EFFECT OF VARYING LEVELS OF PROTEIN INTAKE ON GROWTH, PUBERTY AND SEMEN QUALITY OF BUNAJI AND FRIESIAN X BUNAJI (CROSSBRED) BULLS

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CERTIFICATION

This thesis/dissertation titled, "Effect of varying levels of protein intake on growth, puberty and semen quality of Bunaji and Friesian x Bunaji (Crossbred) bulls" by PETER IBRAHIM REKWOT meets the regulation governing the award of the degree of Master of Science of Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to my late father Mr. REKWOT KATO and my mother Mrs. KAIDWAN REKWOT, who all gave me the education that I now have. To them I say thank you.

DECLARATION

The work in this Thesis was carried out in the Department of Veterinary Surgery and Medicine and Department of Animal Reproduction and Artificial Insemination, National Animal Production Research Institute, Ahmadu Bello University, Zaria under the supervision of Professor O.O. Akerejola, Dr. J. Kumi-Diaka and Dr. M.O. Oyedipe.

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This study was undertaken to investigate the influence of postweaning nutrition on:

1. attainment of puberty;
2. condition score, scrotal circumference and body growth parameters;
3. sperm output and semen characteristics;
4. morphological changes of sperm of young bulls;
5. haematologic parameters; in young Bunaji and Friesian x Bunaji bulls.

Twenty-one Bunaji (BJ) and twenty-one Friesian x Bunaji (FRxBJ) bull-calves, approximately six months of age, were each group divided after weaning into two and fed isocaloric rations (2.40 ME Mcal/kg DM) containing two crude protein levels of 14.45% for high protein diet and 8.51% for low protein diet, for a period of 16 months, to determine the effect of varying protein intake on puberty. Puberty was defined as the age at which an ejaculated semen contained at least 50 x 10^6 spermatozoa with a minimum of 10% motility.

Bulls on high protein diets ejaculated first motile spermatozoa and attained puberty at significantly ($P<0.05$) earlier ages, lighter body weights, smaller scrotal circumference, better body condition and with better sperm motility than those on low protein diets.

Ages at puberty (months) on low and high protein diets for Bunaji bulls were 16.50 ± 0.53 and 14.32 ± 0.68 respectively and for Friesian x Bunaji bulls the ages were 17.97 ± 0.82 and 12.94 ± 0.60 respectively ($P<0.05$). The Bunaji bulls attained puberty later than the crossbreds (FR:BJ) when placed on high protein. The reverse was the case when placed on low protein diets. Mean body weights at puberty (kg) on low and high protein diets for Bunaji were 203.06 ± 7.59 and 188.18 ± 6.02 respectively and for Friesian x Bunaji the mean body weight values were 212.86 ± 11.49 and 191.01 ± 12.54 respectively. Mean scrotal circumference (cm) at puberty on low and high protein diets for Bunaji were 21.33 ± 0.63 and 20.73 ± 0.44 respectively and for Friesian x Bunaji the values were 25.00 ± 1.37 and 22.94 ± 1.26 respectively. Body condition score at puberty on low and high protein diets for Bunaji averaged 3.89 ± 0.26 and 5.00 ± 0.20 respectively and for Friesian x Bunaji crossbreds, the values were 3.85 ± 0.47 and 4.88 ± 0.01 respectively ($P<0.05$).

Mean percentage sperm motility at puberty on low and high protein diets for Bunaji were 39.90 ± 3.95 and 49.35 ± 2.84 respectively and for Friesian x Bunaji the mean percentage sperm motility were 40.97 ± 4.41 and 44.68 ± 3.13 respectively ($P<0.05$).

Following puberty, bulls on high protein diet had significantly ($P<0.05$) higher sperm producing capacity than those on low protein. Mean volume of semen on low and high protein diets for Bunaji bulls were 2.93 ± 0.94 ml

and 4.19 ± 1.04 ml respectively and for Friesian x Bunaji the values were 3.08 ± 1.14 ml and 4.10 ± 1.24 ml respectively. Mean sperm concentration ($x10^6$/ml) on low and high protein diets for Bunaji were 58.00 ± 18.60 and 114.43 ± 40.66 respectively and for FRxBJ bulls the values were 88.50 ± 26.50 and 127.11 ± 46.68 respectively. At corresponding ages mean total sperm ($x10^6$) on low and high protein diets for Bunaji were 172.84 ± 18.08 and 479.46 ± 42.29; and for FRxBJ the values were 316.83 ± 30.21 and 521.15 ± 57.88 respectively. Sperm output increased significantly with age. There were no significant differences in sperm defects between low and high protein diets and also between breeds.

Proximal cytoplasmic droplets and sperm head defects significantly ($P<0.05$) decreased from 40% between the ages of 12 and 15 months to below 10% at the age of 17 months and above.

The bulls on high protein diets had significantly ($P<0.05$) higher packed cell volume, red blood cell, haemoglobin, white blood cell count and serum total protein values than those on low protein diets. There was no significant ($P<0.1$) effect of protein diet on white blood cell differential count.

The present study indicated that bull on high protein diets attain puberty at younger age with superior pubertal traits than those on low protein diets. The indigenous Bunaji bulls attained puberty later than the crossbreds when placed on high protein diets and the reverse was observed on low protein diets.

The significant influence of level of protein intake on semen production traits was also evident during the postpubertal period, while the incidence of spema morphological defects were not seriously affected. It is concluded that adequate protein intake and good management of the young selected sire appears to be a sinequanon for optimum sperm cell production in our indigenous Bunaji bulls and their Friesian crossbreds.

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CHAPTER ONE

INTRODUCTION

The importance of genetically superior bulls in an artificial insemination programme is obvious. For economic reasons and early genetic testing for either beef or milk production, the objective of good feeding and management of the carefully selected young sire , would be to bring him into optimum sperm cell production at an early age. In order to maximize the reproductive potential of young sires, adequate feeding levels are a prerequisite to increase the number of spermatozoa available for artificial insemination. Salisbury et al., (1978) reported that liberal feeding reduces the generation interval which is of genetic advantage in cattle improvement programmes.

General body growth and development are prerequisites for the initiation of sexual function in males and females. Early puberty is also an important trait to achieve optimum reproductive performance in cattle. Puberty can be achieved at an earlier age with improved protein intake and this would in turn reduce the generation interval and thus increase the rate of genetic gain of our indigenous livestock. Age at puberty is important in both natural and artificial breeding programmes, because the shorter the age at puberty of a bull, the earlier in life it can be used for breeding. Nutrition is an important factor that can influence growth rate, and also has a direct influence on age at puberty.

Protein is one of such nutrients, essential to growth. There is also a definite role played by protein in tissue building processes.

Crossbreeding of Friesian with indigenous cattle have been practised over the years in order to achieve genetic improvement. The influence of protein levels on growth rate and age at puberty could be important in genetic selection, planning of management programmes especially for maximising the reproductive efficiency of Bunaji and their Friesian crossbred bull-calves.

Studies on puberty in Zebu bulls and their Friesian crossbreds under tropical conditions have been reported (Aire and Akpokodje, 1975; Oyedipe et al., 1981) but the long term nutritional effects during the post-weaning period on body and testicular growth, semen characteristics, have not been well documented. This study was therefore designed to investigate the influence of postweaning nutrition on:

i. growth patterns for body weight, chest girth, height at withers and scrotal circumference;

ii. age at first appearance of spermatozoa in the ejaculate;

iii. age at puberty, sperm output and semen characteristics;

iv. haematologic parameters of Bunaji and Friesian x Bunaji bulls.

LITERATURE REVIEW

1.1. POSTNATAL SEXUAL DEVELOPMENT

Puberty has been defined by many workers. Roberts (1971) defined it as the age or time at which the generative organs of reproduction become functional and reproduction may occur. It has also been defined as the developmental stage when an ejaculate contains 50 x 10^6 spermatozoa with a minimum of 10% motility (Almquist and Cunningham, 1967; Lunstra et al., 1978; Fields et al., 1982). Puberty is an important trait in achieving optimum reproductive performance in a cow herd (Arije and Wiltbank, 1971; Spitzer et al., 1975; Wiltbank, 1978; Oyedipe, 1981). Therefore any delay in attainment of puberty will have a detrimental effect on breeding efficiency.

Age, body weight and seminal characteristics at attainment of puberty in bulls vary greatly among and within breeds (Wolf et al., 1965; Almquist and Barber, 1974; Barber and Almquist, 1975). A lower reproductive rate for bulls of Bos indicus than Bos taurus has been reported (Igboeli and Rakha, 1971). The ages at puberty for White Fulani (WF), Sokoto Gudali (SG), and Friesian x White Fulani (FRxWF) bulls reared under natural conditions were found to be 66.89 ± 1.0 weeks, 73.4±2.2 weeks and 66.4±1.7 weeks respectively (Oyedipe et al., 1981).

General body growth and genital development are prerequisite to the development of the sexual organs in both male and female (VanDemark and Hauger, 1964; Salisbury et al., 1978).

Testicular and body growth of a large number of dairy bulls are highly correlated to sperm output (VanDemark and Mauger, 1964). The same author showed that 80% of the variations in testis size were associated with changes in body size and these changes reflected the capabilities of a bull to produce semen. Postnatal sexual development and attainment of puberty is influenced by several factors such as age, breed, nutrition and other related traits.

