, 1972).

6) Scrotal Skin

Ectoparasitic infestation of the scrotum has been reported as a cause of severe scrotal dermatitis (Alhaji, 1976; Watson, 1964). In Nigeria tick infestation and streptotrichosis of the scrotum are considered causes of testicular degeneration (Osori, 1975). Severe parasitism is believed to cause dermatitis associated with thickening of the scrotal skin and resultant testicular degeneration (Pols, 1960;

Roberts, 1971; Humphrey and Ladds, 1975). Traumatic injuries of the scrotum from thorns and spikes are also important in Nigeria and other tropical countries (Osori, 1975). Cattle are subjected to bruises and lacerations as they wander about through thick bushes in search of food and water.

c. Testicular Measurements

The objective of scrotal and testicular measurements is to select bulls with satisfactory fertility. It is now recognised that testicular size and sperm cell production are related (Cates, 1975). Cates (1975) suggested that scrotal shape should be assessed first since the best sized testicles are found in bulls with a normal shaped scrotum (pendulous with a distinct neck).

Based on clinical observations on bulls for breeding soundness, Cates (1975) suggested that a 34 cm scrotal circumference was the minimum for satisfactory fertility in a bull, two years of age or over. He regarded an average circumference of 35.8 cm as satisfactory.

Durfey (1975) employed a tonometer for measuring testicular consistency and a self-releasing tape for scrotal circumference.

The testes of Bos indicus are smaller than those of Bos taurus. The following testicular dimensions have been reported for Bos taurus breeds: length 10 to 14 cm, diameter 6 to 8 cm, and weight 250 to 500 g (Lagerlof, 1939; Ellenberger-Baum, 1939; Sisson and Grossman, 1953).

MATERIALS AND METHODS

Source of Testes

Testes from nomadic Fulani bulls were collected from the abattoirs at Bauchi (Bauchi State), Kaduna (Kaduna State) and Ahmadu Bello University. Prior to slaughter, bulls in good physical condition were randomly selected, and their age determined by examination of teeth and by interviewing the owners. Six pairs of testes were collected twice a month for a year (January to December, 1975). The testes were placed in a well-insulated cool box and immediately transported to the laboratory for examination.

Gross Examination

The testes were dissected from the tunica vaginalis and the spermatic cord severed 0.5 cm above the dorsal pole of each testis. Each pair of testes was carefully examined for lesions. The following parameters were recorded: weight with epididymis attached; length from the ventral to dorsal pole, width

at greatest diameter, shape, and consistency (soft, moderately firm, firm, slightly hard, hard, and very hard).

Microscopic Examination

The equatorial segment was selected as the most representative area for study after various intra-testicular locations were sectioned and examined. An equatorial segment 0.5 - 1.0 cm thick, was removed from each testis, and 1.0 cm wide section taken. The section was divided into two equal halves and fixed in Bouins solution for 72 hours. The medial half was trimmed and processed in a Tissuematon*, embedded in paraffin, cut at 5-6 μ, mounted, stained by haematoxylin and eosin (HE) and by periodic acid-Schiff (PAS), and cover slip applied after Gurr's media.

Sections were screened under low magnification and only tubules which were round in cross section were examined under high dry and oil immersion. Seminiferous

*Fisher Scientific Company, Chicago, Illinois, USA.

epithelium was examined for cell types and their appearance. The cells were identified and counted in 20 selected tubules. The presence of abnormal cells was noted. The acrosomic system of the spermatids was studied in PAS stained sections.

Tubular diameter of 12 tubules per testis was measured by a Leitz micrometer**. The eyepiece was calibrated against the micrometer slide. In order to ascertain that the measurements were representative of the entire section, the section was divided into strips, and the appropriate number of tubules measured.

Testes were evaluated monthly and the findings were related to the various seasons.

Criteria For Classifying Testicular Hypoplasia and Degeneration.

The following criteria were used for classifying testicular hypoplasia and degeneration.

** E. Leitz, Wetglar, West Germany.

	Degeneration	Hypoplasia
a.	Smaller or normal in size, softer and flabby or firmer	Smaller and softer than normal
b.	Cut-section— yellowish-white, flecked appearance. Does not bulge on section	Smaller, fibrotic in extreme forms. Usually bulges on section
c.	Thickened, hyalinised basement membrane (BM)	Few or most tubules hypoplastic, decreased tubular diameter
d.	Wave-like thickening and detachment of BM	Arrested spermato-genesis, tubules mostly lined by Sertoli cells
e.	Necrotic germ cells - cytoplasmic vacuolation of spermatocytes - karyolysis - pyknosis - desquamation - hydropic degeneration - restitution nuclei	Interstitial cell hyper-plasia; increased peri-tubular connective tissue
f.	Spermatidic giant cells	Fibrosis
g.	Calcification	

RESULTS

The testes from 144 bulls belonging to nomadic Fulani herdsmen were examined. The bulls were all in good condition and were 5 to 10 years of age. The scrotum of 58 bulls (40%) had mild to moderate tick infestation.

1. Gross Dimensions

The average monthly dimensions for the whole year are summarized in Table 8. The individual findings are tabulated in Appendix 1 (Tables 1 - 12) and the statistical analyses in Appendix 4.

The monthly average testicular length is presented in Table 9 and Fig. 1. Testicular length over the year ranged from 10.9 to 12.1 cm. Inter-month but not intra-month variation was highly significant ($P < 0.01$).

The monthly average diameter of the testes is presented in Table 10 and Fig. 1. The diameter ranged from 4.7 to 5.7 cm. The inter - month but not intra - month variation was highly significant ($P < 0.01$).

Table 8: Average monthly weight, length, and diameter of testes, and diameter of seminiferous tubules of indigenous bulls in Nigeria.

Month	Average weight (g)	Average length (cm)	Average diameter (cm)	Average diameter of seminiferous tubule (μ)
January	172.9	12.1	5.4	223.0
February	144.9	10.9	4.7	190.0
March	152.6	12.0	4.9	194.0
April	151.2	11.7	4.7	192.0
May	149.7	11.7	5.0	187.0
June	140.0	11.7	4.9	198.0
July	189.6	11.5	5.5	192.0
August	139.1	12.1	5.7	167.0
September	~~142.6~~ (6 g.)	11.9	5.6	196.0
October	187.4	11.2	5.3	176.0
November	209.7	11.1	5.4	206.0
December	188.9	11.1	4.9	224.0
Average	164.1	11.6	5.2	195.0

Table 9: Average monthly length of testes of indigenous bulls in Nigeria.

Month	Range (cm)	Average (cm)	S.D.*
January	9.5 - 14.5	12.1	1.6
February	9.4 - 12.1	10.9	0.8
March	8.5 - 13.5	12.0	1.7
April	10.3 - 15.1	11.7	1.6
May	10.0 - 13.1	11.7	1.0
June	10.0 - 14.5	11.7	1.4
July	6.1 - 16.1	11.5	3.2
August	9.5 - 15.0	12.1	1.5
September	10.0 - 14.0	11.9	1.2
October	9.1 - 12.1	11.2	0.8
November	8.6 - 12.5	11.0	1.5
December	9.5 - 14.3	11.1	1.6

* Standard Deviation

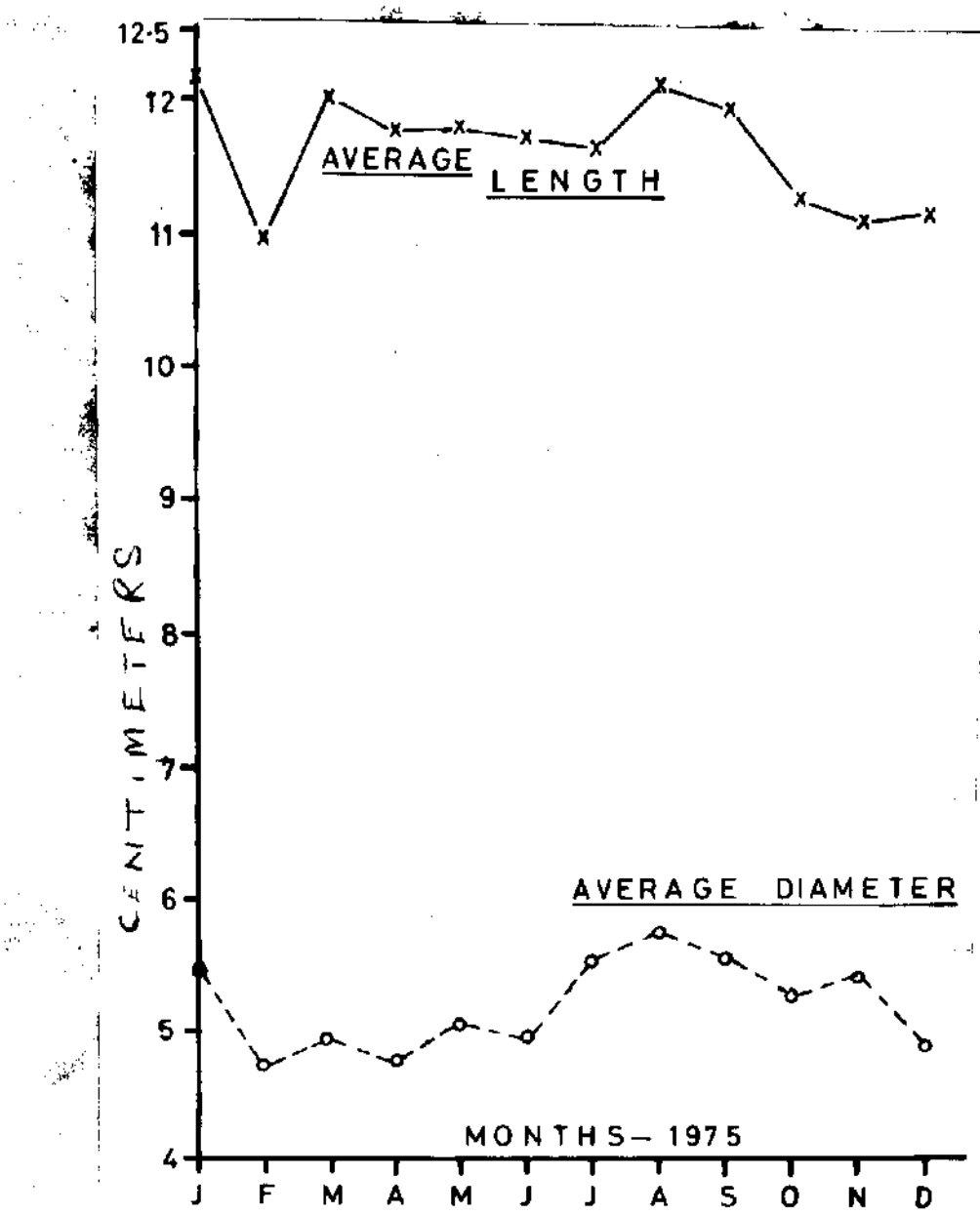


Fig. 1. Monthly dimensions of the testes.

Table 10: Average monthly diameter of testes of indigenous bulls in Nigeria.

Month	Range (cm)	Diameter (cm)	S.D.*
January	4.3 - 5.9	5.4	0.6
February	4.2 - 5.1	4.7	0.4
March	4.3 - 5.4	4.9	0.3
April	4.3 - 5.9	5. 0	0.6
May	4.1 - 5.9	4.7	0.5
June	4.3 - 5.3	4.9	0.3
July	4.0 - 6.9	5.5	1.1
August	4.4 - 6.9	5.7	0.8
September	5.0 - 6.0	5.6	0.4
October	4.5 - 5.7	5.2	0.4
November	4.6 - 6.9	5.4	0.7
December	4.0 - 5.5	4.9	0.4

* Standard Deviation

The monthly average weight of the testes is presented in Table 11 and Fig. 2. The average weight was 172.9 g (range 139.1 to 209.7). Inter - month but not intra - month variation was significant ($P < 0.05$).

Gross Lesions

The monthly clinical assessment for testicular lesions is summarised in Table 12 and the individual findings are presented in Appendix 1 (Tables1-12). Nine of the 144 pairs of testes (6.3%)were affected: degeneration 2.8%, inflammation 2.1%, and hypoplasia 1.4%. Gross testicular lesions were found only during five months of the year, the highest frequency in November.

3. Microscopic Examination of Seminiferous Tubules

The average monthly finding of the diameter of the seminiferous tubules and type of cells present are summarized (Table 13; Appendix 2, Tables 13-18).

The monthly average diameter of seminiferous tubules was 195 μ, range 167 to 224 μ (Fig. 3). Inter - month but not intra - month variation was highly significant ($P < 0.01$).

Table 11: Average monthly weight of testes of indigenous bulls in Nigeria.

Month	Range (g)	Average (g)	S.D.*
January	141.0 - 199.1	172.9	23.2
February	97.3 - 193.7	144.9	33.0
March	38.1 - 190.8	152.6	54.4
April	123.2 - 201.0	151.2	26.6
May	91.5 - 201.9	149.7	46.0
June	86.2 - 184.5	140.0	35.9
July	31.9 - 338.2	189.6	110.1
August	72.1 - 199.9	139.1	38.2
September	123.5 - 264.2	164.1	48.3
October	117.9 - 238.3	187.4	41.8
November	107.1 - 369.1	209.7	73.4
December	145.5 - 214.8	188.9	24.1

* Standard Deviation.