1.1.1 Breed

Physiological differences within and between breeds could be important in genetic selection and in planning of management programmes. Reports indicate that short horn Zebu bulls indigenous to the tropics grow slowly and attain puberty later than the taurine breeds (Igboeli and Rakha, 1971). A low fertility rate of *Bos indicus* as against *Bos taurus* is manifested most clearly by reduced pregnancy rates in commercial beef herds (Fields *et al.*, 1982). Growth rate and reproductive traits at puberty were found to be significantly better for Brahman bulls than Angus bulls, with the former attaining puberty at an earlier age (Almquist and Cunningham, 1967; Fields *et al.*, 1982). It has been found that larger breeds of cattle tend to have a later onset of puberty than the smaller breeds within the same environment (Roberts, 1971; Hafez, 1980). Breed of sire also had a significant influence on calving and weaning rate at puberty of some breeds of cattle (Arije and Wiltbank, 1971).

1.1.2 Age

The influence of age on testicular growth has been studied (Coulter et al., 1975; Fields et al., 1979). The latter have reported high rate of testicular growth in young bulls (birth to three years), limited growth in mature bulls (three to five years), and slight decrease in old bulls (six years and above). Scrotal circumference has been found to be related to age and body weight by curvilinear relationships (Hahn et al., 1969b), with correlation coefficients of r = 0.87 and r = 0.12 before and after six years of age respectively (Hahn et al.,1969b).

1.1.3. Nutrition

The most important management factor affecting sexual maturity is the level of feeding. The provision of protein, energy and mineral supplements is a sinequanon of successful management for good reproductive performance of cattle (Lamond, 1970; Topps, 1977; Hafez, 1980; Morrow, 1980). Poor nutrition has been found to significantly retard developmental growth (Joubert, 1964; Morrow, 1980). Limiting the amount of feed to growing bulls to a level below that needed for maximum growth would extend the age at puberty and sexual function. Ultimately sperm cell production corresponds to the extent of limitation in nutritive intake (VanDemark and Mauger, 1964). Delayed puberty will occur when the young male animal is fed a low plane of nutrition (Bratton et al., 1959; Flipse and Almquist, 1960).

High level of feeding in growing bulls may also lead to overweight condition resulting in slowness, difficulty or inability to copulate (Flipse and Almquist, 1960). Excessively fat mature bulls may have heavy adipose tissue around the testis which might affect spermatogenesis as a result of scrotal insulation (Lagerlof, 1934; Roberts, 1971).

Warnick et al. (1961) reported low feed intakes, loss of weight, weakness and reduced libido and sperm cell production in bulls and rams when fed on a ration with less than 2% crude protein. Low protein (1-3% crude protein) and low energy (34-40% TDN) of low quality hay in the dry season have resulted in loss of body weight and corresponding low levels of reproduction in cattle grazing poor pastures (Elliot and Topps, 1963; Topps, 1977). A review of relevant data by Hentges (1967) indicates that bulls fed on a low protein diet showed a decline in libido which became more pronounced as the animals lost weight. The latter however reported that endocrine changes, semen production and its quality were not seriously affected. The effects of two levels of TDN intake 60% and 100% showed that the underfed bulls were eight months slower in reaching their mature sperm producing capacity than the control bulls (VanDemark and Mauger, 1964). The latter demonstrated that underfeeding energy diets for an extended period during growth of a bull is detrimental not only to growth and development, but

also to the sperm producing capacity. Attempts to correct the damage caused by the shortage of energy after bulls had reached 46 months of age appeared irreversible.

Investigation of the effect of low nutrient intake (TDN) on reproductive performance of young bulls have been reported to result in retardation of growth and delay in reaching puberty, but these reproductive traits were restored with supply of above normal energy (Bane, 1954; Bratton et al., 1959). It has also been reported that high level of energy intake shortened the onset of sperm production in dairy bulls (Asdell, 1955; Flipse and Almquist, 1960; Almquist and Barber, 1974; Barber and Almquist, 1975).

Body condition score has been defined as the amount of fat and muscle cover of the animal (Pullan, 1978). There is an association between fertility and body condition score and this has application in investigating means of improving fertility (Lowman et al., 1973; Pullan, 1978). Bulls and rams fed on poor quality hay especially in tropical environments in the dry season have resulted in loss of body weight and fat cover, weakness, reduced libido and sperm cell production (Hentges, 1967; Topps, 1977).

The restrictive effects of limited feed, delays the sexual function primarily due to diminished gonadotropin output and releasing factors from the pituitary and hypothalamus - pituitary - testis axis. This pathway or axis comprises the gonadotropin releasing factors (GnRH) from the hypothalamus, which influence the pituitary to secrete the gonadotropins (luteinizing hormone and

follicle stimulating hormone), which finally act on the testis for sperm cell production (McDonald, 1975; Salisbury et al., 1978; Hafez, 1980).

Salamon (1964) in his studies of nutritional regimen on the potential semen production of rams found that high level of supplementary feeding had a higher significant influence on semen production than those on low level with average daily sperm output of 12.7×10^9 spermatozoa for high plane and 3.8×10^9 spermatozoa for low plane. Differences in testicular traits have been attributed to inheritance and varied nutritional regimes and rearing systems (Flipse and Almquist, 1960; VanDemark and Mauger 1964).

Several studies are in agreement with regard to the relationship between plane of nutrition and semen production (James, 1950; Mann and Rowson, 1956; Bratton et al., 1959). The effects of low and high levels of energy diets in rams indicate that those on high plane were better in terms of body condition, sperm voided in urine, scrotal circumference, concentration of spermatozoa in semen and also gonadotropins (luteinizing hormone, LH, and follicle stimulating hormone, FSH) and testoterone output (Alkass and Bryant, 1982).

The role of vitamins in reproductive function of the male has been investigated by many workers (Asdell, 1955; Roberts, 1971). Vitamin A is highly essential for spermatogenesis and development and maintenance of the seminiferous epithelium. Defficiency of Vitamin A may cause

nightblindness, stiffness, decline in semen quality and loss of libido. Vitamin E or - tocopherol is an anti-oxidant that is required by dairy cattle, for the maintenance of integrity of skeletal muscle in calves and cardiac muscle in older bulls. There is however, no proof that it is necessary for reproduction in domestic animals (Salisbury et al., 1978). However there is an earlier conflicting report by Asdell (1955) that vitamin E or - tocopherol is important in bovine reproduction and that many causes of infertility can be cured if it is fed in significant amounts.

Bulls of poor breeding records have been improved by administering ascorbic acid, a precursor of vitamin C (Asdell, 1955). Vitamin C is important for growth and development of epithelial cells of the tubular genitalia and also in the stimulation of sperm cell production and libido (Salisbury et al., 1978). Vitamin D is required by the growing animal for utilising calcium and phosphorus as well as for proper bone development. However, the effects of vitamin D deficiency on the testis and reproduction of bulls has not been reported (Salisbury et al., 1978).

Adequate mineral supply is essential for optimum reproduction in the male. Ward (1968) reported significant increase of 21% animal production over six years of mineral supplementation. However mineral deficiencies affecting reproduction in the male are rare (Roberts, 1971). Calcium, manganese, zinc, iodine, potassium, cobalt, iron

and copper deficiencies may cause anaemia, lack of appetite, loss of weight, and can have adverse effect on muscle development. Phosphorus deficiency has often been associated with a lack of protein and low levels of vitamin A resulting in reduced appetite, loss of body condition and reduced reproductive function (Roberts, 1971). Phosphorus deficiency interfers with ovarian activity and the requirement of 10-12 mg phosphorus per cow for efficient reproduction has been documented (Asdell, 1955).

Deficiencies of phosphorus or vitamin A in cattle are known to have adverse effects on fertility and combination of supplement and injection of vitamin A increased fertility by 20 to 50 percent (Ward, 1968). Excess dietary calcium has been reported to cause osteopetrosis with accompanying spondylitis and arthritis in the bull (Roberts, 1971). Low manganese intakes on rations of poor quality hay have resulted in reduced sperm concentration and percentage motility (Lardy et al., 1942). Severe zinc deficiencies have been reported in young bulls resulting in slow body and testicular growth with high sperm defects (Miller, 1970). Selenium in minimal amounts has some indications in reproduction and is particularly useful to prevent muscular dystrophy (White Muscle Disease) in calves and lambs. Cadmium and Molybdenum are hifhly toxic to bull calves and would lead to complete lack of libido and prevention of spermatogenesis and interstitial cell development (Roberts, 1971; Salisbury et al., 1978). Iodine is essential for thyroxine production needed for metabolic activities of the animal and its deficiency can

lead to lowered metabolic activity, reduced libido and poor quality semen in some bulls (Asdell, 1955).

1.2 Blood picture

Haematologic parameters can provide useful information on the health status, etiology of low reproductive function of Zebu cattle indigenous to tropical Africa (Saror and Coles, 1973a). This may be due to a combination of one or more of environmental, genetic, physiologic or nutritional influences whose effects may be expressed in the blood picture (Roubicek et al., 1968). Poor growth rate is brought about by limitation in dietary intake of a particular nutrient and may also result in abnormalities in blood chemistry (Payne et al., 1970). Normal values of blood picture for both temperate and tropical breeds have been reported (Schalms, 1965; Coles, 1967; Saror and Coles, 1973a,b). Rowland and Manston (1976) established normal values of blood chemistry for dairy cattle and identified some potential uses of blood biochemical parameters. Association between nutrition, blood profile and infertility have been reported (Greig and Boyne, 1956; Payne et al.,1970; Hewett, 1974a,b) with significant correlations between blood components and rate of weight gain. Haemoglobin and packed cell volume are influenced by feeding levels and improved husbandry practices (Hewett, 1974a,b; Saror and Coles, 1975; Oyedipe et al., 1984).