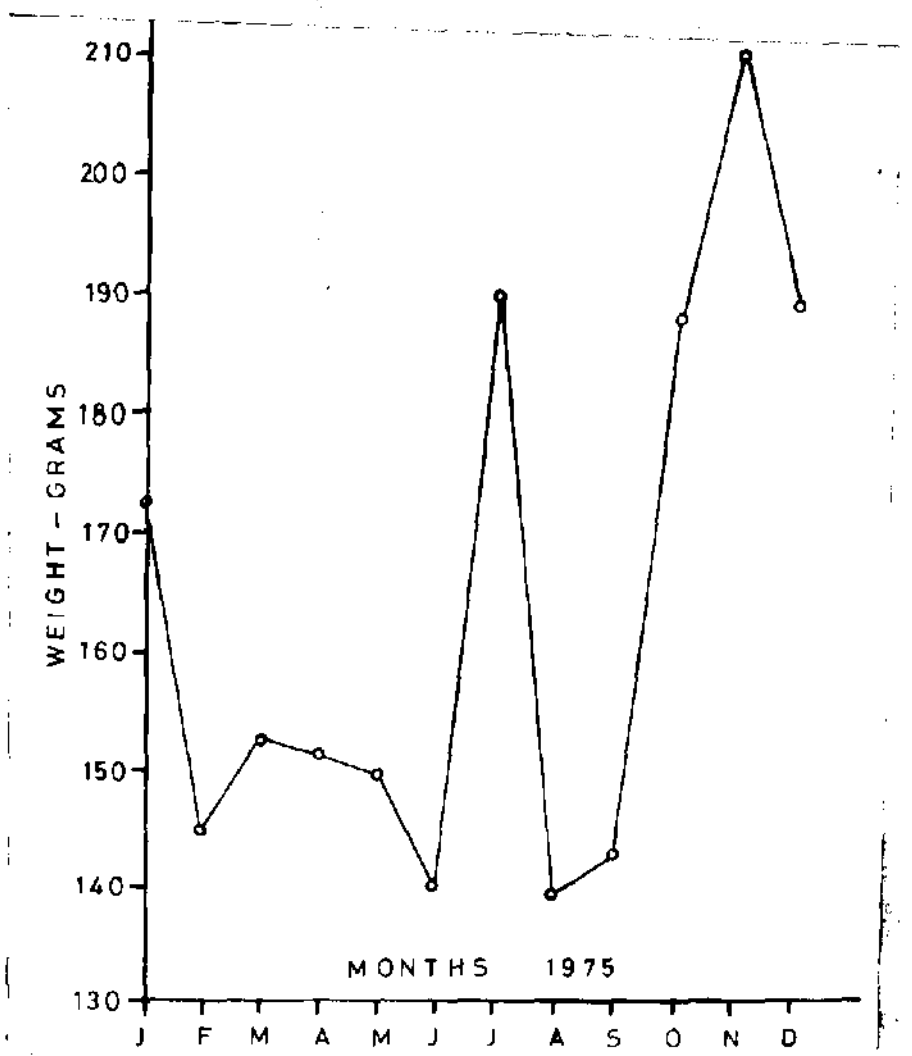


Fig. 2. Monthly average weights of the testes.

Table 12: Monthly clinical evaluation for gross testicular lesions in indigenous bulls in Nigeria.

Month	Pairs of Testes		Lesion
	No. Examined	No. With Lesions	
January	12	0	
February	12	0	
March	12	2 (16.7%)	Hypoplasia + inflammation
April	12	2 (16.7%)	Degeneration + inflammation
May	12	0	
June	12	1 (8.3%)	Degeneration
July	12	1 (8.3%)	Hypoplasia + Degeneration
August	12	0	
September	12	0	
October	12	0	
November	12	3 (25%)	Degeneration + Inflammation
December	12	0	
Total	144	9 (6.3%)	

Table 13: Summary of the monthly microscopic examination of seminiferous tubules* of indigenous bulls in Nigeria.

Month	Spermatogonia		Spermatocytes		Spermatids		Average tubular diameter (u)
	A	B	1	11	Round	Elong.	
January	3.8	4.5	51.6	-	85.2	32.9	223.0
February	3.9	10.2	44.2	-	75.1	21.2	190.0
March	4.1	11.6	55.1	-	95.6	30.4	194.0
April	5.1	7.2	59.6	-	90.5	38.7	192.0
May	5.0	5.7	38.9	-	47.6	22.8	187.0
June	4.1	5.4	61.9	-	111.1	44.1	198.0
July	3.9	4.3	44.6	-	91.8	30.5	192.0
August	4.3	4.5	40.5	-	86.0	19.9	167.0
September	4.1	4.9	45.6	-	95.5	31.9	196.0
October	4.4	4.9	46.7	-	85.3	25.1	176.0
November	4.5	4.9	46.7	-	93.7	34.9	206.0
December	4.1	4.6	53.5	-	78.9	32.9	224.0
Average	4.2	6.1	49.8	-	86.4	30.5	195.0

* 12 tubules per testis

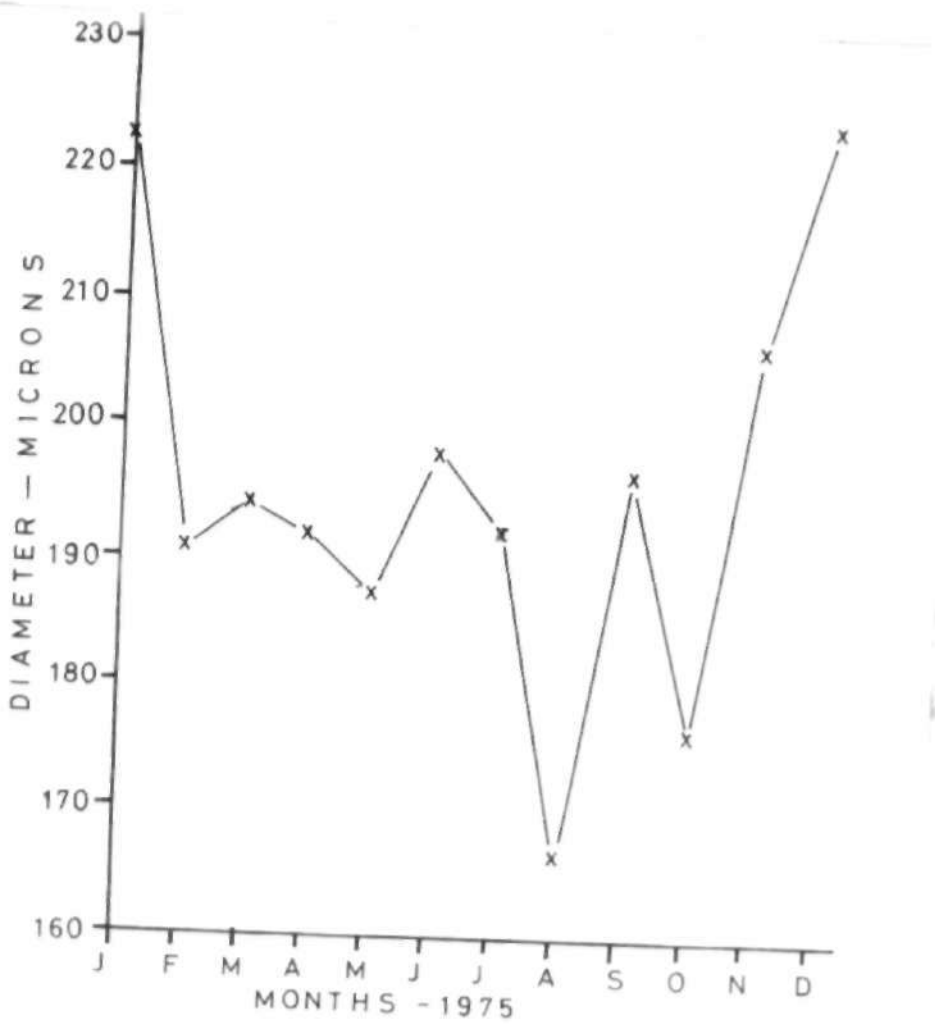


Fig. 3. Monthly average diameter of the seminiferous tubules.

The average number of spermatogonia-A cells per month was 4.2, range 3.8 to 5.1 (Table 13; Fig. 4). The inter - and intra - month variation were not significant. Typical spermatogonia-A and B cells are shown in Fig. 7.

The average monthly number of spermatogonia-B cells was 6, range 4.3 to 11.6 (Table 13; Fig. 4). The inter - month but not the intra - month variation was highly significant ($P < 0.01$).

The monthly average number of primary spermatocytes was 49.8, range 38.9 to 62 (Table 13; Fig. 5). The inter - month but not the intra - month variation was highly significant ($P < 0.01$). The transitory secondary spermatocytes were difficult to identify and distinguish from round spermatids.

The monthly average number of spermatids ~~are~~ presented in Table 13 and Fig. 6. Typical round and elongated spermatids are shown in Fig. 7 and 8. The average number of round and elongated spermatids was 86.4 (range 47.6 to 111) and 30.5 (range 19.8 to 44), respectively. There was a significant and highly significant inter - month variation in the number of

round (P 0.05) and elongated (P 0.01) spermatids, respectively. The variation within months for both types of spermatids was not significant.

4. Histopathology

Microscopic testicular lesions observed are summarized in Table 14 and the individual findings are tabulated in Appendix 3(Table 19 - 30).

Orchitis was manifested by intra - and/or inter-tubular leukocytosis. The incidence was 6.3%. The highest frequency was observed in November, and the majority of cases were found between November and February.

An average incidence of 20% testicular degeneration was observed monthly. The majority of cases were mild and involved one to three tubules per section (Appendix 3, Tables 19 - 30). Manifestations of testicular degeneration are shown in Figs. 9 - 11.

The incidence of testicular hypoplasia was 4.2%. Typical hypoplasia without evidence of spermatogenesis is shown in Fig. 12.

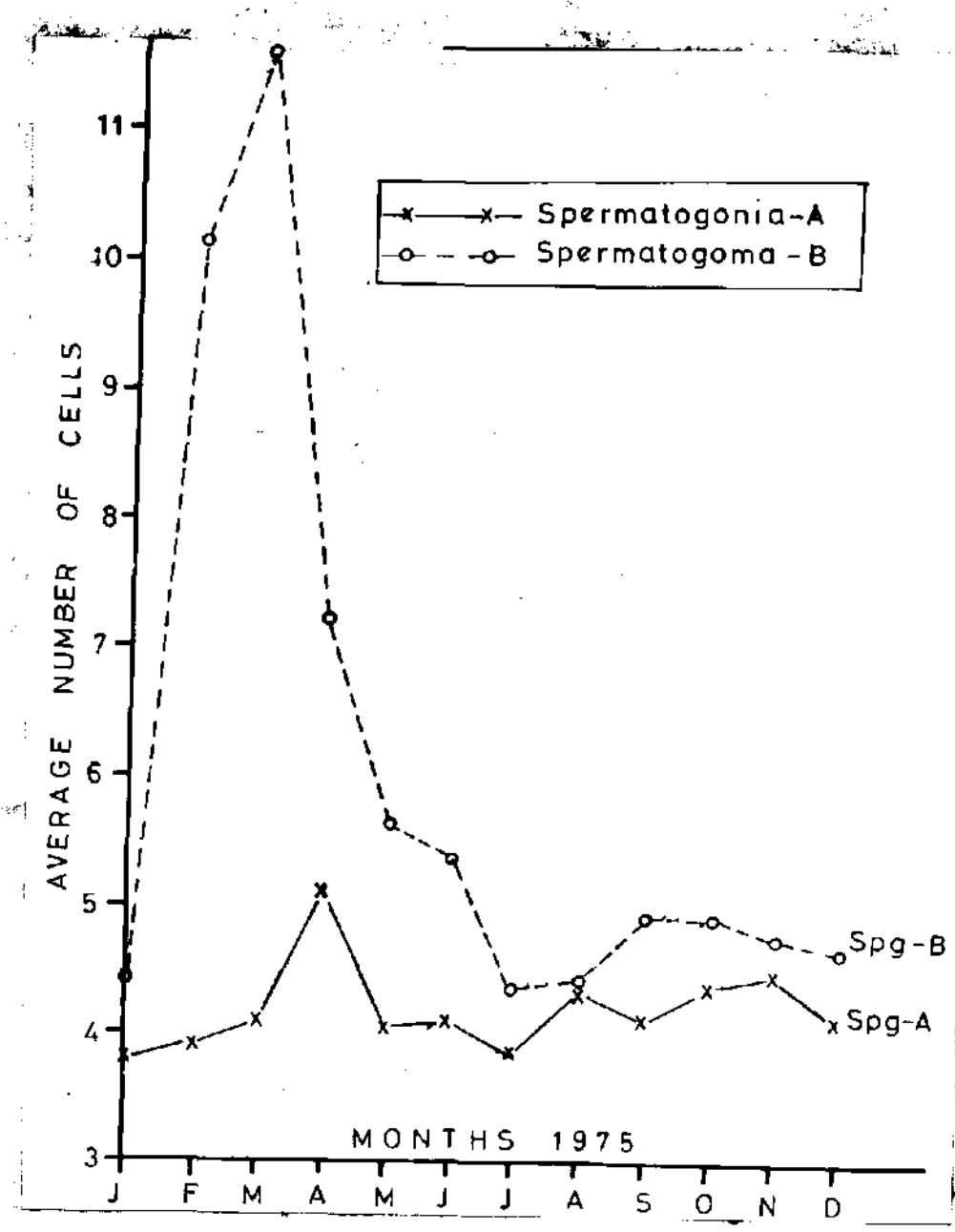


Fig. 4. Monthly average number of cells present (spermatogonia - A and - B).

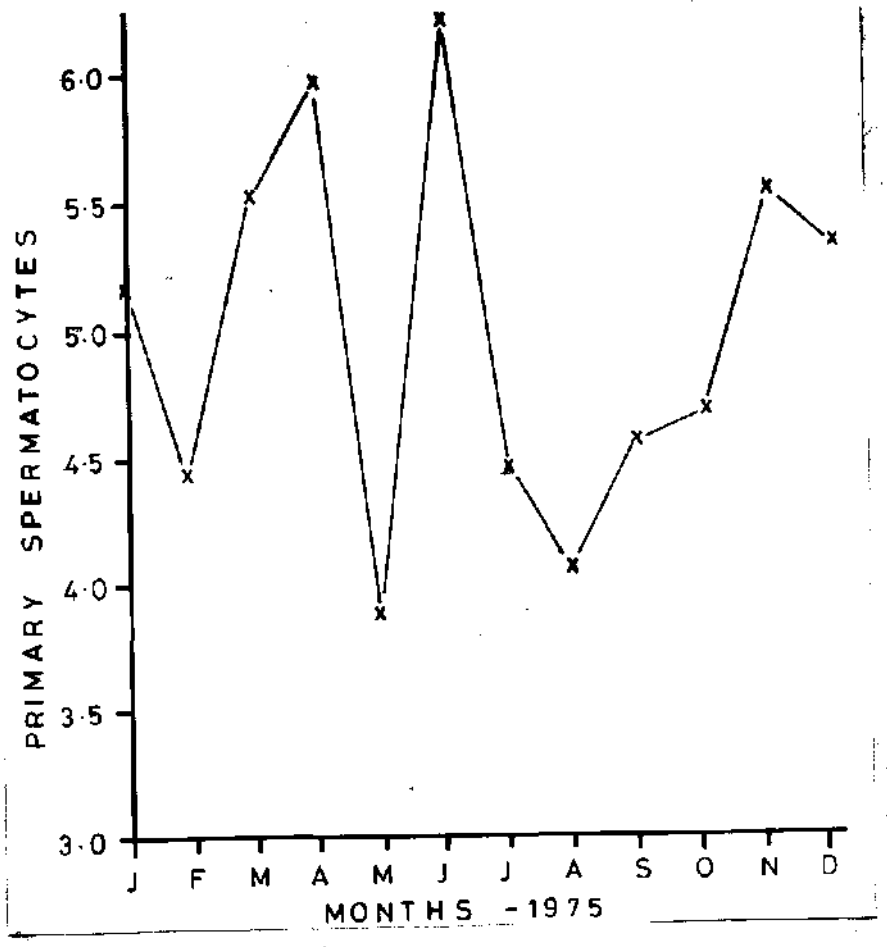


Fig. 5. Monthly average number of primary spermatocytes present.