Varying levels of haemoglobin, red blood cell; hematocrit and serum proteins for Hereford and Zebu cows placed on different levels of protein diets have been reported (Bedrak et al., 1956; Oyedipe et al., 1984). Higher values of packed cell volume, red blood cell, haematocrit and total protein have been recorded for animals on high protein diets than those on low protein intake

(Hewett, 1974a; Oyedipe et al., 1984). Saror and Coles (1973a,b; 1975) have indicated that haemoglobin and packed cell volume were low in range Zebu cattle than those under improved management practices. The latter also reported that native owned Zebu cattle had consistently lower packed cell volume, haemoglobin values than Bunaji and Friesian x Bunaji cows managed in institutional and governmental farms.

Monitoring of protein components in blood could be a means of evaluating the variations in the amount of dietary protein intake as they relate to development and performance. The usefulness of serum protein determination in disease conditions has been investigated by Leland (1961), in relation to growth by Wright et al.(1962) and in relation to parturition by Larson and Kendall (1957) and in relation to reproduction by Oyedipe (1981). Comparative values for serum protein components of Zebu and their Friesian crossbreds have also been reported by Saror and Coles (1973a,b).

Ross (1960) found seasonal variations in serum proteins which are probably linked to availability of forage during the different periods of the year. These variations may be more pronounced under range conditions where marked seasonality of rainfall determines the protein content of herbage and pasture conditions (Lamond, 1970). Circulating amounts of protein are known to contribute to most body building processes and body weight gains (Kunkel et al., 1957;

Pfander, 1971). There has been significant correlation between some serum protein components and fertility (Rowland and Manston, 1976).

1.3. SEMEN PRODUCTION

Physical fitness and semen evaluation of a bull are among the most important components of breeding soundness examination (Ball et al., 1974; Morrow, 1980). Several techniques which are based on physical, morphoological and biochemical criteria are utilised for assessment of semen quality (Melrose and Laing, 1970; Ball et al., 1974; Morrow, 1980). The physical evaluation of semen includes examination for color, mass activity, volume, sperm concentration, pH and microscopic examination for morphological characteristics and patterns of motility (Zemjanis, 1970; Ball et al., 1974).

Morphological characteristics of the sperm cell are usually studied microscopically (Dott and Foster, 1972; Harasymowycz et al., 1976). Generally head morphology and live-dead ratio are studied, using prepared eosin-nigrosin stained slides under light microscopy with oil immersion lens (Dott and Foster, 1972; Dott, 1975). Wet fixed semen in buffered formol saline has been used to study defects of cytoplasmic droplets, midpiece and tail defects (Rao, 1971; Harasymowycz et al., 1976; Sekoni et al., 1981).

Ball et al. (1974) cited two primary criteria in assessing semen quality: (1) repeatability of the measurements (ii) degree of correlation between the criterion being measured and fertility. Concentration

of sperm cells in the ejaculate has been correlated positively with fertility (Ball et al., 1974). The latter further stated that concentration of semen probably reflects the condition of the testis. Bulls capable of regular production of concentrated semen would be expected to have functional seminiferous epithelium.

Scrotal circumference, testicular consistency, libido, ejaculatory frequency, age, nutrition, management, season and diseases are some of the factors that can affect sperm output.

1.3.1. Scrotal circumference

The relationship of testicular growth and development to quantitative aspect of sperm output have been reported by many workers (Ball et al., 1974; Osinowo, 1979). Testicular weight is an important trait that provides an accurate estimate of the amount of sperm producing parenchyma in the testis (Almquist and Amann, 1961; Amann, 1970).

Scrotal circumference is measured by a self-releasing reflexible metal tape graduated in centimeters (Ball et al., 1974). The measurement of the scrotal circumference is an accurate predictor of both testicular weight and sperm output in growing bulls subjected to high frequency of semen collection (Hahn et al., 1969b; Almquist et al., 1976). Significant correlations between scrotal circumference, testis weight and sperm output have been reported for young bulls (Willet and Ohms, 1957; Fagerlin et al., 1971). Use of scrotal circumference is

a relatively accurate estimate of a bull's ability to produce semen at a given time (Ball et al., 1974). These workers have thus recommended the incorporation of scrotal circumference measurements in evaluation of bulls for breeding soundness because of its accuracy as an index of semen producing capacity. They also suggested that most yearling bulls (Bos taurus) should have a scrotal circumference of at least 30 cm.

1.3.2. Testicular consistency

This is a measure of testicular firmness as an indicator of sperm quality. Testes with soft consistency is often related to poor seminal quality (Hahn et al., 1969a; Foote et al., 1970; Coulter and Foote, 1979). Some workers have introduced the tonometer to provide a more objective measure of testicular consistency than the conventional palpation method (Hahn et al., 1969a; Foote et al., 1970; Coulter and Foote, 1979). Testicular consistency is also useful as a predictor or pointer of testicular damage. Using the tonometer for testing it was found that testicular radiation damage resulted in a softening of testis within 5-6 weeks and an increase in firmness 11-12 weeks after treatment. These authors also reported high significant correlations between testicular consistency, semen quality and fertility.

1.3.3. Libido

Knowledge of the factors influencing sex drive and mating behaviour in bulls is important in natural breeding programmes. Blocky (1975) illustrated the importance of including an assessment of mating behaviour in a routine breeding soundness examination in bulls. In 56 two-year old bulls assessed by Libido score, correlations between libido score and pregnancy rates; semen quality and pregnancy rates were reported (Blocky, 1975). Contrary to this, Chenoweth et al., (1984) found no relationship between libido and semen quality in bulls.

1.3.4. Frequency of semen collection and sexual preparation

Amann (1970) reported that adequate sexual stimulation of bulls prior to semen collection improves the quality and quantity of semen. This may be achieved by prompt and intensive teasing and false mounting. Several workers have shown the importance of frequency of ejaculation to semen quality. Removal of large numbers of sperm by frequent collection is one of the indirect methods of estimating sperm production and for detecting effects of nutritional and seasonal factors on semen (Salamon, 1964). Ejaculate volume, sperm concentration and total sperm increased with increased frequency of collection from biweekly to six times per week with no deleterious effects (Almquist and Amann, 1962). An earlier contradictory report by Oloufa (1956) indicated that high frequency of semen production in eight indigenous bulls, collected three times a week for thirteen weeks led to poor semen

concentration than when collected once a week.

1.3.5 Age

There is a curvilinear relationship between semen producing capacity of bulls and age with r=0.87 before six years and r=0.12 after that age (Hahn et al., 1968b; Fagerlin et al., 1971). Ejaculate volume and semen concentration increased in Holstein bulls from puberty to 2 years of age (Almquist and Amann, 1962). Angus and Hereford bulls showed highly significant increases in ejaculate volume and weekly total spermatozoa output as the bulls aged from one to two years (Almquist and Cunningham, 1967). Data collected on 1021 artificial insemination bulls aged 2-11 years by Fasko (1974) indicated that highest conception rate (55.8%) to first A.I. was achieved by 5-year olds and lowest (49.2%) by the 11-year olds. A study by Ivankov (1975) showed that bulls aged 3-7 years had better semen quality than younger or older bulls. Semen production in Charolais and Zebu bulls between puberty and 2 years of age was studied by Almquist et al.,(1976), Osinowo (1979), Oyedipe et al.(1981) who reported significant increases in semen volume, semen concentration, sperm motility and total spermatozoa output, as bulls aged.

1.3.6. Nutrition and Management

Melrose (1962) has reviewed the effects of feeding level, type of ration on sexual maturity, semen production and fertility. Puberty may be delayed in underfed bulls but the effects on semen volume and quality are variable. In most studies, differences in semen quality attributed to the level of feeding were not significant. Zinc and vitamin A deficiencies may impair reproductive function under experimental conditions but a significant effect on fertility under natural management condition is yet to be demonstrated (Asdell, 1955). Mudra (1974) reported that age at first ejaculate was significantly correlated with nutrient consumption to 9 months of age. Pilat and Pindak (1974) fed five groups of young bulls with the following rations: group 1, hay and silage; group 2, maize and silage; group3, lib grazing; group 4, hay; group 5, a pelleted food mixture. The average daily gains respectively were 948g, 876g, 1129g, 1003g and 1080g. The animals in group two with lowest average daily gains produced the best quality semen, having the highest ejaculate volume, sperm motility and concentration. High level of supplementary feeding has also been reported as having a significant influence on sperm production (Salamon, 1964).

1.3.7. Season

Although, the testis and scrotum of the bull possess a number of intricate physiological mechanisms for the regulation of internal temperature, there are seasonal effects on the quality and fertility of

bull semen (Salisbury et al., 1978; Sekoni and Gustafson, 1980) Semen quality was better in summer than other seasons of the year (Oloufa, 1956). Hereford breeds showed a decline in testicular size and Semen quality due to environmental stress of the semi-tropical climate. Wells et al. (1972) reported seasonal, monthly and weekly variations in percentage normal acrosome at infrequent collection regimen. Ejaculate volume, normal spermatozoa and percentage live spermatozoa in short horn Zebu bulls were significantly higher in wet season than dry season (Igboeli and Rakha, 1971; Sekoni, 1979). Incidence of sperm abnormalities were higher in younger than adult bulls and during the hot season than in the rainy seasons respectively (Sekoni and Gustafson, 1980).