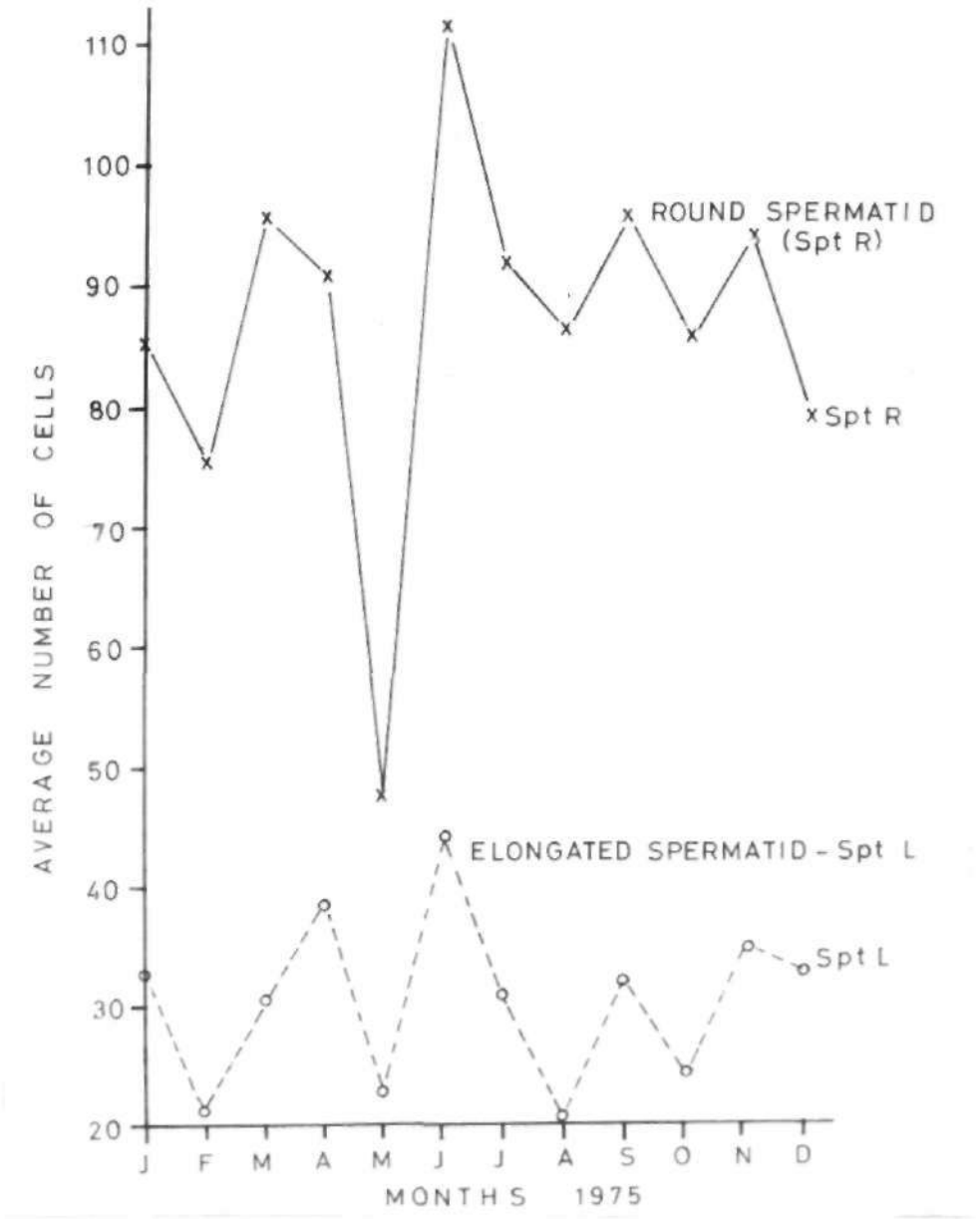


Fig. 6. Monthly average number of spermatids present.

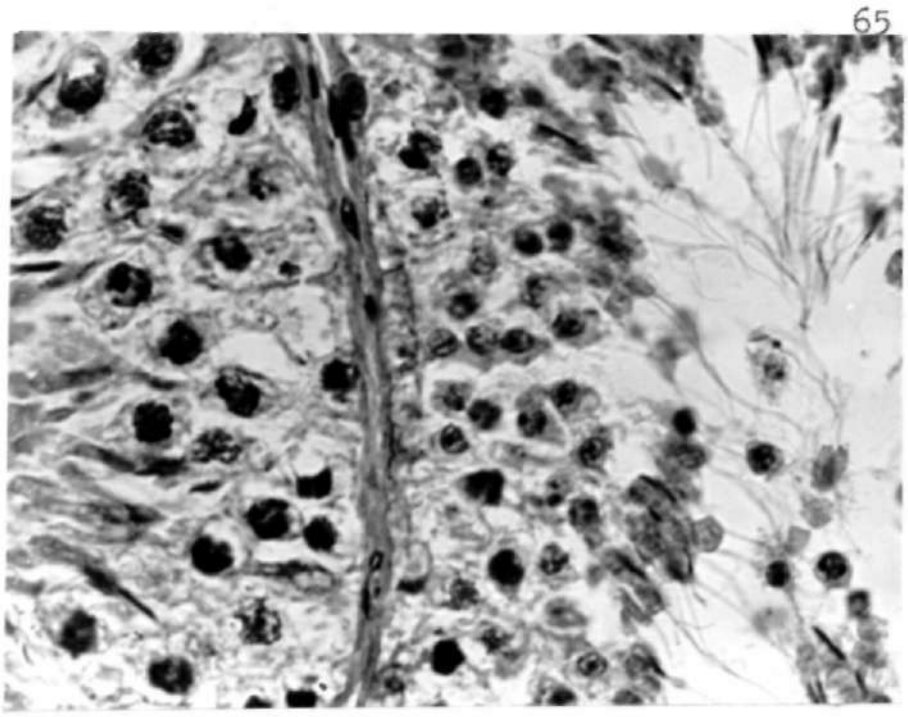


Fig. 7. Normal spermatogenesis showing uninterrupted spermatogenesis. H. & E. x 400.

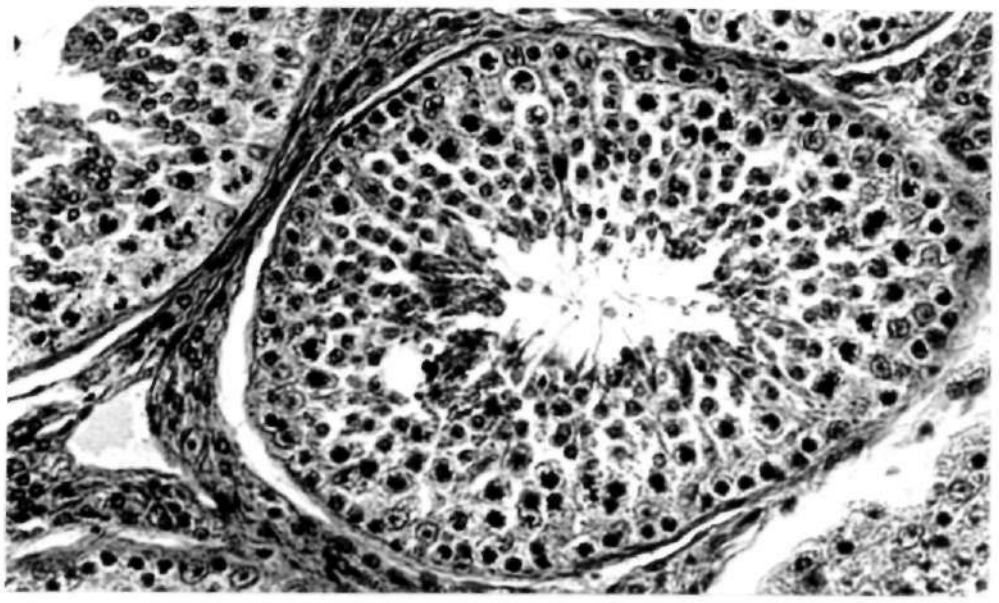


Fig. 8. Uninterrupted spermatogenesis in a normal testis showing round spermatids. H. & E. x 400.

Uninterrupted spermatogenesis in a normal testis is shown in Figs. 7 and 8. Over 80% of such testes were observed monthly indicating active spermatogenesis throughout the four seasons (dry, pre-rain, rain and pre-dry).

5. Seasonal effect on Spermatogenesis

Although spermatogenesis was found to be active throughout the year, there was an increased peak during October to December and July. This was evident by the correlation of testicular weight, length and diameter, and diameter of the seminiferous tubules (Table 15).

Table 14: Frequency of orchitis and testicular degeneration and hypoplasia encountered in indigenous bulls in Nigeria.

Month	Orchitis	Degeneration	Hypoplasia
January	2 (16.7%)	+*	-
February	1 (8.3%)	+	-
March	-	+	2 (16.7%)
April	-	+	-
May	1 (8.3%)	+	-
June	-	+	-
July	1 (8.3%)	+	3 (25%)
August	-	+	1 (8.3%)
September	-	+	-
October	-	+	-
November	3 (25%)	+	-
December	1 (8.3%)	+	-
Incidence	6.3%	20%	4.2%

* Degenerative changes present in at least one testis per month, usually mild.

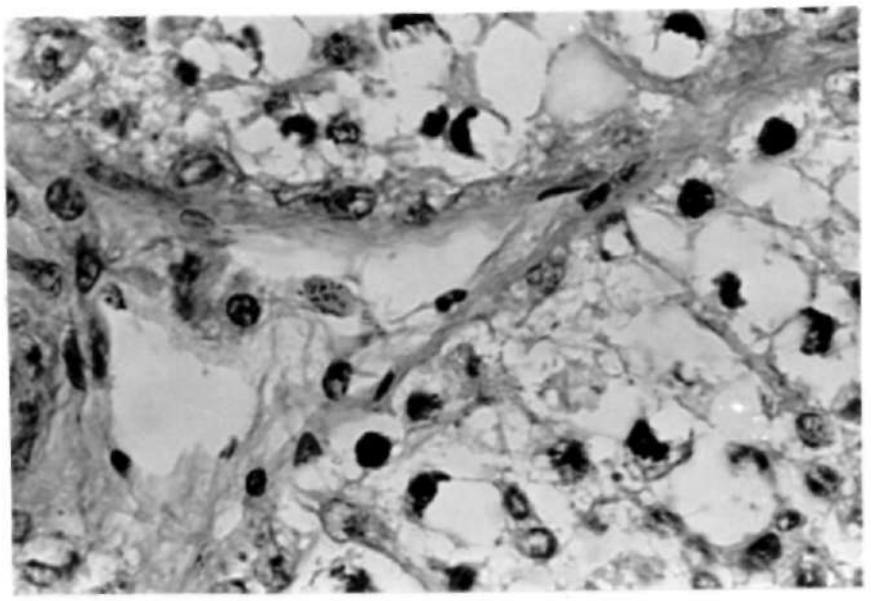


Fig. 9. Testicular degeneration showing degenerated germ cells. H. & E. x 400.

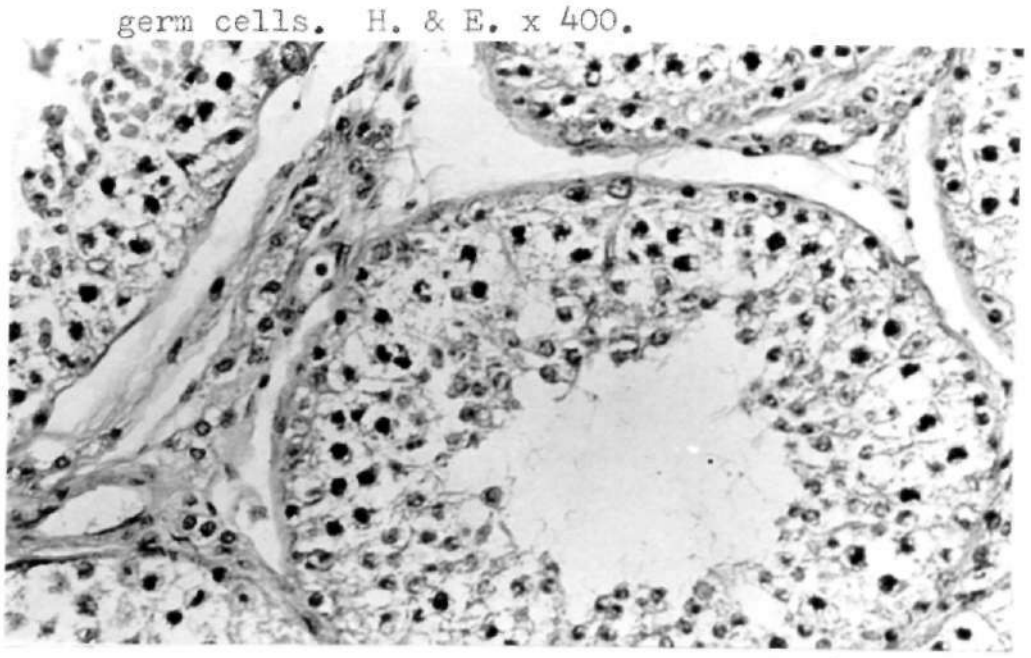


Fig. 10. Testicular degeneration showing pyknotic nuclei and karyolysis. H. & E. x 400.