1.3.8. Pathological and disease factors

Morbid changes or functional disturbances in the testis, epididymis, vas deferens or in the accessory glands can lead to a significant increase in the number of morphological sperm abnormalities in the ejaculate (Morrow, 1980). Testicular hypoplasia, degenerative changes of the seminiferous epithelium and inflammatory changes have been associated with defective spermatogenesis (Hafez, 1980). Bacteria, viral and other disease conditions accompanied by increased body temperatures, and general loss of body condition have been known to affect spermatogenesis (Roberts, 1971).

1.4. SPERM MORPHOLOGY

Spermiogram evaluation for bulls is an important aspect of breeding soundness examination for selection purposes in natural or artificial insemination services. Abnormal spermatozoa can lower fertility. A relationship between the incidence of abnormal spermatozoa and infertility is well established in the bull (Rao, 1971; Linford et al., 1976). Lagerlof (1934) found that abnormal spermatozoaa in fertile bulls ranged from 10-11% and was close to 35% in bulls with low fertility or sterility. The latter indicated that abnormal spermatozoa should not exceed 17-18% for good fertility rates. Several groups of bulls of varying fertility, had mean percentages of 11.8%, 15.0% and 12.4% abnormal spermatozoa (Rollinson, 1951; Melrose and Laing, 1970; Sekoni, 1979) which compared well with the finding of Lagerlof (1934). Nemjanis (1970) reported a maximum of 10-20% total abnormal spermatozoa, which include 2-3% proximal droplets, 5% detached acrosome, 10% bent tails for semen to be used for breeding. He also showed that the occurrence of pathological spermatozoa was associated with disturbances in spermatogenesis, and inflammatory changes in the testis or epididymis.

Various morphological classifications of abnormal spermatozoa have been in use in the past, some of which have undergone tremendous modifications (Blom, 1973).

Blom (1973) also suggested that the division of pathological spermatozoa into primary and secondary abnormalities which he had earlier proposed should be changed to major and minor sperm defects.

Increased numbers of proximal droplets of spermatozoa indicated either degenerative (disease or old age) or regenerative processes of the spermatogenic epithelium but might in rare cases reflect an epididymal dysfunction (Blom, 1973). In the bull the most striking morphological change taking place in the sperm during their passage through the epididymis is the migration of the cytoplasmic droplet from a proximal to a distal position on the midpiece (Hancock, 1955).

Rao (1971) reported an average proportion of 26% of head defects in infertile bulls, and 6.0% head defects in fertile bulls. This same work reported 2%, 0.8% and 3.5% of cytoplasmic droplets, midpiece and sperm tail defects respectively in fertile bulls. In his recommendation he cited that age of the bull should be taken into consideration in sperm morphological studies. He reported that the proportion of defective heads in the ejaculate was 4.8% in young bulls (not more than 3 years), 6% in 3-9 year old bulls, and 11% in healthy old bulls (more than 9 years). Proximal cytoplasmic droplets were 0.8%, 1.9% and 4.8% in the three age groups respectively.

A standard classification of the head, midpiece, tail and acrosomal defects have been given by Rao (1971). He classified the abnormal heads into: micro, abnormal, narrow, narrow at base, pear, small normal, small abnormal, short broad, underdeveloped, giant, double, and tailless. Classification of other sperm defects were: proximal, and distal cytoplasmic droplets, free normal heads, free abnormal heads, coiled tails, reverse and bent tails, tails coiled around the head, rough, abaxial, swollen and bent midpieces, irregular, rough and swollen acrosomes. Factors that can influence sperm morphology are hereby discussed.

1.4.1. Stress and osmotic pressure

Factors associated with adverse and climatic changes and high ambient temperatures could affect semen quality (Salisbury et al., 1978). The percentage of abnormal sperm cells have been reported to increase with extremes of temperature as demonstrated by experimental heat stress, experimental insulation of the scrotum, scrotal frost bite and exposure to the combined effects of cold and wind (Faulkner et al., 1967; Rathore, 1971; Wells et al., 1972). Coiling and spiralization of mammalian spermatozoa on contact with drops of water, and a sudden change in temperature has been known to cause "cold-shock" or sudden death of sperm cells (Zemjanis, 1970; Salisbury et al., 1978). Fast cooling of bull sperm or extension in hypo and hyper-osmotic media

will induce coiling, bending of sperm tails and can cause serious effects on livability and morphology of bovine spermatozoa (Pursley and Herman, 1950). Exposure of bulls to elevated ambient temperatures led to an increase in percentage of aged acrosomes and reduction in sperm quality (Meyerhoeffer et al., 1976). In another report by Silvada (1976) direct exposure of Zebu bulls to temperatures above 30°C during the first three weeks of spermatogenesis led to a decrease in semen quality and high correlations with proportion of primary and secondary abnormalities.

1.4.2. Disease condition

Diseases affecting reproduction are manifold. There are diseases, which by the production of general disability, could lead to lowered performance in libido and sperm production (Roberts, 1971). Congenital testicular hypoplasia, acquired testicular degeneration, genital tract infections and inflammations, have been found to arrest spermatogenesis and thus are associated with a high frequency of abnormal sperm cells (Zemjanis, 1970; Gustaffson et al., 1972).

1.4.3. Genetic factors

Certain inherited conditions could modify several reproductive traits in the bull. Working on identical twin bulls it was found that the frequency and total

number of abnormal sperm heads and cytoplasmic droplets were influenced genetically (Bane, 1954). Tightly or strongly coiled and folded tails ("Dag defect") of spermatozoa in the semen of two subfertile Jersey bull brothers suspected to be hereditary has been reported (Blom, 1966). Blom (1959) and Munro et al. (1961) reported a rare sperm abnormality ("Corkscrew" sperm) of the midpiece. Later, Blom and Birch-Anderson (1968) reported a heritable pseudo - droplet defect of the midpiece in two half brother bulls. Another hereditary condition of Guernsey, Swedish Red and White bulls, in which more than fifty percent of the sperm heads were detached from the tails but still showed motility, has been reported by Salisbury et al. (1978). The latter have also reported an apparent congenital sperm defect in which a small lateral appendage was implanted in fossa at the posterior end of the sperm head. Such hereditary sperm cell defects could adversely affect semen quality and subsequent fertility.

1.4.4. Season

Many researchers have reported seasonal variations in bull semen picture. High incidence of secondary abnormalities and increased protoplasmic droplets have been reported in the dry season than in the rainy season (Hultnas, 1959; Sekoni, 1979; Kumi-Diaka et al., 1981). Significant seasonal, monthly and weekly variations in percentage aged acrosomes have been reported,

with later fall and winter conditions being more detrimental (Salisbury et al., 1978). Higher sperm defects in the hot periods than the cool periods, with significant age effects on sperm morphology in dairy bulls has been reported (Sekoni and Gustafson, 1980).

1.4.5. Age

Increased number of proximal cytoplasmic droplets indicate either degenerative or regenerative processes of the spermatogenic epithelium in aging and prepubertal bulls respectively (Rao, 1971). Loose normal heads often occur due to degenerative changes in the testis, but these abnormalities could occur due to careless handling of semen (Roberts, 1971). High percentage of sperm abnormalities have been reported in aged bulls as a result of senile degeneration (Kumi-Diaka et al., 1981).

CONCLUSION

It is generally considered that diets which are capable of maintaining body weight and general health are also sufficient for normal spermatogenesis. Inanition may impair spermatozoa production and may delay puberty caused by either general effect of nutrition or concomitant specific deficiencies. For example deficiencies of protein, energy, vitamins and minerals in rations have been reported to reduce fertility in bulls and rams (Asdell, 1955).

Puberty can be achieved at an early age with improved protein intake and this would in turn reduce the generation interval and thus increase the rate of genetic gain of our indigenous livestock. The influence of protein on growth rate, age at puberty and maintenance of semen production could be important in genetic selection , planning of management programs especially for maximizing the reproductive efficiency of Bunaji bulls and their Friesian crosses.

Studies on puberty in Zebu bulls under tropical routine management conditions have been reported (Aire and Akpokodje, 1975; Oyedipe et al., 1981) but the long term nutritional effects during postweaning period on body and testicular growth, semen characteristics have not well been documented. This study was therefore designed to investigate the influence of two levels of protein intake on:

(a) growth patterns in relation to body weight, chest girth, withers height, scrotal size and body condition score;

(b) age and related phenomena at first appearance of spermatozoa in the ejaculate;

(c) age and related phenomena at puberty;

(d) postpubertal semen production and seminal characteristics;

(e) haematology; of Bunaji bulls and their Friesian crosses.

CHAPTER TWO

EFFECTS OF VARYING LEVELS OF PROTEIN INTAKE ON GROWTH AND PUBERTY IN BUNAJI AND FRIESIAN x BUNAJI (CROSSBRED) BULLS

2.1. INTRODUCTION

General body growth and development are prerequisites to the development of sexual function in both male and female (VanDemark and Mauger, 1964). Postnatal development of the endocrine and spermatogenic function of the bull testis, is largely due to tubular changes in the testis. Postnatal growth of the testis in cattle, sheep and goat is curvilinear with an initial period of rapid growth upto puberty followed by a period of minimal growth (Willet and Ohms, 1957; Osinowo, 1979). Testicular growth in dairy bulls is highly correlated with body growth and sperm output (VanDemark and Mauger, 1964). The latter shows that 80% of the variation in testis size was associated with changes in body size which also reflect the capabilities of bulls to produce semen.

Physiological differences within and between breeds could also be important in determining variations in reproductive functions and in genetic selection and planning of management programmes. Slower growth rate and late attainment of puberty of Bos indicus has been manifested in lower fertility rate than for Bos taurus (Igboeli and Rakha, 1971). Oyedipe et al., (1981) reported significant differences in age at attainment at puberty among three breeds of cattle reared under tropical conditions in Nigeria.

The most important management factor affecting sexual maturity is the level of feeding. Limiting the amount of feed for growing bulls to a level below that needed for maximum growth would extend the age of first appearance of sperm-cells in the ejaculate. Joubert (1954) observed that poor nutrition significantly retarded growth and sexual development.

Delayed puberty will occur when there is a low plane of nutrition available to the young male animal (Bratton et al., 1959; Flipse and Almquist, 1960).

It has been observed that age at puberty is significantly correlated with body weight gains from birth to puberty (Arije and Wiltbank, 1971). Pfander (1971), Lamond (1970) and Topps (1977) have indicated that under-nutrition is more likely to occur in cattle grazing tropical and sub-tropical pastures whose protein content is extremely low. Nutrition therefore is probably the most important factor influencing growth, age at puberty and subsequent reproductive performance of cattle in these areas. The importance of reproductive performance in determining the economics of cattle industry in the tropics necessitates finding means and ways of achieving early puberty so as to improve animal production enterprises.

This study was therefore designed to investigate the influence of postweaning nutrition on:

i. growth pattern for body weight, chest girth and wither's height;

ii. body condition and scrotal development;

iii. age and pubertal traits at first appearance of spermatozoa in the ejaculates;

iv. age and pubertal traits at puberty.

2.2. MATERIALS AND METHODS

2.2.1. Bulls

Forty-two bull-calves made up of twenty-one Bunaji and twenty-one Friesian x Bunaji were divided into two nutritional treatments viz: low and high protein diets.

The period of study was from January 1984 to June, 1985. The low plane had ten bulls while the high plane had eleven bulls of each breed. The Bunaji bulls were obtained from Kaduna State Livestock ranches, while the Friesian x Bunaji crosses were first generation (F1 progeny) obtained from NAPRI Dairy Farm. The animals were weaned at approximately six months of age at the time of introduction to the experiment. All experimental bulls were screened for blood and helminth parasites, and appropriate treatments and vaccinations carried out before introduction to experiment. They were regularly dewormed and sprayed at monthly intervals with acaricides, throughout the period of study.

The management of these bulls was such that, the bulls were intensively fed with calculated rations on group basis. The bulls were divided into four groups and allocated to four paddocks, and each paddock had a shelter for the animals in case of rainfall or sunshine. The bulls were allocated as follows: 10 BJ bulls in pen A, 11 BJ bulls in pen B, 10 FRxBJ in pen C and 11 FRxBJ bulls in pen D.

The bulls were in strict confinement and were not allowed to graze until at the end of study. At the end of each two weeks the animals were yarded to the crush for semen collection and body measurements.

2.2.2. Nutrition

Two isocaloric rations (2.40 ME Mcal/kg DM) varying in protein level (Table 1) were formulated to contain 8.51% crude protein (low protein, LP) and 14.45% crude protein (High protein, Hp). Proximate analysis of the two rations used were determined in the laboratory (Table 2.2). The protein diets were formulated based on nutrient requirement of beef cattle (National Research Council, NRC, 1970) designed to gain 0.5 kg/head/day for high protein diet, and 0.29 kg/

head/day for low protein diet. The animals were fed on group basis as shown in Table 2.1). The composition of the high and low protein diets are shown in Table 2.1. Mineral lick and water were provided ad-libitum to all experimental animals. The bulls were fed for a period of 16 months; from six months of age until at 21 months of age.

2.2.3. Body Measurements

Body measurements including body weight, withers height, chest girth, scrotal circumference, condition score were taken bi-weekly from six months through twenty-one months of age. Body weights were taken by use of a weighing scale (kg), withers height by use of a linear ruler (cm), chest girth by use of a tape (cm), scrotal circumference by use of standard metal scrotal tape (cm), and condition score determined according to the method of Pullan (1978). Bulls were restrained for all measurements, after which attempts were then made to collect semen by electroejaculation, using a probe with longitudinal electrodes[1] as described by Zemjanis (1970).

Volume of semen, sperm motility and sperm concentration of all samples were determined by visual inspection in a graduated centrifuge tube, field microscope and a haemocytometer respectively (Zemjanis, 1 970). Electroejaculation produced semen, but failed to consistently produce a penile protrusion and hence did not enable us to score penile adherence (Ashdown, 1960) as originally intended. Puberty was defined as the age at which an ejaculated semen contained at least 50×10^6 spermatozoa with a minimum of 10% motility (Lunstra et al., 1978).

2.2.4. Statistical Analysis

The influence of ration, breed, age effects on withers height, chest girth, body weight, scrotal circumference, condition score was

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[1] Standard Precision Electronics Denver, Colorado, U.S.A.

studied by Multiple Analysis of Variance (ANOVA) procedures (Steel and Torrie, 1960). Breakdown (oneway) analysis was used to compare pubertal traits at first appearance of sperm cells and at puberty. Pearson's correlation analysis was carried out to study relationships between age, body weight, scrotal circumference, condition score, withers height and chest girth and seminal characteristics. Oneway analysis of variance and Scheffee multiple range test (0.05) was used to test for significant differences of pubertal traits between the four treatments groups.

2.3. RESULTS

2.3.1. Attainment of puberty

Table 2.3 shows age and related phenomena at first appearance of sperm cell and at puberty for Bunaji (BJ) and Friesian x Bunaji (FRxBJ) bull-calves. Bulls on high protein diets produced first motile spermatozoa and attained puberty earlier than those on low protein diets. Mean ages (months) at first appearance of motile sperm on low and high protein diets for Bunaji bulls were 12.50 ± 0.69 and 11.82 ± 0.35 (P(0.05) and for Friesian x Bunaji the ages were 15.36 ± 0.57 and 9.18 ± 0.12 (P(0.05) respectively. Mean ages at puberty on low and high protein diets for Bunaji bulls were 16.50 ± 0.53 and 14.82 ± 0.68 (P(0.05) and for Friesian x Bunaji the ages were 17.97 ± 0.82 and 12.94 ± 0.60 (P(0.05) respectively. The FRxBJ bulls attained puberty earlier than Bunaji when placed on high protein diet, but the reverse was the case when the animals were on low protein diet.

2.3.2. Growth traits

Animals on high protein diet attained puberty at significantly lighter body weights than those on low protein diets (P(0.05). Body weight (kg) at first appearance of motile sperm in the ejaculate were

142.50 ± 7.68 and 142.64 ± 6.44 for BJ on low and high protein respectively. The difference were not significant. Body weights (kg) at first appearance of sperm for FRxBJ on low and high proteins were 183.14 ± 8.60 and 162.88 ± 10.60 respectively, which differed significantly (P(0.05). Mean body weights at puberty on low and high protein diets for BJ were 203.06 ± 7.49 and 188.18 ± 6.02 and for FRxBJ the values were 212.86 ± 11.49 and 191.01 ± 12.54 respectively (P(0.05).

Body weight changes of the bulls are presented in Table 2.6. Average daily gains in body weights were 0.24 kg and 0.31 kg for Bunaji on low and high protein diets respectively and 0.32 kg and 0.45 kg for Friesian x Bunaji on low and high protein diets respectively. The bulls on high protein diets had significantly higher growth rates than those on low protein diets. Generally, the Friesian x Bunaji had higher average daily gains than the Bunaji. Withers height, chest girth and body condition scores from six months of age to 21 months are presented (Tables 2.4-2.7).

Mean chest girth at puberty indicate that bulls on the high protein had significantly lower chest girth than those on low protein diet, with no breed differences. Also mean withers height did not show any significant difference between low and high protein diets at first motile sperm and at puberty.

Condition score of bulls on high protein were significantly higher than those on low protein (P(0.01). Mean body condition score at first motile sperm were 3.40 ± 0.25 and 4.68 ± 0.13 for Bunaji on low and high protein diets respectively. Mean condition score at first motile sperm were 3.71 ± 0.23 and 4.63 ± 0.16 for Friesian x Bunaji on low and high protein diets respectively. Condition score at puberty on low and high protein diets for BJ bulls were 3.89 ± 0.26 and 5.00 ± 0.20 and for FRxBJ the values were 3.85 ± 0.47 and 4.88 ± 0.01 respectively.

There were no breed differences in body condition score (P)0.10).

2.3.3. Scrotal and seminal traits

Animals on high protein attained puberty with significantly smaller scrotal circumference than those on low protein. Mean scrotal circumference (cm) at first motile sperm on low and high protein diets for Bunaji bulls were 17.35 ± 0.36 and 18.18 ± 0.60 respectively and for Friesian x Bunaji the values were 21.57 ± 0.97 and 19.69 ± 1.33 respectively. At puberty the scrotal circumference for Bunaji on low and high protein diets were 21.33 ± 0.63 and 20.73 ± 0.44 respectively (P)0.01) and for FRxBJ the values were 25.00 ± 1.37 and 22.93 ± 1.26 respectively (P(0.05). The Friesian x Bunaji bulls had significantly higher scrotal circumference than Bunaji at first motile sperm and at puberty.

Mean percentage motility was significantly (P(0.05) higher for bulls on high protein than for those on low protein. . Volume of semen in this study did not show significant nutritional or breed differences (P)0.01).