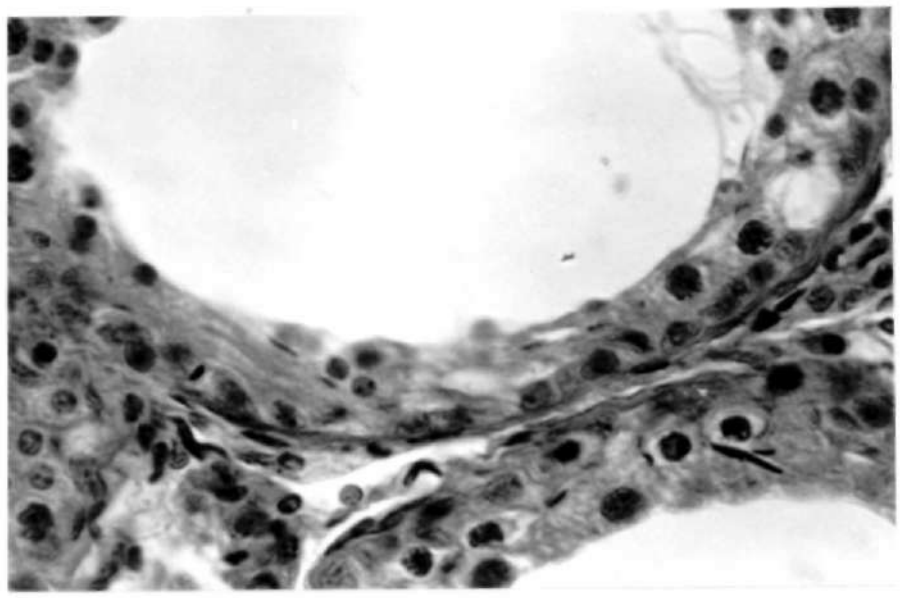


Fig. 11. Testicular hypoplasia with absence of germ cells in hypoplastic tubules. H. & E. x 400.

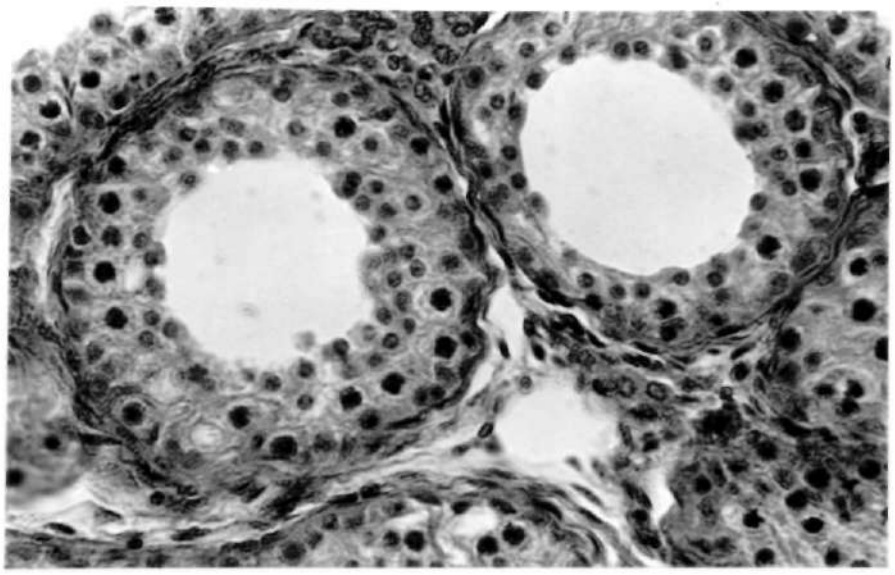


Fig. 12. Testicular hypoplasia showing interstitial cell hyperplasia. H. & E. x 400.

Table 15: Relationship between weight, diameter, and length of testes, and diameter of seminiferous tubules of indigenous bulls in Nigeria over a 12 month period.

Month	Weight / Length	Weight / Diameter	Weight / *DST	Diameter / Length	DST / Weight	DST / Length	DST / Dia.	Weight / Length / Diameter
January	14.3	32.0	0.8	0.5	1.3	18.4	41.2	78.6
February	13.3	30.8	0.8	0.4	1.3	17.4	40.4	63.0
March	12.8	31.1	0.8	0.4	1.3	16.2	39.6	63.6
April	12.9	32.0	0.8	0.4	1.3	16.4	40.6	60.5
May	12.8	29.9	0.8	0.4	1.3	16.0	37.4	65.1
June	12.0	28.6	0.7	0.4	1.4	17.0	40.5	58.3
July	16.4	34.3	1.0	0.5	1.0	16.6	34.7	90.3
August	11.5	24.3	0.8	0.5	1.2	13.8	29.1	66.2
September	12.0	25.6	0.7	0.5	1.4	16.5	35.3	67.9
October	16.7	35.6	1.1	0.5	0.9	15.7	33.5	89.3
November	19.0	38.7	1.0	0.5	1.0	18.6	38.0	104.8
December	17.0	38.6	0.8	0.4	1.2	20.2	45.7	82.1

* DST = Average diameter of seminiferous tubules.

DISCUSSION

Testicular dimensions and spermatogenesis of bulls indigenous to Nigeria ~~was~~ were studied and the findings were related to the seasons. To reduce non-seasonal factors to a minimum, only testes from mature bulls in good condition were selected. Problems inherent in abattoir studies in Nigeria such as collection of specimens, reluctance to permit antemortem inspection, and increasing cost of the specimens, were encountered in this investigation.

Diameter, length and weight of the testes examined were smaller than those reported for Bos taurus breeds (Ellenberger-Baum, 1939). Although variation in testicular dimensions may reflect individual variation, there was no significant intra-month variation; the inter-month variation, however, was highly significant. Correlation of the gross dimensions indicated increased testicular activity during the rainy (June-September) and pre-dry (October-December) seasons, a finding in keeping with the better nutrition during these periods. Seminiferous tubular activity was greater during the rainy season.

Incidence of gross testicular lesions was lower than reported elsewhere (Lagerlof, 1938, 1939; Barker, 1956; Ball *et al.*, 1968). This may have been due to age and physical condition of the bulls sampled, criteria used for classifying testicular degeneration and hypoplasia, breed difference, and environmental factors. Testicular degeneration, orchitis, testicular hypoplasia and tick infestation of the scrotum, occurred randomly and had no seasonal pattern. The incidence of testicular hypoplasia in this study was low. The incidence of orchitis ranged from 8.3 to 25%, which compared with the 24% incidence reported in Sweden (Lagerlof, 1938). Barker (1956) in Canada reported an incidence of 25% chronic degeneration and atrophy in 158 bovine testes. Ball *et al.* (1968) in the U.S.A. observed orchitis in 52% of 78 young bulls and in 35% of testes *postmortem*.

The two most common testicular changes affecting spermatogenesis are hypoplasia and degeneration (Lagerlof, 1938; Gledhill, 1973). Clinical or microscopic differentiation between hypoplasia and degeneration is not always possible and especially if degenerative changes are superimposed on hypoplasia

(Lagerlof, 1938; McEntee, 1970). The criteria for distinguishing between these two conditions used in this study were found to be satisfactory. Testicular degeneration was the most common histopathological change found. The monthly incidence was 20% and there was no seasonal pattern. In all cases, primary spermatocytes were damaged more than the other germ cells. Testicular degenerative changes were manifested by varying degrees of vacuolation and desquamation of cells, pyknosis and karyolysis, spermatidic giant cells, and wave-like thickening of the basement membrane. These changes agreed with those reported previously (Lagerlof, 1938; Knudsen, 1954; Konig, 1964; McEntee, 1970; Humphrey and Ladds, 1975). Some of these changes may be due to artifacts. Lagerlof (1934) regarded spermatidic giant cells to be indicative of degenerative changes. In this study when degenerative changes involved 15% or less of the tubules, spermatogenesis was not adversely affected.

The incidence of 20% testicular degeneration is in sharp contrast to the approximate 41% in Sweden (Lagerlof, 1938). The difference may be due to breed and different aetiological agents. Indigenous bulls

in Nigeria apparently have acquired adaptation to some environmental factors. Lagerlof (1934) demonstrated the degenerative effect of heat on bovine testes and one would expect this to occur in Nigeria. This was not so in this investigation as testicular degenerative changes were not more prevalent during the hot period in Nigeria (January to May). It would appear that indigenous cattle breeds in tropical environments have developed an adaptive thermoregulatory mechanism in their scrotum to protect against high environmental temperatures (Bonsma, 1940). In light of the findings in this study and of Bonsma's, the thickness and structure of scrotal skin of indigenous bulls should be investigated. The lack of marked seasonal fluctuation in temperature in Nigeria for any appreciable period of time may explain the little seasonal variation in spermatogenesis. This is in agreement with earlier work in East Africa (Lasley and Bogart, 1943).

Testicular hypoplasia, as found by histopathological examination, was not common in this study. The incidence of 4.2% is much lower than the 23% reported in Sweden (Lagerlof, 1938). This difference may be due to breed,

method of selection of testes, criteria for classifying hypoplasia, and environmental factors. Lagerlof (1938) stated that testicular hypoplasia is comparatively common in young bulls of certain breeds, especially in Sweden. The results of this study suggests that testicular hypoplasia is of minor significance in the fertility of Fulani cattle in Nigeria.

The mean diameter of the seminiferous tubules provides a useful and simple guide for assessing bovine testicular development and function (Hay et al., 1961). The diameter of seminiferous tubules of indigenous bulls in Nigeria has not previously been reported. The range of 167 to 224 μ was within the range of 170 to 300 μ, but less than the maximum, that Lagerlof (1939) reported in his study of exotic breeds. The highly significant inter-month variation may be due to individual differences but may also be due to some, yet unexplained, factors related to seasonal changes.

Spermatogenic activity is manifested by various stages in the development and maturation of spermatozoa in most seminiferous tubules. Different stages of development are seen in different tubules giving spermatogenesis a wave-like development. The

monthly values indicated increased activity early in the rainy season and extending towards the end of the pre-dry season. The significant inter-month variation may be due partly to age of the bulls or environmental factors. There is a significant relationship between a bull's age and testicular weight and spermatogenesis (Knudsen, 1954; Hay et al., 1961). The various seminiferous germ cells vary in their susceptibility to injurious agents (Knudsen, 1954). Spermatogonia-B cells show little or no change even with severe testicular degeneration but spermatogonia-A cells are injured and reduced in number; the other cells in the spermatogenic epithelium are also injured.

In Nigeria one would expect severe undernutrition and malnutrition to disturb spermatogenesis. Mann and Walton (1953) reported that testicular function was remarkably resistant to undernutrition. Whether this is so in indigenous bulls under traditional methods of husbandry in Nigeria needs to be investigated.

Another factor, which may partly explain the random distribution of testicular degeneration, is ectoparasitism. Tick infestation of cattle in Nigeria is common throughout the year (Alhaji, 1975; Osori, 1975)

and it may play a role in testicular changes. It has been established that ticks cause testicular inflammation and degeneration in rams (Watson, 1964).

Although spermatogenesis in indigenous bulls was found to be active throughout the year, correlation of testicular dimensions, diameter of seminiferous tubules, and activity of the spermatogenic epithelium, indicated increased spermatogenic activity during the rainy and pre-dry seasons. These seasonal peaks coincide with better nutrition during these two periods. This synchronises with the seasonal breeding activity of Fulani cows. Osori (1976) found that indigenous cows in Nigeria were seasonal breeders with peak activity during the rainy and pre-dry seasons. He recommended that cows be bred in July and August as this would permit at least three services, if required. This study supports his findings.

It is concluded from this investigation that:

1. Spermatogenesis in indigenous bulls is influenced by seasonal factors resulting in increased activity during the rainy and pre-dry seasons. Apart from improved nutrition, no environmental factor was identified.

2. Testicular lesions have no seasonal pattern and occur randomly throughout the year, the most important being degeneration.
3. Testicular hypoplasia appears to be of little significance in the fertility of indigenous cattle.
4. The role of the bull in the low reproductive efficiency of indigenous cattle needs to be clarified. It is recommended that more research on male fertility and infertility, including cytogenetic, be carried out.

In an attempt to improve the reproductive performance of indigenous bulls the following suggestions are made.

1. A policy of rigid selection of local bulls be established.
2. Purchase of better Zebu bulls from neighbouring countries with similar climatic and environmental conditions.
3. Selection and upgrading of bulls of the various indigenous breeds at the Government L.I.B.C. farms for dissemination of their progeny to private herds.

4. Encourage castration of all bulls with poor body composition before maturity.
5. Mass education of Fulani herdsmen about the advantages of:
   a. keeping good bulls and culling poor quality bulls, and
   b. profit-motivated cattle husbandry.

SUMMARY

Testicular dimensions and spermatogenesis were evaluated in 144 pairs of testes from indigenous bulls in Nigeria over a period of a year. The bulls aged 5 to 10 years, belonged to nomadic Fulani herdsmen, and were all in good condition at the time of slaughter. The scrotum of 58 (40%) had mild to moderate tick infestation.

The average monthly length, diameter, and weight of the testes were 11.6 cm. (10.9 - 12.1), 5.2 cm. (4.7 - 5.7), and 172.9g (139 - 209.7), respectively. Inter-month but not the intra-month variation for each dimension was significant ($P<0.01$).

Nine of the 144 pairs of testes had gross lesions (6.3%); degeneration 2.8%, orchitis 2.1%, and hypoplasia 1.4%. Microscopically, the incidence of testicular degeneration was 20%, orchitis 6.3%, and testicular hypoplasia 4.2%. Testicular degeneration occurred monthly and the involvement was usually mild. Orchitis and hypoplasia occurred randomly and had no seasonal pattern.

Microscopic examination of the seminiferous tubules revealed the following monthly averages: diameter 195μ

(167-224); spermatogonia-A cells 4.2 (3.8 - 5.1); spermatogonia-B cells 6 (4.3 - 11.6); primary spermatocytes 49.8 (38.9 - 62); and round and elongated spermatids 86.4 (47.6 - 111) and 30.5 (19.8 - 44), respectively. Except for spermatogonia-A, the inter-month but not the intra - month variations were significant ($P < 0.01$). Secondary spermatocytes were transitory and difficult to distinguish and identify from round spermatids.

Although spermatogenesis was found to be active in indigenous bulls throughout the year (estimated to be over 80%), correlation of testicular dimensions, diameter of seminiferous tubules, and activity of spermatogenic epithelium indicated increased activity during the rainy and pre-dry seasons. Tropical heat and other environmental factors did not alter the pattern of spermatogenesis.

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APPENDIX 1

Monthly evaluation of Weight, Length, Diameter
and Gross Lesions

Tables 1-12

Table 1: The relationship between weight, length, diameter and gross pathological condition of bovine testes for January, 1975.