2.3.4. Relationship among growth traits and seminal characteristics

Simple correlation coefficients among growth traits and seminal characteristics are presented in Appendices 2.3 to 2.10. Correlations among and between body weights and other traits were generally high and significant through out the period of study for all the four groups. The degree of association of these growth traits were stronger for all the bulls on high protein diets than those on low protein diets (P)0.01). The relationship between age and body weight were highly significant (P(0.001). The correlation coefficients between age and body weight for BJ on low and high planes were r = 0.81 and r = 0.96 respectively, while corresponding values were r = 0.60 and r = 0.94 for FRxBJ on low and high plane respectively (P(0.001). Correlation coefficients

between age and scrotal circumference were also significant (P<0.01). The correlation coefficients were r = 0.81 (BJ, LP), r = 0.91 (BJ, HP), r = 0.71 (FRxBJ, LP), r = 0.99 (FRxBJ, HP).

Age and condition score, age and withers height age and chest girth were found to be significantly correlated (P<0.01). Correlation coefficients between body weight and scrotal circumference were highly significant (P<0.001) with r = 0.92 (BJ, LP), r = 0.97 (BJ, HP), r = 0.75 (FRxBJ, LP) and r = 0.96 (FRxBJ, HP). Changes in scrotal circumference were significantly associated with body weight changes. Body weight and withers height, body weights and chest girth were significantly correlated (P<0.01). Associations between condition score and withers height, and also chest girth were significantly correlated (P<0.01). Withers height and chest girth were significantly correlated (P<0.01) for all the treatment groups. Body weight, scrotal circumference and body condition were positively correlated to volume of semen, sperm motility, sperm concentration and total spermatozoa (P<0.05).

2.4. DISCUSSION

Results in this study indicate that high protein diet significantly induced earlier puberty in cattle than low protein diet. This is in agreement with many reports which show that bulls on low plane of nutrition had delayed puberty and retarded development when compared to those on high level of nutrition (Joubert, 1954; Bratton et al., 1959; Barber and Almquist, 1975). The observed pubertal changes between 9.18 ± 0.12 and 17.97 ± 0.82 months of age in this study are in accord with values reported by Igboeli and Rakha (1971), Wildeus et al. (1984).

The significantly earlier puberty for FRxBJ on high protein and the reverse on low protein when compared to BJ could be due to certain genetic traits inherent in the exotic breeds. This could be attributed to the ability of the indigenous breeds to with stand harsh nutritional

conditions than the exotic breeds. The significantly higher average daily gains for FRxBJ than BJ confirms a slower rate of sexual maturation of Bos indicus breeds than Bos taurus (Igboeli and Rakha, 1971).

The lighter body weights, smaller scrotal circumference attained at first ejaculated sperm and at puberty for bulls on high plane than low is in accord with the work of Asdell (1955), Barber and Almquist (1975), who showed that fast growing bulls were younger and lighter at puberty than moderately growing bulls. The finding on chest girth and withers height are in accord with the work of Oyedipe et al. (1981) who reported that chest girth at puberty for Zebu bulls and their crosses were not significantly different. The significant larger body weights and larger scrotal circumference of the FRxBJ than the BJ in this study confirms an earlier report (Igboeli and Rakha, 1971) but contradicts the findings of Oyedipe et al. (1981), who reported non-significant differences in body weight and scrotal circumference of Zebu bulls and their Friesian crosses at puberty.

The higher body condition score for bulls on high protein diet than for those on low protein confirm earlier reports that have shown significant association between plane of nutrition and condition score (Elliot and Topps, 1963; Alkass and Bryant, 1982).

The range of percentage sperm motility at puberty for all the groups compares with those reported by other workers (Fields et al., 1982; Wildeus et al., 1984).

In the present study, values for scrotal circumference at puberty for Bos indicus bulls agree with those reported by Oyedipe et al. (1981) and Wildeus et al. (1984). This investigation demonstrates a positive association between scrotal growth and nutrition of the young bull which is desirable for the attainment of sexual function. The results indicate that protein level, age,

and breed have significant influence on body growth patterns as has been shown in some reports (Almquist and Barber, 1974; Barber and Almquist, 1975; Coulter et al., 1975). The growth patterns for withers height chest girth, body weight and scrotal circumference show that the FRxBJ were better than the BJ. The latter is in agreement with reports by Fields et al. (1982). Similarly, body growth measurements for animals on high protein diet were significantly better than for those on low protein confirming the relationship between nutrition and physical growth traits (VanDemark and Mauger, 1964). The significant associations between plane of nutrition, condition score, scrotal circumference, and body weight in this study is in agreement with findings of VanDemark and Mauger (1964), Pullan (1978).

The significant correlation coefficients for body measurements and age reported in this work are comparable to those of Berry et al. (1983), Monsoor et al. (1984) who have reported positive significant relationships between age, body weight, scrotal circumference and other seminal characteristics. These significant correlations between age and reproductive traits in this study are in accord with the findings of Hahn et al. (1969b), Coulter et al. (1975), Bongso et al. (1982), Bongso et al. (1984). The results from this study also show that body weight was significantly correlated with volume of semen, semen concentration and condition score. These significant associations indicate that most of the changes in semen volume, sperm concentration, total sperm and body condition score were significantly associated with body weight changes as has been shown by Hahn et al. (1969b). The latter reported that testicular and body growth of a large number of dairy bulls were highly correlated and also to semen production traits. It is evident from the present data that animals on high protein diets attained puberty at younger age with better pubertal traits than those

placed on low protein diets. The indigenous Bunaji attained puberty later than the Friesian x Bunaji crossbreds when placed on high protein diets and the reverse when on low protein diets.

Adequate protein intake and good management of the young selected sire is a sine-qua-non in all breeding centres as this would lead to early and optimum sperm cell production. Attainment of early puberty by improved protein intake would lead to reduction in time interval between generations which is of genetic advantage in cattle improvement programmes. Adequate protein supplementation should be recommended in any successful cattle management, especially in the tropical regions where marked seasonality of rainfall results in extremely low availability of pasture and herbage conditions during the dry seasons. Thus the young carefully selected sire should be fed and managed adequately so as to bring him into early and optimum production of spermatozoa. Such a sire would become a producer of large quantities of normal, fertile spermatozoa which is beneficial in natural breeding or artificial insemination programmes.

Table 2.1: Ration formulation

Feed	Low protein diet Feed in ration (%)	High Protein diet Feed in ration (%)
Cotton seedcake	2.50	17.32
Wheat bran	44.80	23.42
Molasses	49.30	25.90
Brewer's dried grains	3.36	33.32
Common salt	0.02	0.02
Bone meal	0.02	0.02
Mineral lick	ad-lib	ad-lib
Water	ad-lib	ad-lib

Table 2.2: Proximate analysis of rations

	Dry Matter %	Crude Protein %	Ether Extract %	Fibre %	Ash %
Low Protein	75.39	8.51	1.94	6.36	5.56
High Protein	90.31	14.45	4.22	11.94	4.94

Table 2.3: Pubertal characteristics of Bunaji and Friesian x Bunaji bulls on two protein diets.

	Mean ± Standard Errors			
	Bunaji		Friesian x Bunaji	
Pubertal characteristics	LP n=10	HP n=11	LP n=10	HP n=11
Age (months) at				
First appearance of spermatozoa	12.50±0.69[a]	11.82±0.35[a]	15.36±0.57[b]	9.18±0.12[c]
50 x 10^6 sperm per ejaculate and at least 10% motility	16.50±0.53[a]	14.82±0.68[b]	17.97±0.82[c]	12.94±0.60[d]
Body weight (kg) at				
First appearance of spermatozoa	142.50±7.68[a]	142.64±6.44[a]	183.14±8.60[b]	162.88±10.6[c]
50 x 10^6 sperm per ejaculate and at least 10% motility	203.06±7.59[a]	188.18±6.02[b]	212.86±11.49[c]	191.01±12.54[b]
Chest girth (cms) at				
First appearance of spermatozoa	117.20±0.65[a]	117.36±0.83[a]	128.29±2.15[b]	126.63±2.38[b]
50 x 10^6 sperm per ejaculate and at least 10% motility	134.70±1.84[a]	129.36±1.43[b]	135.57±2.82[a]	129.88±3.23[b]
Withers height (cms) at				
First appearance of spermatozoa	103.01±1.08[a]	103.09±1.35[a]	108.43±1.65[b]	108.50±1.65[b]
50 x 10^6 sperm per ejaculate and at least 10% motility	107.78±1.7	108.00±1.05	109.43±1.78	109.75±1.61

[a,b,c,d]Data with different superscripts within rows are significantly different (P<0.05).

Table 2.3 Contd.

	Bunaji		Friesian x Bunaji	
Condition score at	LP	HP	LP	HP
First appearance of spermatozoa	3.40±0.25[a]	4.68±0.13[b]	3.71±0.13[a]	4.63±0.16[b]
50 x 10^6 sperm per ejaculate and at least 10% motility	3.89±0.26[a]	5.00±0.20[b]	3.85±0.47[a]	4.88±0.01[b]
Scrotal circumference (cms) at				
First appearance of spermatozoa	17.35±0.36[a]	18.18±0.60[a]	21.57±0.97[b]	19.69±1.33[c]
50 x 10^6 sperm per ejaculate and at least 10% motility	21.33±0.63[a]	20.73±0.44[a]	25.00±1.37[b]	22.94±1.26[c]
Motility (%) at				
First appearance of spermatozoa	30.31±2.46[a]	34.28±2.30[b]	20.84±1.13[a]	30.71±2.16[a]
50 x 10^6 sperm per ejaculate and at least 10% motility	39.90±3.95[a]	49.35±2.84[b]	40.97±4.41[a]	44.68±3.13[c]
Volume of semen (mls) at				
First appearance of spermatozoa	1.04±0.21	1.36±0.26	1.09±0.22	1.12±0.31
50 x 10^6 sperm per ejaculate and at least 10% motility	1.77±0.23	2.02±0.29	1.97±0.29	1.84±0.18

[a,b,c,d]Data with different superscripts within rows are significantly different (P<0.05).