Testis No.	Weight (g)	Length (cm)	Diameter (cm)	Clinical Examination
L1	183.0	10.5	4.9	Grossly normal
R1	199.1	13.5	6.0	" "
L2	158.8	11.0	5.4	" "
R2	161.8	11.0	5.4	" "
L3	198.0	13.6	6.1	" "
R3	195.4	14.0	6.0	" "
L4	144.5	9.5	4.3	" "
R4	141.0	10.5	4.7	" "
L5	193.5	12.5	5.9	" "
R5	193.7	12.5	6.0	" "
L6	142.2	11.5	4.9	" "
R6	164.7	14.5	5.3	" "
Average	172.9	12.1	5.4	

Table 2: The relationship between the weight, length, diameter and gross pathological condition of bovine testes for February, 1975.

Testis No.	Weight (g)	Length (cm)	Diameter (cm)	Clinical Examination
L1	193.4	12.0	5.1	Grossly normal
R1	128.2	10.8	4.5	" "
L2	170.3	11.4	4.8	" "
R2	193.7	12.1	5.0	" "
L3	97.3	9.4	4.2	" "
R3	111.2	10.1	4.5	" "
L4	138.5	10.8	5.0	" "
R4	188.5	11.6	5.0	" "
L5	128.5	10.8	4.5	" "
R5	126.7	10.6	4.5	" "
L6	129.2	10.7	4.6	" "
R6	133.5	10.8	4.8	" "
Average	144.9	10.9	4.7	

Table 3: The relationship between the weight, length diameter and gross pathological condition of bovine testes for March, 1975.

Testis No.	Weight (g)	Length (cm)	Diameter (cm)	Clinical Examination
L1	145.3	12.0	4.8	Grossly normal
R1	160.5	12.1	5.1	" "
L2	188.7	12.5	5.3	" "
R2	172.6	13.0	4.9	" "
L3	186.9	13.0	4.9	" "
R3	168.6	12.5	5.0	" "
L4	190.8	13.5	5.4	" "
R4	183.1	12.6	4.9	" "
L5	186.9	13.1	5.0	" "
R5	168.5	12.3	4.8	" "
L6	38.1	8.5	4.3	Firmer than usual; thickened, adhered tunica vaginalis and albuginea
R6	41.5	8.5	4.5	
Average	152.6	12.0	4.9	

Table 4: The relationship between the weight, length, diameter and gross pathological condition of bovine testes for April, 1975.

Testis No.	Weight (g)	Length (cm)	Diameter (cm)	Clinical Examination
L1	138.9	11.2	5.0	Grossly normal
R1	134.0	10.8	5.0	" "
L2	128.0	11.0	4.7	" "
R2	141.2	11.3	5.1	" "
L3	144.0	10.5	4.8	" "
R3	129.7	10.3	4.4	" "
L4	123.2	11.0	4.3	" "
R4	128.5	11.0	4.3	" "
L5	183.1	11.8	5.7	" "
R5	157.4	11.8	5.3	Soft, meaty on cut surface
L6	201.0	15.1	5.9	Grossly normal
R6	187.9	15.0	5.7	Cut surfce is firm fibrotic
Average	151.2	11.7	5.0	

Table 5: The relationship between the weight, length, diameter and gross pathological condition of bovine testes for May, 1975.

Testis No.	Weight (g)	Length (cm)	Diameter (cm)	Clinical Examination
L1	92.8	11.0	4.1	Grossly normal
R1	94.1	10.0	4.5	" "
L2	186.9	12.0	5.0	" "
R2	202.0	13.1	5.9	" "
L3	186.9	13.0	4.8	" "
R3	200.9	13.1	4.9	" "
L4	145.4	11.0	4.3	" "
R4	141.0	11.5	4.1	" "
L5	188.7	12.5	5.0	" "
R5	173.6	11.5	4.9	" "
L6	91.5	11.0	4.7	" "
R6	92.8	11.0	4.7	" "
Average	149.7	11.7	4.7	

Table 6: The relationship between weight, length, diameter and gross pathological condition of bovine testes for June, 1975.

Testis No.	Weight (g)	Length (cm)	Diameter (cm)	Clinical Examination
L1	166.3	12.5	4.9	Soft, meaty on cut surface
R1	157.0	13.5	4.3	Grossly normal
L2	150.1	11.5	5.0	" "
R2	157.1	14.5	4.6	" "
L3	137.3	11.5	4.8	" "
R3	169.5	12.1	5.0	" "
L4	93.3	10.0	5.0	" "
R4	105.8	10.1	5.0	" "
L5	86.2	10.1	4.8	" "
R5	93.6	10.5	4.8	" "
L6	184.5	12.0	5.3	" "
R6	179.4	12.0	5.3	" "
Average	140.0	11.7	4.9	

Table 7: The relationship between weight, length, diameter and gross pathological condition of bovine testes for July, 1975.

Testis No.	Weight (g)	Length (cm)	Diameter (cm)	Clinical Examination
L1	227.2	13.1	5.9	Grossly normal
R1	232.1	13.0	6.4	" "
L2	47.5	7.0	4.0	" "
R2	43.7	8.1	4.1	" "
L3	275.1	14.0	6.1	" "
R3	245.5	14.0	6.2	" "
L4	338.2	14.0	6.9	" "
R4	336.2	16.1	6.9	" "
L5	31.9	6.1	4.0	Soft, meaty on cut surface
R5	88.0	9.0	4.8	Grossly normal
L6	195.8	12.0	5.4	" "
R6	213.8	12.0	5.9	" "
Average	189.6	11.5	5.5	

Table 8: The relationship between the weight, length, diameter and gross pathological condition of bovine testes for August, 1975.

Testis No.	Weight (g)	Length (cm)	Diameter (cm)	Clinical Examination
L1	72.1	9.5	4.4	Grossly normal
R1	125.8	12.5	4.9	" "
L2	199.9	14.1	6.8	" "
R2	194.4	15.0	6.9	" "
L3	118.2	11.5	5.9	" "
R3	118.6	10.0	5.8	" "
L4	171.9	12.0	5.9	" "
R4	177.1	13.0	6.1	" "
L5	120.6	12.0	5.1	" "
R5	125.5	11.0	5.5	" "
L6	115.7	12.0	4.9	" "
R6	128.9	12.0	5.4	
Average	139.1	12.1	5.7	

Table 9: The relationship between the weight, length, diameter and gross pathological condition of bovine testes for September, 1975.

Testis No.	Weight (g)	Length (cm)	Diameter (cm)	Clinical Examination
L1	147.3	12.0	5.9	Grossly normal
R1	123.5	12.0	5.9	" "
L2	134.6	11.6	5.7	" "
R2	140.2	11.1	5.7	" "
L3	264.2	14.0	5.4	" "
R3	262.4	14.0	6.0	" "
L4	136.0	11.0	5.0	" "
R4	150.6	11.2	5.1	" "
L5	163.1	10.0	6.0	" "
R5	174.2	11.5	5.0	" "
L6	137.1	12.1	5.7	" "
R6	136.4	12.1	5.4	" "
Average	164.0	11.9	5.6	

Table 10: The relationship between the weight, length, diameter and gross pathological condition of bovine testes for October, 1975.

Testis No.	Weight (g)	Length (cm)	Diameter (cm)	Clinical Examination
L1	118.1	9.1	5.0	Grossly normal
R1	117.9	10.3	5.1	" "
L2	238.3	12.0	4.5	" "
R2	231.3	12.1	5.3	" "
L3	192.5	11.5	5.6	" "
R3	196.3	11.7	5.7	" "
L4	204.1	11.1	5.5	" "
R4	220.9	11.1	5.7	" "
L5	189.6	11.6	5.4	" "
R5	191.1	11.6	5.5	" "
L6	137.1	11.0	5.0	" "
R6	150.6	11.2	5.0	" "
Average	187.4	11.2	5.3	" "

Table 11: The relationship between the weight, length, diameter and gross pathological condition of bovine testes for November, 1975.

Testis No.	Weight (g)	Length (cm)	Diameter (cm)	Clinical Examination
L1	369.1	13.1	6.9	Grossly normal
R1	181.0	10.1	5.6	Calcification, cut surfaces
L2	187.1	11.5	5.1	Grossly normal
R2	171.2	10.0	4.9	" "
L3	107.1	8.6	4.8	Softer than normal
R3	117.4	9.5	4.6	Grossly normal
L4	204.8	10.0	5.5	Softer, petechiae
R4	186.7	11.0	5.5	" "
L5	312.6	13.5	6.6	Grossly normal
R5	228.8	12.0	5.3	" "
L6	231.2	12.4	4.8	" "
R6	219.4	11.0	5.4	" "
Average	209.7	11.1	5.4	

Table 12: The relationship between the weight, length, diameter and gross pathological condition of bovine testes for December, 1975.

Testis No.	Weight (g)	Length (cm)	Diameter (cm)	Clinical Examination
L1	214.8	11.5	5.0	Grossly normal
R1	214.2	11.0	5.5	" "
L2	193.5	9.5	5.0	" "
R2	192.1	10.0	5.0	" "
L3	170.5	10.3	5.1	" "
R3	172.4	9.6	5.0	" "
L4	193.4	14.3	4.3	" "
R4	187.9	14.0	4.9	" "
L5	214.8	11.5	5.0	" "
R5	214.2	11.0	5.5	" "
L6	154.1	10.0	4.5	" "
R6	145.5	10.5	4.0	" "
Average	188.9	11.1	4.9	

APPENDIX 2

Monthly Evaluation of the Seminiferous tubules

Tables 13-18

Table 13: Average diameter of the seminiferous tubules of testes of indigenous bulls in Nigeria.

Month	Range (μ)	Average (μ)	S.D.
January	187 - 151	223 μ	22.2
February	170 - 212	190 "	14.9
March	189 - 250	194 "	27.4
April	168 - 227	192 "	17.5
May	148 - 212	187 "	21.5
June	175 - 244	198 "	20.6
July	128 - 246	192 "	40.8
August	121 - 197	167 "	26.1
September	169 - 240	196 "	21.5
October	157 - 188	176 "	10.3
November	172 - 239	206 "	19.8
December	194 - 247	224 "	17.4

Table 14: Average number of spermatogonia - A present in seminiferous tubules of indigenous bulls in Nigeria.

Month	Range μ	Average	S. D.
January	3 - 9	3.8	2.2
February	2.6 - 5.7	3.9	0.9
March	2.5 - 6.6	4.1	1.4
April	2.9 - 12.9	5.1	2.6
May	1.8 - 6.8	4.1	1.4
June	2.1 - 6.2	4.1	1.4
July	1.6 - 5.7	3.9	1.4
August	2.4 - 6.5	4.3	1.1
September	2.3 - 6.3	4.1	1.4
October	2.1 - 6.7	4.4	1.2
November	2.1 - 5.3	4.5	1.2
December	2.1 - 6.6	4.1	1.5

Table 15: Average number of spermatogonia - B cells in seminiferous tubules of indigenous bulls in Nigeria.

Month	Range	Average	S D.
January	3 - 8	4.5	2.0
February	7.8 - 16.5	10.2	2.6
March	9.2 - 16.6	11.6	4.3
April,	4.3 - 13.6	7.2	3.1
May	3.3 - 7.9	5.7	1.8
June	2.8 - 7.3	5.4	1.3
July	2.6 - 6.5	4.3	1.3
August	2.5 - 6.8	4.5	1.2
September	2.5 - 7.0	4.9	1.5
October	2.0 - 4.9	4.9	1.2
November	3.2 - 6.7	4.7	0.9
December	2.4 - 7.1	4.6	1.6

Table 16: Monthly average number of primary spermatocytes present in seminiferous tubules of indigenous bulls in Nigeria.

Month	Range	Average	S. D.
January	30.8 - 75.8	51.6	13.9
February	31.3 - 57.3	44.2	9.2
March	44.5 - 72.1	55.1	9.8
April	41.8 - 83.8	59.6	12.8
May	6.7 - 58.0	38.9	17.6
June	25.1 - 88.3	62.0	21.3
July	10.5 - 78.2	44.6	18.5
August	2.3 - 60.4	40.5	17.9
September	21.3 - 67.2	45.6	14.5
October	31.5 - 62.9	46.7	10.8
November	25.2 - 79.1	55.2	16.6
December	41.9 - 73.2	53.5	9.8

Table 17: Monthly average number of round spermatids present in seminiferous tubules of indigenous bulls in Nigeria.

Month	Range	Average	S. D.
January	39.3 - 126.1	85.2	28.5
February	37.5 - 121.2	75.1	25.0
March	70.0 - 133.9	95.6	21.8
April	54.3 - 134.8	90.5	30.4
May	14.9 - 93.9	47.7	26.1
June	29.3 - 214.5	111.1	66.3
July	19.3 - 209.1	91.8	58.5
August	0.0 - 141.5	85.9	49.6
September	28.8 - 171.6	95.5	42.7
October	35.8 - 122.2	85.3	28.1
November	46.7 - 126.8	93.7	25.1
December	35.6 - 122.8	78.9	25.3

Table 18: Monthly average number of elongated spermatids present in seminiferous tubules of indigenous bulls in Nigeria.

Month	Range	Average	S.D.
January	18.4 - 71.1	32.9	16.1
February	8.6 - 32.7	21.2	7.8
March	15.3 - 45.8	30.4	10.8
April	12.6 - 81.2	38.7	20.9
May	0.0 - 59.8	22.8	17.8
June	10.6 - 90.0	44.1	30.1
July	0.0 - 60.0	30.5	18.2
August	0.0 - 65.7	19.9	18.4
September	13.2 - 63.2	31.9	15.4
October	8.3 - 39.0	25. 1	10.3
November	2.3 - 57.9	34.9	14.9
December	16.1 - 46.2	32.9	10.4

APPENDIX 3

Monthly Histological Examination of Bovine Testes - Tables 19-30

Key

1 = Present in one tubule

2 = Present in two tubules

3 = Present in 3-6 tubules

4 = Present in more than 6 tubules

\- = Absent

Table 19: Histological examination of bovine testis for January, 1975.