Table 2.4: Withers height (cm) of Bunaji and Friesian x Bunaji bulls on two levels of protein diets.

Age (months)	Bunaji		Friesian x Bunaji	
	LP	HP	LP	HP
6	97.40±1.06	97.36±1.70	95.80±2.04	100.09±1.89^{a}
7	96.25±1.16	97.14±1.44	96.25±1.16	100.86±2.21
8	96.95±1.18	97.96±1.70	97.00±1.81	101.74±2.10^{a}
9	101.85±0.73^{ab}	103.91±1.78^{b}	99.80±1.72^{a}	104.32±2.08^{b}
10	103.35±1.09	105.05±1.07	103.75±1.88	105.31±2.11
11	102.10±1.01	105.14±0.90	103.75±2.20	105.11±1.84
12	101.80±0.99	104.00±1.15	103.65±1.50	108.17±2.14^{a}
13	102.70±1.02^{a}	105.10±1.25^{ab}	106.65±0.65^{bc}	109.78±2.51
14	103.90±1.31^{a}	105.73±1.19^{ab}	106.90±2.86^{bc}	109.11±2.31^{c}
15	104.60±1.63	106.10±1.41	105.50±2.25	110.81±2.02^{a}
16	107.05±1.51^{a}	109.41±1.37^{ab}	112.21±1.67^{bc}	115.88±2.10^{c}
17	109.65±1.40	110.77±1.20	111.24±1.65	118.81±4.09^{a}
18	109.75±1.58^{a}	111.95±1.10^{a}	115.43±1.54^{b}	119.06±2.09c
19	109.72±1.77	112.82±0.95	116.57±1.86^{a}	120.88±2.62^{b}
20	111.67±1.59^{a}	114.00±1.05^{ab}	116.50±1.82^{ab}	120.50±2.55^{c}
21	112.89±1.35^{a}	114.52±2.10^{ab}	116.54±2.23^{ab}	122.00±2.49^{c}
Overall mean ±s.e.m	104.79±6.38^{a}	106.39±7.02^{a}	108.67±28.22^{ab}	111.51±10.49^{b}

^{a,b,c,d}Data with different superscripts within rows are significantly different (P<0.05).

Table 2.5: Chest girth (cms) of Bunaji and Friesian x Bunaji bulls on two levels of protein diet

Age (months)	Bunaji		Friesian x Bunaji	
	LP	HP	LP	HP
6	103.40±1.54	103.91±1.51	103.51±1.49	112.18±1.97^{a}
7	103.85±1.12	103.23±1.10	103.71±1.10	112.32±1.98^{a}
8	105.70±1.47^{a}	108.57±1.64^{ab}	110.60±2.42^{b}	115.32±2.90^{c}
9	106.95±1.63^{a}	113.32±1.53^{b}	113.68±2.68^{b}	119.14±3.13^{c}
10	113.65±1.24	115.55±1.29	116.19±3.30	120.14±2.82^{a}
11	114.20±1.66^{a}	114.91±1.14^{a}	118.69±2.20^{b}	119.61±3.46^{b}
12	117.75±2.17^{a}	119.73±1.77^{ab}	120.20±2.17^{b}	124.00±2.62^{c}
13	121.10±1.70^{a}	124.18±1.75^{b}	123.05±4.16^{ab}	131.11±4.01^{c}
14	123.15±1.94	125.73±2.01	124.77±3.90	131.61±3.44^{a}
15	125.15±2.03	127.61±2.11	127.47±3.98	133.38±4.41^{a}
16	128.40±3.13	128.59±2.27	128.71±4.45	136.63±4.34^{a}
17	126.35±3.50^{a}	133.27±2.35^{b}	133.64±3.85^{b}	142.21±4.67^{c}
18	131.55±3.68^{a}	132.50±2.05^{a}	137.79±4.63^{b}	146.75±4.45^{c}
19	135.53±2.65^{a}	134.27±2.22^{a}	144.38±5.31^{b}	149.63±4.80^{c}
20	133.11±3.20^{a}	135.36±2.66^{a}	142.71±5.63^{b}	152.63±1.77^{c}
21	134.61±3.20^{a}	137.09±2.93^{b}	146.85±5.41^{c}	154.75±4.00^{d}
Overall mean ± s.e.m.	121.54±12.54^{a}	123.31±13.25^{ab}	125.23±26.58^{b}	130.63±18.92^{c}

^{a,b,c,d}Data with different superscripts within rows are significant different (P(0.05).

Table 2.6: Body weight (kgs) of Bunaji and Friesian x Bunaji bulls on two levels of protein diet

Age (months)	Bunaji		Friesian x Bunaji	
	LP	HP	LP	HP
6	99.30±4.18	100.82±4.14	117.30±4.18^{b}	128.82±7.40^{a}
7	100.10±4.40	100.11±3.69	118.45±6.11^{a}	131.65±9.71^{a}
8	105.65±4.34^{a}	114.14±4.64^{b}	121.00±7.61^{c}	137.00±9.73^{d}
9	123.90±5.18^{a}	128.77±5.02^{b}	131.70±8.13^{c}	150.73±11.08^{d}
10	129.60±5.30^{a}	135.95±4.07^{b}	136.88±8.20^{b}	153.31±1.10^{c}
11	131.60±5.56^{a}	136.77±3.26^{b}	140.71±10.25^{c}	164.77±12.56^{d}
12	144.10±7.00^{a}	149.72±6.25^{b}	150.40±10.50^{b}	170.33±13.78^{c}
13	155.50±7.35^{a}	167.27±6.74^{b}	166.56±15.69^{b}	195.78±16.20^{c}
14	163.60±7.21^{a}	174.73±7.57^{b}	167.29±14.70^{a}	198.78±17.31^{c}
14	163.60±7.21^{a}	174.73±7.57^{b}	167.29±14.70^{a}	198.78±17.31^{c}
15	170.75±8.07^{a}	183.55±7.32^{b}	178.43±15.08^{c}	198.12±17.40^{d}
16	184.40±12.36	184.73±9.15	185.93±16.63	219.00±19.19^{a}
17	199.60±9.74	200.95±9.24	205.64±16.63^{a}	243.33±20.47^{b}
18	192.00±10.81^{a}	204.36±8.53^{b}	222.91±18.27^{c}	264.06±20.69^{d}
19	200.33±10.66^{a}	206.68±9.22^{b}	241.71±19.27^{c}	278.38±23.01^{d}
20	197.50±10.75^{a}	212.09±10.61^{b}	259.43±26.82^{c}	293.13±23.40^{d}
21	208.67±14.47^{a}	239.64±12.54^{b}	265.46±28.10^{c}	316.13±24.05^{d}
Overall mean ±s.e.m.	156.00±38.36^{a}	165.02±42.66^{b}	175.80±49.97^{c}	201.39±62.93^{d}

^{a,b,c,d}Data with different letter superscripts within rows are significantly different (P(0.05).

Table 2.7: Conditions score of Bunaji and Friesian x Bunaji bulls on two levels of protein diet

Age (months)	Bunaji		Friesian x Bunaji	
	LP	HP	LP	HP
6	1.70±0.20	1.50±0.15	1.70±0.21	2.42±0.37^{a}
7	2.20±0.24	2.73±0.25	1.80±0.16^{a}	2.73±0.25
8	2.60±0.19^{a}	3.91±0.20^{b}	2.80±0.24^{b}	3.95±0.33^{b}
9	2.93±0.26^{a}	4.36±0.17^{b}	2.71±0.32^{a}	4.26±0.21^{b}
10	3.23±0.25^{a}	4.67±0.14^{b}	3.14±0.24^{a}	4.16±0.15^{b}
11	2.23±0.08^{a}	4.52±0.20^{b}	2.50±0.40^{a}	4.56±0.18^{b}
12	3.29±0.25^{a}	4.77±0.11^{b}	3.00±0.45^{a}	4.50±0.18^{b}
13	3.20±0.20^{a}	4.77±0.12^{b}	3.22±0.40^{a}	4.53±0.20^{b}
14	3.38±0.23^{a}	4.57±0.21^{b}	3.36±0.32^{a}	4.42±0.13^{b}
15	3.59±0.20^{a}	4.57±0.22^{b}	3.97±0.34^{a}	4.90±0.10^{b}
16	3.50±0.13^{a}	4.57±0.09^{b}	3.15±0.28^{a}	5.00±0.0^{b}
17	3.50±0.16^{a}	5.02±0.15^{b}	4.07±0.48^{a}	5.0±0.0^{b}
18	3.33±0.30^{a}	5.09±0.09^{b}	4.07±0.45^{a}	4.81±0.18^{b}
19	3.50±0.17^{a}	4.93±0.15^{b}	3.36±0.45^{a}	5.00±0.17^{b}
20	3.47±0.41^{a}	5.00±0.18^{b}	3.57±0.51^{a}	5.24±0.15^{b}
21	3.65±0.37^{a}	5.12±0.20^{b}	3.57±0.45^{a}	5.00±0.0^{b}
Overall mean ±s.e.m.	3.18±0.92^{a}	4.52±0.96^{b}	3.25±1.13^{a}	4.47±0.88^{b}

^{a,b}Data with different letter superscripts within rows are significantly different (P(0.05).