Microscopic findings	Testis Number											
	L1	R1	L2	R2	L3	R3	L4	R4	L5	R5	L6	R6
Seminferous tubules												
Dilatation	-	-	-	-	-	-	-	-	-	-	-	-
Atrophic	-	-	-	-	-	-	-	-	-	-	-	-
Hypoplastic	-	-	-	-	-	-	-	-	-	-	-	-
Basement membrane												
Detachment	-	4	1	3	2	-	-	-	-	2	1	-
Thickening	-	-	3	3	-	-	-	-	-	-	1	-
Sertoli cell												
Normal	4	4	4	4	4	4	4	4	4	4	4	4
Hyperplastic	-	-	-	-	-	-	-	-	-	-	-	-
Atrophic	-	-	-	-	-	-	-	-	-	-	-	-
Desquamated	-	-	-	-	-	-	-	-	-	-	-	-
Spermatogonia												
A	4	4	4	4	4	4	4	4	4	4	4	4
B	4	4	4	4	4	4	4	4	4	4	4	4
Intermediate	-	-	-	-	-	-	-	-	-	-	-	-
Vacuolation	1	-	-	-	-	-	-	-	-	-	-	-
Desquamation	-	-	-	-	-	-	-	-	-	-	-	-
Primary spermatocytes	4	4	4	4	4	4	4	4	4	4	4	4
Vacuolation	1	-	1	-	-	-	-	-	-	2	-	-
Pyknosis	1	-	-	-	-	-	1	1	-	2	-	-

Table 19: Continued

Microscopic findings	Testis Number											
	L1	R1	L2	R2	L3	R3	L4	R4	L5	R5	L6	R6
Karyolysis	1	-	-	2	1	1	-	1	-	2	2	-
Desquamation	-	1	1	1	-	-	-	-	-	1	-	-
Hydropic degeneration	1	1	-	-	-	-	-	-	-	1	-	-
Restitution nuclei	1	1	-	-	-	-	-	-	-	1	-	-
Contracted bivalents	1	-	-	-	-	-	-	-	-	-	-	-
Secondary spermatocytes	-	-	-	-	-	-	-	-	-	-	-	-
Change in shape	-	-	-	-	-	-	-	-	-	-	-	-
Change in size	-	-	-	-	-	-	-	-	-	-	-	-
Spermatids												
Elongated	3	4	4	4	4	3	4	3	3	4	3	3
Rounded	4	4	4	4	4	4	4	4	4	4	4	4
Desquamated	-	-	2	1	-	-	-	-	-	1	-	-
Degeneration	-	-	-	1	-	-	-	-	-	-	-	-
Giant cell	-	-	1	1	-	1	-	-	1	-	-	-
Spermatozoa												
Present	4	3	2	3	3	2	3	4	2	2	1	2
Normal	4	3	2	3	3	2	3	4	2	2	1	2
Abnormal	-	-	-	-	-	-	-	-	-	-	-	-
Others												
Tubular debris	2	3	3	-	-	-	-	-	2	2	-	2
Calcification	-	-	-	-	-	-	-	-	-	-	-	-
Leukocytosis	-	-	-	-	-	-	-	-	2	2	-	-
Fibrosis	-	-	-	-	-	-	-	-	-	-	-	-
Inertubular changes												
Interstitial cell hyperplasia	-	-	3+	3+	-	-	-	-	-	-	-	-
Leukocytosis	-	-	-	-	-	-	-	-	-	-	-	-

Table 20: Histological examination of bovine testis for February, 1975.

Microscopic findings	Testis Number											
	L1	R1	L2	R2	L3	R3	L4	R4	L5	R5	L6	R6
Seminiferous tubules												
Dilatation	-	-	-	-	-	-	-	-	-	-	-	-
Atrophic	-	-	-	-	-	-	-	-	-	-	-	-
Hypoplastic	-	-	-	-	-	-	-	-	-	-	-	-
Basement membrane												
Detachment	-	-	1	2	-	1	-	2	3	2	2	-
Thickening	-	-	-	-	-	-	-	-	-	-	-	2
Sertoli cell												
Normal	3	4	4	4	4	4	4	4	4	4	4	4
Hyperplastic	-	-	-	-	-	-	-	-	-	-	-	-
Atrophic	-	-	-	-	-	-	-	-	-	-	-	-
Desquamated	1	-	-	-	-	-	-	-	-	-	-	-
Spermatogonia												
A	4	4	4	4	4	4	4	4	4	4	4	4
B	4	4	4	4	4	4	4	4	4	4	4	4
Intermediate	-	-	-	-	-	-	-	-	-	-	-	-
Vacuolation	-	-	-	-	-	-	-	-	-	-	-	-
Desquamation	-	-	-	-	-	-	1	-	-	-	-	-
Primary spermatocytes	4	4	4	4	4	4	4	4	4	4	4	4
Vacuolation	-	1	1	-	-	-	1	-	-	-	-	-
Pyknosis	-	-	-	-	-	1	2	-	1	1	1	-
Karyolysis	-	-	-	1	1	-	2	-	-	-	-	-
Desquamation	-	-	-	1	-	-	2	-	-	-	-	-

Table 20: Continued

Microscopic findings	Testis Number											
	L1	R1	L2	R2	L3	R3	L4	R4	L5	R5	L6	R6
Hydropic degeneration	-	-	-	-	-	-	2	-	-	-	-	-
Restitution nuclei	-	-	-	-	-	-	-	-	-	-	-	-
Contracted bivalents	-	-	-	-	-	-	-	-	-	-	1	-
Secondary spermatocytes	-	-	-	-	-	-	-	-	-	-	-	-
Change in shape	-	-	-	-	-	-	-	-	-	-	-	-
Change in size	-	-	-	-	-	-	-	-	-	-	-	-
Spermatids												
Elongated	4	4	4	4	4	4	3	3	4	4	4	4
Rounded	4	4	4	4	4	4	4	4	4	4	4	4
Desquamated	-	1	-	-	-	-	1	-	-	-	-	-
Degeneration	-	-	-	-	-	-	-	-	-	-	-	-
Giant cells	-	-	-	-	-	-	-	-	-	-	-	1
Spermatozoa												
Present	1	2	3	2	1	1	-	3	1	3	-	1
Normal	1	2	3	2	1	1	-	3	1	3	-	1
Abnormal	-	-	-	-	-	-	-	-	-	-	-	-
Other												
Tubular debris	-	-	-	1	-	-	2	1	-	-	-	-
Calcification	-	-	-	-	-	-	-	-	-	-	-	-
Leukocytosis	-	-	-	-	-	-	2	-	-	-	-	-
Fibrosis	-	-	-	-	-	-	-	-	-	-	-	-
Intertubular changes												
Interstitial cell hyperplasia	-	-	-	-	-	-	-	-	-	-	-	-
Leukocytosis	2	-	-	-	-	-	2+	2+	-	-	-	-

Table 21: Histological examination of bovine testis for March, 1975.

Microscopic findings	Testis Number											
	L1	R1	L2	R2	L3	R3	L4	R4	L5	R5	L6	R6
Seminiferous tubules												
Dilatation	-	-	-	-	-	-	-	-	-	-	-	-
Atrophic	-	-	-	-	-	-	-	-	-	-	-	-
Hypoplastic	-	-	-	-	-	-	-	-	-	-	3	3
Basement membrane												
Detachment	2	-	-	3	-	1	-	-	-	1	-	1
Thickening	-	-	-	-	-	-	-	-	-	-	-	-
Sertoli cell												
Normal	4	4	4	4	4	4	4	4	4	4	4	4
Hyperplastic	-	-	-	-	-	-	-	-	-	-	-	-
Atrophic	-	-	-	-	-	-	-	-	-	-	-	-
Desquamated	-	-	-	-	-	-	-	-	-	-	-	-
Spermatogonia												
A	4	4	4	4	4	4	4	4	4	4	4	4
B	4	4	4	4	4	4	4	4	4	4	4	4
Intermediate	-	-	-	-	-	-	-	-	-	-	-	-
Vacuolation	-	-	-	-	-	-	-	-	-	-	-	-
Desquamation	-	-	-	-	-	-	-	-	-	-	-	-
Primary spermatocytes	4	4	4	4	4	4	4	4	4	4	4	4
Vacuolation	-	-	-	-	-	-	-	-	-	-	-	1
Pyknosis	-	-	-	-	-	-	-	-	-	1	2	2
Karyolysis	-	-	-	-	-	-	-	-	-	-	-	-
Desquamation	-	1	2	-	-	-	-	-	-	-	-	-
Hydropic degeneration	-	-	-	-	-	-	-	-	-	-	1	1

Table 21: Continued

Microscopic findings	Testis Number											
	L1	R1	L2	R2	L3	R3	L4	R4	L5	R5	L6	R6
Restitution nuclei	-	-	-	-	-	-	-	-	-	-	-	-
Contracted bivalents	-	-	-	-	-	-	-	-	-	-	1	-
Secondary spermatocytes	-	-	-	-	-	-	-	-	-	-	-	-
Change in shape	-	-	-	-	-	-	-	-	-	-	-	-
Change in size	-	-	-	-	-	-	-	-	-	-	-	-
Spermatids												
Elongated	3	3	4	4	4	4	4	4	4	4	4	3
Rounded	4	4	4	4	4	4	4	4	4	4	4	4
Desquamated	-	-	-	-	-	1	1	-	-	-	1	-
Degeneration	-	-	-	-	-	-	-	-	-	-	-	-
Giant cells	-	-	-	-	-	-	-	-	-	-	-	-
Spermatozoa												
Present	-	1	1	2	3	3	1	3	3	2	2	2
Normal	-	1	1	2	3	3	1	3	3	2	2	2
Abnormal	-	-	-	-	-	-	-	-	-	-	1	-
Other												
Tubular debris	1	-	-	1	-	2	1	-	-	-	-	-
Calcification	-	-	-	-	-	-	-	-	-	-	-	-
Leukocytosis	-	-	-	-	-	-	-	-	-	-	+	+
Fibrosis	-	-	-	-	-	-	-	-	-	-	+	+
Intertubular changes												
Interstitial cell hyperplasia	-	-	-	-	-	-	-	-	-	-	-	-
Leukocytosis	+	-	-	-	-	-	-	-	-	-	+	+

Table 22: Histological examination of bovine testis for April, 1975.

Microscopic findings	Testis Number											
	L1	R1	L2	R2	L3	R3	L4	R4	L5	R5	L6	R6
Seminiferous tubules												
Dilatation	-	-	-	-	-	-	-	-	-	-	-	-
Atrophic	-	-	-	-	-	-	-	-	-	-	-	-
Hypoplastic	-	-	-	-	-	-	-	-	-	-	-	-
Basement membrane												
Detachment	-	-	-	1	-	-	-	-	3	-	-	2
Thickening	-	-	-	-	1	-	2	-	-	2	-	-
Sertoli cell												
Normal	4	4	4	4	4	4	4	4	4	4	4	4
Hyperplastic	-	-	-	-	-	-	-	-	-	-	-	-
Atrophic	-	-	-	-	-	-	-	-	-	-	-	-
Desquamated	-	-	-	-	-	-	-	-	-	-	-	-
Spermatogonia												
A	4	4	4	4	4	4	4	4	4	4	4	4
B	4	4	4	4	4	4	4	4	4	4	4	4
Intermediate	-	-	-	-	-	-	-	-	-	-	-	-
Vacuolation	-	-	-	-	-	1	-	-	-	-	-	-
Desquamation	-	-	-	-	-	1	1	-	-	-	-	-
Primary spermatocytes	4	4	4	4	4	4	4	4	4	4	4	4
Vacuolation	-	-	2	1	-	-	-	-	-	2	3	1
Pyknosis	-	-	1	1	-	-	2	-	-	3	3	1
Karyolysis	-	1	-	-	-	-	-	1	-	1	3	1
Desquamation	-	-	-	-	-	-	-	-	-	-	4	-

Table 22: Continued

Microscopic findings	Testis Number											
	L1	R1	L2	R2	L3	R3	L4	R4	L5	R5	L6	R6
Hydropic degeneration	-	-	-	-	-	-	-	-	-	2	2	-
Restitution nuclei	-	-	-	-	-	-	-	-	-	-	-	-
Contracted bivalents	-	-	-	-	-	-	-	-	-	-	-	-
Secondary spermatocytes	-	-	-	-	-	-	-	-	-	-	-	-
Change in shape	-	-	-	-	-	-	-	-	-	-	-	-
Change in size	-	-	-	-	-	-	-	-	-	-	-	-
Spermatids												
Elongated	4	4	3	4	4	4	3	4	3	3	3	4
Rounded	4	4	4	4	4	4	4	4	4	4	4	4
Desquamated	2	-	-	-	-	-	-	-	-	-	-	-
Degeneration	-	-	-	-	-	-	-	-	-	2	-	-
Giant cells	-	-	-	-	-	-	-	-	-	-	-	-
Spermatozoa												
Present	-	-	-	1	2	2	1	-	3	2	1	1
Normal	-	-	-	1	2	2	1	-	3	2	1	1
Abnormal	-	-	-	-	-	-	-	-	-	-	-	-
Other												
Tubular debris	-	-	-	-	-	1	1	-	-	-	-	-
Calcification	-	-	-	-	-	-	-	-	-	-	-	-
Leukocytosis	-	+	-	-	-	-	-	-	-	-	-	-
Fibrosis	-	-	-	-	-	-	-	-	-	-	+	-
Intertubular changes												
Interstitial cell hyperplasia	-	-	-	-	-	-	-	-	-	-	+	-
Leukocytosis	-	2+	-	-	-	-	-	-	-	-	-	-

Table 23: Histological examination of bovine testis for May, 1975.

Microscopic findings	Testis Number											
	L1	R1	L2	R2	L3	R3	L4	R4	L5	R5	L6	R6
Seminiferous tubules												
Dilatation	-	-	-	-	-	-	-	-	-	-	-	-
Atrophic	-	-	-	-	-	-	-	-	-	-	-	-
Hypoplastic	-	-	-	-	-	-	-	-	-	-	-	-
Basement membrane												
Detachment	-	1	1	-	-	-	-	2	1	2	-	-
Thickening	-	-	-	-	-	-	-	-	-	-	-	-
Sertoli cell												
Normal	4	4	4	4	4	4	4	4	4	4	4	4
Hyperplastic	-	-	-	-	-	-	-	-	-	-	-	-
Atrophic	-	-	-	-	-	-	-	-	-	-	-	-
Desquamated	1	-	-	-	-	-	-	-	-	-	-	-
Spermatogonia												
A	4	4	4	4	4	4	4	4	4	4	4	4
B	4	4	4	4	4	4	4	4	4	4	4	4
Intermediate	-	-	-	-	-	-	-	-	-	-	-	-
Vacuolation	-	-	-	-	-	2	-	-	-	1	-	-
Desquamation	1	-	-	-	1	1	-	-	-	1	-	-
Primary spermatocytes	4	4	4	4	4	4	4	4	4	4	4	4
Vacuolation		-	-	-	-	-	-	-	-	-	-	-
Pyknosis	-	-	-	2	1	2	-	-	-	1	-	-
Karyolysis	-	-	-	4	1	3	-	-	-	-	1	-
Desquamation	1	-	-	4	-	3	-	-	-	-	1	-

Table 23: Continued

Microscopic findings	Testis Number											
	L1	R1	L2	R2	L3	R3	L4	R4	L5	R5	L6	R6
Hydropic degeneration	-	-	-	4	-	3	-	-	-	-	-	-
Restitution nuclei	-	-	-	2	-	4	-	-	-	-	-	-
Contracted bivalents	-	-	-	2	-	-	-	-	-	-	-	-
Secondary spermatocytes	-	-	-	-	-	-	-	-	-	-	-	-
Change in shape	-	-	-	-	-	-	-	-	-	-	-	-
Change in size	-	-	-	-	-	-	-	-	-	-	-	-
Spermatids												
Elongated	4	4	3	-	4	-	3	3	4	4	3	4
Rounded	4	4	4	3	4	4	4	4	4	4	4	4
Desquamated	-	-	2	3	2	3	1	-	1	1	1	-
Degeneration	-	-	-	4	-	3	-	-	-	-	-	-
Giant cells	-	-	-	3	-	2	-	-	-	-	-	-
Spermatozoa												
Present	-	-	-	-	-	-	3	1	2	1	-	1
Normal	-	-	-	-	-	-	3	1	2	1	-	1
Abnormal	-	-	-	-	-	-	-	-	-	-	-	-
Other												
Tubular debris	-	-	2	2	-	3	-	1	1	-	-	-
Calcification	-	-	-	-	-	-	-	-	-	-	-	-
Leukocytosis	-	-	1	-	-	-	-	-	-	-	-	-
Fibrosis	-	-	-	-	-	-	-	-	-	-	-	-
Intertubular changes												
Interstitial cell hyperplasia	-	-	-	-	-	-	-	-	-	-	-	-
Leukocytosis	-	-	+	-	-	-	-	-	-	-	-	-

Table 24: Histological examination of bovine testis for June, 1975.

Microscopic findings	Testis Number											
	L1	R1	L2	R2	L3	R3	L4	R4	L5	R5	L6	R6
Seminiferous tubules												
Dilatation	-	-	-	-	-	-	-	-	-	-	-	-
Atrophic	-	-	-	-	-	-	-	-	3	2	-	-
Hypoplastic	-	-	-	-	-	-	-	-	-	-	-	-
Basement membrane												
Detachment	-	-	-	-	1	2	-	-	1	-	-	-
Thickening	-	-	2	-	-	-	-	-	3	1	1	-
Sertoli cell												
Normal	4	4	4	4	4	4	4	4	4	4	4	4
Hyperplastic	-	-	-	-	-	-	-	-	-	-	-	-
Atrophic	-	-	-	-	-	-	-	-	-	-	-	-
Desquamated	-	-	-	-	-	-	-	-	-	-	-	-
Spermatogonia												
A	4	4	4	4	4	4	4	4	4	4	4	4
B	4	4	4	4	4	4	4	4	4	4	4	4
Intermediate	-	-	-	-	-	-	-	-	-	-	-	-
Vacuolation	-	-	-	-	-	-	-	-	-	-	-	-
Desquamation	-	-	-	-	-	-	-	-	-	-	-	-
Primary spermatocytes	4	4	4	4	4	4	4	4	4	4	4	4
Vacuolation	-	1	-	-	-	-	-	-	2	-	-	-
Pyknosis	-	2	-	-	-	-	-	-	1	2	-	1
Karyolysis	-	-	-	-	-	-	1	-	-	3	-	1
Desquamation	-	-	-	1	-	-	-	-	-	-	-	-

Table 24: Continued

Microscopic findings	Testis Number											
	L1	R1	L2	R2	L3	R3	L4	R4	L5	R5	L6	R6
Hydropic degeneration	-	1	-	-	-	-	-	-	-	2	-	-
Restitution nuclei	-	-	-	-	-	-	-	-	-	-	-	-
Contracted bivalents	-	-	-	-	-	-	-	-	-	-	-	-
Secondary spermatocytes	-	-	-	-	-	-	-	-	-	-	-	-
Change in shape	-	-	-	-	-	-	-	-	-	-	-	-
Change in size	-	-	-	-	-	-	-	-	-	-	-	-
Spermatids												
Elongated	4	4	4	4	4	4	3	4	4	4	3	3
Rounded	4	4	4	4	4	4	4	4	4	4	4	4
Desquamated	-	-	-	-	-	-	-	-	-	1	-	-
Degeneration	-	-	-	-	-	-	-	-	-	-	-	-
Giant cells	-	-	-	-	-	-	-	-	-	-	-	-
Spermatozoa												
Present	1	2	2	2	1	1	2	3	2	3	3	2
Normal	1	2	2	2	1	1	2	3	2	3	3	1
Abnormal	-	-	-	-	-	-	-	-	-	-	-	-
Other												
Tubular debris	-	-	-	-	1	1	-	-	-	-	-	-
Calcification	-	-	-	-	-	-	-	-	-	-	-	-
Leukocytosis	-	-	-	-	-	-	-	-	-	-	-	-
Fibrosis	-	-	-	-	-	-	-	-	-	-	-	-
Intertubular changes												
Interstitial cell hyperplasia	-	-	-	-	-	-	-	-	-	-	-	-
Leukocytosis	-	-	1	1	-	-	-	-	-	-	-	-

Table 25: Histological examination of bovine testis for July, 1975.

Microscopic findings	Testis Number											
	L1	R1	L2	R2	L3	R3	L4	R4	L5	R5	L6	R6
Seminiferous tubules												
Dilatation	-	-	-	-	-	-	-	-	-	-	-	-
Atrophic	-	-	-	-	-	-	-	-	-	-	3	3
Hypoplastic	4	-	4	4	-	-	-	-	-	-	-	-
Basement membrane												
Detachment	2	3	-	2	-	-	-	-	-	-	1	2
Thickening	-	-	-	-	-	-	-	-	-	2	-	1
Sertoli cell												
Normal	4	4	4	4	4	4	4	4	4	4	4	4
Hyperplastic	-	-	-	-	-	-	-	-	-	-	-	-
Atrophic	-	-	-	-	-	-	-	-	-	-	-	-
Desquamated	-	-	-	-	-	-	-	-	-	-	-	-
Spermatogonia												
A	4	4	4	3	4	4	4	4	4	4	4	4
B	4	4	4	3	4	4	4	4	4	4	4	4
Intermediate	-	-	-	-	-	-	-	-	-	-	-	-
Vacuolation	-	-	-	-	-	-	-	-	-	-	-	-
Desquamation	-	-	-	-	-	-	-	-	-	-	-	-
Primary spermatocytes	4	4	3	3	4	4	4	4	4	4	4	4
Vacuolation	-	-	-	-	-	-	-	-	-	-	-	-
Pyknosis	-	-	-	-	-	1	1	-	3	2	-	-
Karyolysis	-	-	-	-	-	-	-	-	2	-	-	-
Desquamation	-	-	-	-	-	-	-	-	1	-	-	-

Table 25: Continued

Microscopic findings	Testis Number											
	L1	R1	L2	R2	L3	R3	L4	R4	L5	R5	L6	R6
Hydropic degeneration	-	-	-	-	-	-	-	-	2	-	-	-
Restitution nuclei	-	-	-	-	-	-	-	-	-	-	-	-
Contracted bivalents	-	-	-	-	-	-	-	-	1	-	-	-
Secondary spermatocytes	-	-	-	-	-	-	-	-	-	-	-	-
Change in shape	-	-	-	-	-	-	-	-	-	-	-	-
Change in size	-	-	-	-	-	-	-	-	-	-	-	-
Spermatids												
Elongated	3	4	-	-	3	4	3	4	4	4	4	3
Rounded	4	4	4	4	4	4	4	4	4	4	4	4
Desquamated	-	-	-	-	-	-	-	-	-	-	-	-
Degeneration	-	-	-	-	-	-	-	-	-	-	-	-
Giant cells	-	-	-	-	-	-	-	-	-	-	-	-
Spermatozoa												
Present	2	3	-	-	3	-	2	3	3	3	-	-
Normal	2	3	-	-	3	-	2	3	3	3	-	-
Abnormal	-	-	-	-	-	-	-	-	-	-	-	-
Other												
Tubular debris	-	-	-	-	-	-	-	-	-	-	-	-
Calcification	-	-	-	-	-	-	-	-	-	-	-	-
Leukocytosis	-	-	-	-	-	-	-	-	1	-	-	-
Fibrosis	-	-	-	-	-	-	-	-	-	-	-	-
Intertubular changes												
Interstitial cell hyperplasia	-	-	-	-	-	-	-	-	-	-	-	-
Leukocytosis	-	-	-	-	-	-	-	-	2	2	2	-

Table 26: Histological examination of bovine testis for August, 1975.

Microscopic findings	Testis Number											
	L1	R1	L2	R2	L3	R3	L4	R4	L5	R5	L6	R6
Seminiferous tubules												
Dilatation	-	-	-	-	-	-	-	-	-	-	-	-
Atrophic	-	-	-	-	-	-	3	-	-	-	4	-
Hypoplastic	-	-	-	-	4	-	-	-	-	-	-	-
Basement membrane												
Detachment	-	-	-	-	-	-	-	-	-	-	-	-
Thickening	4	1	1	2	4	4	3	3	-	-	1	-
Sertoli cell												
Normal	4	4	4	4	4	4	4	4	4	4	4	4
Hyperplastic	-	-	-	-	-	-	-	-	-	-	-	-
Atrophic	-	-	-	-	-	-	-	-	-	-	-	-
Desquamated	-	-	-	-	-	-	-	-	-	-	-	-
Spermatogonia												
A	4	4	4	4	4	4	4	4	4	4	4	4
B	4	4	4	4	4	4	4	4	4	4	4	4
Intermediate	-	-	-	-	-	-	-	-	-	-	-	-
Vacuolation	-	-	-	-	-	-	-	-	-	-	-	-
Desquamation	-	-	-	-	-	-	2	-	-	-	-	-
Primary spermatocytes	4	4	4	4	4	4	4	4	4	3	4	4
Vacuolation	-	-	-	-	-	-	-	-	-	-	-	-
Pyknosis	1	1	-	1	-	-	-	1	-	-	2	-
Karyolysis	-	-	-	-	-	-	-	-	-	-	-	-
Desquamation	1	2	-	-	-	-	-	-	-	-	-	-

Table 26: Continued

Microscopic findings	Testis Number											
	L1	R1	L2	R2	L3	R3	L4	R4	L5	R5	L6	R6
Hydropic degeneration	-	-	-	-	-	-	-	-	-	-	-	-
Restitution nuclei	-	-	-	-	-	-	-	-	-	-	-	-
Contracted bivalents	-	-	-	-	-	-	-	-	-	-	-	-
Secondary spermatocytes	-	-	-	-	-	-	-	-	-	-	-	-
Change in shape	-	-	-	-	-	-	-	-	-	-	-	-
Change in size	-	-	-	-	-	-	-	-	-	-	-	-
Spermatids												
Elongated	3	3	4	3	3	2	3	3	2	-	3	3
Rounded	4	4	4	4	3	3	4	4	4	-	4	4
Desquamated	-	2	-	-	2	-	-	-	-	-	-	-
Degeneration	-	-	-	-	-	-	-	-	-	-	-	-
Giant cells	-	-	-	-	-	-	-	-	-	-	-	-
Spermatozoa												
Present	-	2	-	2	-	1	1	1	-	-	-	3
Normal	-	2	-	2	-	1	1	1	-	-	-	3
Abnormal	-	-	-	-	-	-	-	-	-	-	-	-
Other												
Tubular debris	-	-	-	-	-	-	-	-	-	-	-	-
Calcification	-	-	-	-	-	-	-	-	-	-	-	-
Leukocytosis	-	-	-	-	-	-	-	-	-	-	-	-
Fibrosis	-	-	-	-	-	-	-	-	-	-	-	-
Intertubular changes												
Interstitial cell hyperplasia	-	-	-	-	-	-	-	-	-	-	-	-
Leukocytosis	-	-	-	1	-	1	2	2	-	-	-	-

Table 27: Histological examination of bovine testis for September, 1975.

Microscopic findings	Testis Number											
	L1	R1	L2	R2	L3	R3	L4	R4	L5	R5	L6	R6
Seminiferous tubules	-	-	-	-	-	-	-	-	-	-	-	-
Dilatation	-	-	-	-	-	-	-	-	-	-	-	-
Atrophic	-	-	-	-	-	-	-	-	-	-	-	-
Hypoplastic	-	-	-	-	-	-	-	-	-	-	-	-
Basement membrane												
Detachment	2	1	3	3	-	1	-	-	-	3	2	-
Thickening	-	2	-	-	-	-	-	-	-	-	1	-
Sertoli cell												
Normal	4	4	4	4	4	4	4	4	4	4	4	4
Hyperplastic	-	-	-	-	-	-	-	-	-	-	-	-
Atrophic	-	-	-	-	-	-	-	-	-	-	-	-
Desquamated	-	-	-	-	-	-	-	-	-	-	-	-
Spermatogonia												
A	4	4	4	4	4	4	4	4	4	4	4	4
B	4	4	4	4	4	4	4	4	4	4	4	4
Intermediate	-	-	-	-	-	-	-	-	-	-	-	-
Vacuolation	-	-	-	-	-	-	-	-	-	-	-	-
Desquamation	-	-	-	-	-	-	-	-	-	-	-	-
Primary spermatocytes	4	4	4	4	4	4	4	4	4	4	4	4
Vacuolation	-	-	-	2	-	-	-	-	-	-	1	-
Pyknosis	-	-	-	2	1	1	-	-	-	1	-	-
Karyolysis	-	-	-	2	1	1	-	-	-	1	1	-
Desquamation	-	-	-	3	-	-	-	-	-	2	-	-

Table 27: Continued

Microscopic findings	Testis Number											
	L1	R1	L2	R2	L3	R3	L4	R4	L5	R5	L6	R6
Hydropic degeneration	-	-	-	-	-	-	-	-	-	-	-	-
Restitution nuclei	-	-	-	-	-	-	-	-	-	-	-	-
Contracted bivalents	-	-	-	-	-	-	-	-	-	-	-	-
Secondary spermatocytes	-	-	-	-	-	-	-	-	-	-	-	-
Change in shape	-	-	-	-	-	-	-	-	-	-	-	-
Change in size	-	-	-	-	-	-	-	-	-	-	-	-
Spermatids												
Elongated	3	2	3	4	3	4	4	4	4	4	3	3
Rounded	4	4	4	4	4	4	3	4	4	4	4	4
Desquamated	-	-	-	2	-	-	-	-	-	-	-	-
Degeneration	-	-	-	2	-	-	-	-	-	-	-	-
Giant cells	1	1	-	1	-	-	-	-	-	-	-	-
Spermatozoa												
Present	2	2	1	3	2	2	3	3	3	2	2	-
Normal	2	2	1	3	2	2	3	3	3	2	2	-
Abnormal	-	-	-	-	-	-	-	-	-	-	-	-
Other												
Tubular debris	2	-	-	3	-	-	-	-	-	2	1	-
Calcification	-	-	-	-	-	-	-	-	-	-	-	-
Leukocytosis	-	-	-	-	-	-	-	-	-	-	-	-
Fibrosis	-	-	-	-	-	-	-	-	-	-	-	-
Intertubular changes												
Interstitial cell hyperplasia	-	-	-	-	-	-	-	-	-	-	-	-
Leukocytosis	-	-	-	-	-	-	-	-	-	-	-	-

Table 28: Histological examination of bovine testis for October, 1975.

Microscopic findings	Testis Number											
	L1	R1	L2	R2	L3	R3	L4	R4	L5	R5	L6	R6
Seminiferous tubules												
Dilatation	-	-	-	-	-	-	-	-	-	-	-	-
Atrophic	-	-	-	-	-	-	-	-	-	-	-	-
Hypoplastic	-	-	-	-	-	-	-	-	-	-	-	-
Basement membrane												
Detachment	2	-	-	2	1	2	1	-	-	-	-	1
Thickening	-	-	-	-	-	-	-	2	-	-	-	2
Sertoli cell												
Normal	4	4	4	4	4	4	4	4	4	4	4	4
Hyperplastic	-	-	-	-	-	-	-	-	-	-	-	-
Atrophic	-	-	-	-	-	-	-	-	-	-	-	-
Desquamated	-	-	-	-	-	-	-	-	-	-	-	-
Spermatogonia												
A	4	4	4	4	4	4	4	4	4	4	4	4
B	4	4	4	4	4	4	4	4	4	4	4	4
Intermediate	-	-	-	-	-	-	-	-	-	-	-	-
Vacuolation	-	-	-	-	-	-	-	-	-	-	-	-
Desquamation	-	-	-	-	-	-	-	-	-	-	-	-
Primary spermatocytes	4	4	4	4	4	4	4	4	4	4	4	4
Vacuolation	-	-	-	-	-	-	-	-	-	-	-	-
Pyknosis	-	-	-	1	-	-	-	-	-	-	-	1
Karyolysis	-	-	-	1	-	-	-	-	-	-	-	-
Desquamation	-	-	2	-	-	-	-	-	-	-	-	-

Table 28: Continued

Microscopic findings	Testis Number											
	L1	R1	L2	R2	L3	R3	L4	R4	L5	R5	L6	R6
Hydropic degeneration	-	-	-	-	-	-	-	-	-	-	-	-
Restitution nuclei	-	-	-	-	-	-	-	-	-	-	-	-
Contracted bivalents	-	-	-	-	-	-	-	-	-	-	-	-
Secondary spermatocytes	-	-	-	-	-	-	-	-	-	-	-	-
Change in shape	-	-	-	-	-	-	-	-	-	-	-	-
Change in size	-	-	-	-	-	-	-	-	-	-	-	-
Spermatids												
Elongated	4	2	3	4	3	3	4	2	2	3	4	4
Rounded	4	4	4	4	4	4	4	4	4	4	4	4
Desquamated	-	-	2	-	-	-	-	-	-	-	-	1
Degeneration	-	-	-	-	-	-	-	-	-	-	-	-
Giant cells	-	-	-	-	-	-	-	-	-	-	-	-
Spermatozoa												
Present	3	2	1	1	1	3	1	-	2	3	3	3
Normal	3	2	1	1	1	3	1	-	2	3	3	3
Abnormal	-	-	-	-	-	-	-	-	-	-	-	-
Other												
Tubular debris	2	2	1	-	2	1	-	-	-	2	-	2
Calcification	-	-	-	-	-	-	-	-	-	-	-	-
Leukocytosis	-	-	-	-	-	-	-	-	-	-	-	-
Fibrosis	-	-	-	-	-	-	-	-	-	-	-	-
Intertubular changes												
Interstitial cell hyperplasia	-	-	-	-	-	-	-	-	-	-	-	-
Leukocytosis	-	-	-	-	-	-	-	-	-	-	-	-

Table 29: Histological examination of bovine testis for November, 1975.

Microscopic findings	Testis Number											
	L1	R1	L2	R2	L3	R3	L4	R4	L5	R5	L6	R6
Seminiferous tubules												
Dilatation	-	-	-	-	-	-	-	-	-	-	-	-
Atrophic	-	-	-	-	4	3	-	-	-	-	-	-
Hypoplastic	-	-	-	-	-	-	-	-	-	-	-	-
Basement membrane												
Detachment	1	-	1	-	1	-	-	-	-	-	1	-
Thickening	-	1	2	-	3	-	-	2	-	-	1	-
Sertoli cell												
Normal	4	4	4	4	4	4	4	4	4	4	4	4
Hyperplastic	-	-	-	-	-	-	-	-	-	-	-	-
Atrophic	-	-	-	-	-	-	-	-	-	-	-	-
Desquamated	-	-	-	-	-	-	-	-	-	-	-	-
Spermatogonia												
A	4	4	4	4	4	4	4	4	4	4	4	4
B	4	4	4	4	4	4	4	4	4	4	4	4
Intermediate	-	-	-	-	-	-	-	-	-	-	-	-
Vacuolation	-	-	-	-	-	1	-	-	-	-	-	1
Desquamation	-	-	-	-	-	-	-	-	-	-	-	-
Primary spermatocytes	4	4	4	4	4	4	4	4	4	4	4	4
Vacuolation	-	-	-	-	3	-	1	1	-	-	-	-
Pyknosis	-	2	-	-	3	1	2	-	-	-	-	1
Karyolysis	-	-	-	-	2	2	-	-	-	-	-	-
Desquamation	-	1	-	-	-	-	2	-	-	-	-	-

Table 29: Continued

Microscopic findings	Testis Number											
	L1	R1	L2	R2	L3	R3	L4	R4	L5	R5	L6	R6
Hydropic degeneration	-	-	-	-	1	-	-	-	-	-	-	-
Restitution nuclei	-	-	-	-	-	-	-	-	-	-	-	-
Contracted bivalents	-	-	-	-	-	-	-	-	-	-	-	-
Secondary spermatocytes	-	-	-	-	-	-	-	-	-	-	-	-
Change in shape	-	-	-	-	-	-	-	-	-	-	-	-
Change in size	-	-	-	-	-	-	-	-	-	-	-	-
Spermatids												
Elongated	4	3	4	3	4	3	4	4	4	4	4	3
Rounded	4	4	4	4	4	4	4	4	4	4	4	4
Desquamated	-	-	-	2	-	-	-	-	-	-	-	-
Degeneration	-	-	-	-	-	-	-	-	-	-	-	-
Giant cells	-	-	-	-	-	-	-	-	-	1	-	-
Spermatozoa												
Present	1	3	1	3	1	4	2	1	2	-	1	3
Normal	1	3	1	3	1	4	2	1	2	-	1	3
Abnormal	-	-	-	-	-	-	-	-	-	-	-	-
Other												
Tubular debris	-	2	1	1	-	-	3	1	-	-	-	-
Calcification	-	2	-	-	-	-	-	-	-	-	-	-
Leukocytosis	-	1	-	-	-	-	2	2	-	-	-	-
Fibrosis	-	-	-	-	-	-	-	-	-	-	-	-
Intertubular changes												
Interstitial cell hyperplasia	-	-	-	-	-	-	-	-	-	-	-	-
Leukocytosis	1	1	-	-	-	-	3	1	2	1	-	-

Table 30: Histological examination of bovine testis for December, 1975.

Microscopic findings	Testis Number											
	L1	R1	L2	R2	L3	R3	L4	R4	L5	R5	L6	R6
Seminiferous tubules												
Dilatation	-	-	-	-	-	-	-	-	-	-	-	-
Atrophic	-	-	-	-	-	-	-	-	-	-	-	-
Hypoplastic	-	-	-	-	-	-	-	-	-	-	-	-
Basement membrane												
Detachment	-	-	-	-	-	2	-	-	-	1	-	-
Thickening	-	2	-	1	-	2	-	-	-	-	-	-
Sertoli cell												
Normal	4	4	4	4	4	4	4	4	4	4	4	4
Hyperplastic	-	-	-	-	-	-	-	-	-	-	-	-
Atrophic	-	-	-	-	-	-	-	-	-	-	-	-
Desquamated	-	-	-	-	-	-	-	-	-	-	-	-
Spermatogonia												
A	4	4	4	4	4	4	4	4	4	4	4	4
B	4	4	4	4	4	4	4	4	4	4	4	4
Intermediate	-	-	-	-	-	-	-	-	-	-	-	-
Vacuolation	-	-	-	1	-	1	-	-	-	1	-	-
Desquamation	-	-	-	1	-	-	-	-	-	1	-	-
Primary spermatocytes	4	4	4	4	4	4	4	4	4	4	4	4
Vacuolation	-	-	-	-	-	-	-	-	-	-	-	-
Pyknosis	-	-	1	1	1	2	-	1	-	-	-	-
Karyolysis	-	-	-	-	1	-	-	-	-	-	-	-
Desquamation	-	-	-	-	-	-	-	-	-	2	-	-

Table 30: Continued

Microscopic findings	Testis Number											
	L1	R1	L2	R2	L3	R3	L4	R4	L5	R5	L6	R6
Hydropic degeneration	-	-	-	-	-	-	-	-	-	-	-	-
Restitution nuclei	-	-	-	-	-	-	-	-	-	-	-	-
Contracted bivalents	-	-	-	-	-	-	-	-	-	-	-	-
Secondary spermatocytes	-	-	-	-	-	-	-	-	-	-	-	-
Change in shape	-	-	-	-	-	-	-	-	-	-	-	-
Change in size	-	-	-	-	-	-	-	-	-	-	-	-
Spermatids												
Elongated	4	4	4	4	4	3	3	4	3	4	4	4
Rounded	4	4	4	4	4	4	4	4	4	4	4	4
Desquamated	-	-	-	-	-	2	-	-	1	2	-	-
Degeneration	-	-	-	-	-	-	-	-	-	-	-	-
Giant cells	-	-	-	-	-	-	-	-	-	-	-	-
Spermatozoa												
Present	-	2	1	2	2	3	3	3	2	3	1	-
Normal	-	2	1	2	2	3	3	3	2	3	1	-
Abnormal	-	-	-	-	-	-	-	-	-	-	-	-
Other												
Tubular debris	-	-	-	-	2	3	-	-	1	1	-	-
Calcification	-	-	-	-	-	-	-	-	-	-	-	-
Leukocytosis	-	-	-	-	-	-	-	-	1	-	-	-
Fibrosis	-	-	-	-	-	-	-	-	-	-	-	-
Intertubular changes												
Interstitial cell hyperplasia	-	-	-	-	-	-	-	-	-	-	-	-
Leukocytosis	-	-	-	-	-	-	-	-	+	-	-	-

APPENDIX 4

Analyses of variance

Table 31: Analysis of variance of the monthly variation in weight, length and diameter of testes of indigenous bulls in Nigeria.

Testicular Parameter	Sources of variation	S. S.	D.F.	Mean Square
Weight	Between months	70313.9	11	6392.17167*
	Within months	130.988	1	130.988
Length	Between months	1481.13	11	134.64829**
	Within months	1.38068	1	1.38062
Diameter	Between months	16.4349	11	1.49408**
	Within months	0.170156	1	0.170016
Diameter of seminiferous tubules	Between months	38537.7	11	3504.70323**
	Within months	63980.2	132	484.69864
Spermatogonia-A	Between months	12.6345	11	1.14859
	Within months	202.632	132	1.53509
Spermatogonia-B	Between months	1187.37	11	107.94313**
	Within months	430.010	132	3.25765
Primary Spermatocytes	Between months	6455.32	11	586.84697**
	Within months	25765.8	132	195.19539
Spermatid - R	Between months	28266.30	11	2569.66345*
	Within months	175602.0	132	1330.31620
Spermatid - L	Between months	17173.10	11	1561.19113**
	Within months	39580.6	132	299.85293

*P $<$ 0.05 **P $<$ 0.01

SPERMATOGENESIS IN INDIGENOUS BULLS IN NIGERIA

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AN ABSTRACT OF A THESIS

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There is little information on the reproductive performance of indigenous cattle, and the role of the bull in infertility has not been investigated in Nigeria. The objectives of this study were to investigate spermatogenesis in indigenous bulls and relate it to the seasons.

Six pairs of testes from indigenous bulls were collected twice a month, for one year, from abattoirs at Kaduna, Bauchi or Ahmadu Bello University, Zaria. The bulls, aged 5 to 10 years, belonged to Fulani herdsmen, and were all in good condition at the time of slaughter.

The average monthly length, diameter, and weight of the 144 pairs of testes were 11.6 cm. (10.9 - 12.1), 5.2 cm. (4.7 - 5.7), and 172.99 (139 - 209.7), respectively. Inter-month but not the intra-month variation for each dimension was significant ($P < 0.01$).

Nine of the 144 pairs of testes had gross lesions (6.3%); degeneration 2.8%, orchitis 2.1%, and hypoplasia 1.4%. Microscopically, the incidence of testicular degeneration was 20%, orchitis 6.3% and testicular hypoplasia 4.2%. Testicular degeneration

occurred monthly and the involvement was usually mild. Orchitis and hypoplasia occurred randomly and had no seasonal pattern.

Microscopic examination of the seminiferous tubules revealed the following monthly averages: diameter 195 μ (167-224); spermatogonia - A cells 4.2 (3.8 - 5.1); spermatogonia - B cells 6 (4.3 - 11.6); primary spermatocytes 49.8 (38.9 - 62); and round and elongated spermatids 86.4 (47.6 - 111) and 30.5 (19.8 - 44), respectively. Except for spermatogonia-A, the inter - month but not the intra - month variations were significant ($P < 0.01$). Secondary spermatocytes were transitory and difficult to distinguish and identify from round spermatids.

Although spermatogenesis was found to be active in indigenous bulls throughout the year (estimated to be over 80%) correlation of testicular dimensions, diameter of seminiferous tubules, and activity of spermatogenic epithelium indicated increased activity during the rainy and pre-dry seasons. Tropical heat and other environmental factors did not alter the pattern of spermatogenesis.