Table 2.8: Scrotal circumference (cms) of Bunaji and Friesian x Bunaji bulls on two levels of protein diet

Age (months)	Bunaji		Friesian x Bunaji	
	LP	HP	LP	HP
6	11.25±0.27	11.55±0.16	11.25±0.27	11.23±0.88
7	11.92±0.33	12.05±0.16	11.05±0.21	13.93±0.89
8	13.18±0.48^{a}	14.43±0.43^{b}	14.20±0.31^{b}	15.18±0.96^{c}
9	14.23±0.34^{a}	15.24±0.43^{b}	15.25±0.74^{b}	17.48±1.16^{c}
10	14.43±0.32^{a}	15.41±0.39^{b}	15.81±0.94^{b}	17.48±1.16^{c}
11	15.81±0.68	16.43±0.50	16.25±0.82	19.22±1.22^{a}
12	16.68±0.60^{a}	17.74±0.63^{ab}	18.13±1.80^{b}	21.11±1.34^{c}
13	17.80±0.70^{a}	19.32±0.79^{b}	19.03±1.26^{b}	22.97±1.53^{c}
14	19.13±1.18^{a}	20.52±0.76^{b}	20.39±1.48^{b}	23.03±1.64^{c}
15	19.50±0.73^{a}	20.77±0.77^{b}	21.20±1.65^{b}	24.44±1.77^{c}
16	19.88±0.89^{a}	20.64±0.75^{a}	22.32±1.63^{b}	25.25±1.64^{c}
17	20.80±0.90^{a}	21.98±0.80^{b}	24.29±1.49^{c}	26.69±1.64^{d}
18	20.95±0.59^{a}	22.68±0.83^{b}	26.38±1.54^{c}	27.97±1.32^{d}
19	21.58±0.95^{a}	22.77±0.88^{b}	27.21±1.54^{c}	28.81±1.23^{d}
20	20.86±1.02^{a}	23.00±0.96^{b}	28.17±1.33^{c}	29.31±1.20^{c}
21	21.47±0.95^{a}	24.17±1.01^{b}	28.25±1.64^{c}	30.25±1.18^{d}
Overall mean ±s.e.m.	17.64±3.58^{a}	19.67±4.05^{b}	19.98±5.73^{b}	22.15±5.89^{c}

^{a,b,c,d}Data with different letter superscripts within rows are significantly different (P(0.05).

CHAPTER THREE

EFFECTS OF LEVEL OF PROTEIN INTAKE ON THE SEMEN QUALITY OF *BUNAJI AND FRIESIAN X BUNAJI (CROSSBRED)* BULLS

3.1. INTRODUCTION

Low protein and energy from poor quality herbage result in loss of body weight and corresponding low levels of reproduction in cattle grazing such pastures (Elliot and Topps, 1963; Topps, 1977). Underfeeding for an extended period during growth of a bull is detrimental not only to his growth and development, but also to his sperm producing capacity (Bratton et al., 1959; VanDemark and Mauger, 1964).

Salamon (1964) found that high level of supplementary feeding had significant influence on sperm production in rams with average daily sperm output of 12.7 x 10^9 spermatozoa for high plane and 8.8 x 10^9 spermatozoa for low plane. The effects of low and high levels of feeding and body condition upon sperm production and gonadotropin concentration in rams show that those on high plane were better in terms of sperm voided in urine and scrotal growth and concentration of spermatozoa in semen (Alkass and Bryant, 1982).

The restrictive effects of limited feed delay the sexual function primarily due to diminished gonadotropin output and releasing factors from the pituitary and hypothalamus (McDonald, 1975). Adequate nutrition is therefore required for proper development and function of the hypothalamos-pituitary-testis axis to initiate and maintain spermatogenesis (Salisbury et al., 1978).

Several studies are in general agreement with regard to relationship between plane of nutrition and semen production (James, 1950). A relationship between the incidence of abnormal spermatozoa and fertility has also been well established in the bull (Rao, 1971). Hentges (1967) indicated that bulls fed on low protein showed a decline in libido which became more pronounced as the animals lost weight. The latter however reported that endocrine changes, sperm production and its quality were not seriously affected.

There are also reports on the influence of plane of nutrition on seminal quality from weaning to one year of age in exotic bulls (Wilsey, 1972; Sitarz et al., 1977; Breuer, 1980; Pruitt, 1983; Coulter and Kozub, 1984).

Data on onset of sexual function in Zebu bulls have been reported by Aire and Akpokodje (1975), Osinowo (1979), Oyedipe et al. (1981). However, the long term nutritional effect on the maintenance of sperm production capacity and sperm defects in Zebu and Friesian x Bunaji (crossbred) bulls have not been well documented.

This study was therefore designed to investigate the influence of age and postweaning nutrition on sperm output and semen characteristics of Bunaji bulls and their Friesian crosses.

3.2. MATERIALS AND METHODS

3.2.1. Animals and Nutrition

The number of bulls and the two levels of protein diets imposed are as described in Chapter 2.

3.2.2. Semen collection and evaluation

Semen was collected from each bull by an electroejaculator biweekly (twice a month). A total of 866 ejaculates were collected and involved in this analysis consisting of 275, 150, 231 and 210 ejaculates for FRxBJ (Hp), FRxBJ (LP) BJ (HP) and BJ (LP) respectively. Semen volume was assessed visually from a graduated centrifuge tube, while percentage sperm motility was determined using a field microscope. Sperm concentration was determined by a Neubauer haemocytometer. Only samples containing more than 50×10^6 million spermatozoa were fixed in buffered formol saline and some stained with eosin-nigrosin stains as described by Harasymowycz et al. (1976). Eosin-nigrosin slides were analysed to study live dead ratio, and sperm head morphology

within one to three days after preparation.

Five hundred cells were counted on each slide by use of a light microscope at 1000 x with oil immersion according to the method of Dott and Foster (1972), Harasymowycz et al. (1976). This was used to study live-dead ratio, micro-head, and giant heads. Wet fixed samples in buffered formol saline (within 3 days preparation) were studied by counting 400 cells at 1000 x with oil immersion using phase contrast microscopy (Rao, 1971; Harasymowycz et al., 1976). The following morphological defects were recorded using the wet fixation: proximal cytoplasmic droplets, distal cytoplasmic droplets, detached heads, coiled tails, reversed tails, rough midpieces, abnormal mid pieces, swollen mid pieces, rough acrosomes, irregular acrosomes and swollen acrosomes.

3.2.3. Statistical Analysis

The influence of ration, breed, and age on volume of semen, sperm motility, sperm concentration, total spermatozoa and morphological defects were studied by ANOVA procedures (Steel and Torrie, 1960).

3.3. RESULTS

The effects of age, ration and breed on seminal characteristics are presented in Appendices 3.1, 3.2, 3.3, 3.4, 3.5, 3.6. The postpubertal characteristics are presented in Tables 3.1 and 3.2. Volume of semen produced was significantly influenced by age and ration ($P<0.05$) but with no breed differences ($P>0.05$). Bulls on high plane produced more volume of semen than those on low plane (Table 3.1). The influence of age on volume of semen produced was highly significant ($P<0.001$) and bulls achieved higher volume of semen with increase in age (Fig. 3.1).

Mean semen volume (ml) on low and high protein diets for Bunaji bulls were 2.98 ± 0.94 and 4.19 ± 1.04, and for Friesian x Bunaji bulls, the values were 3.08 ± 1.14 and 4.10 ± 1.24 respectively.

Percent progressive sperm motility was influenced by age and ration (P(0.05). Bulls on high plane had higher percentage sperm motility than those on low plane (P(0.05). Bull sperm motility also significantly increased with age (Fig. 3.2). Mean % sperm motility on low and high protein diets for Bunaji bulls were 45.14 ± 15.68 and 51.27 ± 22.70 and for Friesian x Bunaji the values were 49.50 ± 16.60 and 59.79 ± 16.84 respectively.

Bulls on high plane of nutrition had significantly higher sperm concentration ($x10^6$/ml) and total sperm output than those on low plane. Mean sperm concentration ($x10^6$/ml) on low and high protein diets for Bunaji bulls were 58.00 ± 18.60 and 114.43 ± 40.66 and for Friesian x Bunaji the values were 88.50 ± 26.50 and 127.11 ± 46.68 respectively. Similarly total spermatozoa ($x10^6$) on low and high protein diets for Bunaji bulls were 172.84 ± 18.08 and 479.46 ± 42.29, and for Friesian x Bunaji the values were 316.83 ± 30.21 and 521.15 ± 57.88 respectively. Age also had significant influence (P(0.05) on sperm concentration and total sperm output, both of which increased with age (Fig. 3.3, 3.4).

There were no significant differences between low and high protein diets and also between breeds in respect of percentage live spermatozoa, detached heads, proximal and distal cytoplasmic droplets, midpiece defects, tail defects, head defects and acrosome defects (P(0.05). However, the Bunaji bulls on low protein had significantly lower percentage proximal droplets than the other three groups (P(0.05). Proximal cytoplasmic droplets and sperm head defects were seen to significantly (P(0.01) decrease with age.

About 40% proximal droplets and 15% sperm head defects between the age of 12 and 14 months significantly decreased to below 10% at the age of 17 months and above (Figs. 3.5 and 3.6).

3.4. DISCUSSION

The results in this study show that semen volume increased with age and also due to high level of nutrition as have been observed by VanDemark and Mauger (1964), Barber and Almquist (1975). The latter reported that semen volume of under fed bulls was 65% to 75% of that of the controls. Percentage sperm motility was also higher for bulls on high protein diets than those on low protein diets as has been earlier reported by Almquist and Barber (1984). There was significant and consistent improvement in percentage sperm motility with age which is consistent with findings by Flipse and Almquist (1960).

Semen concentration and total spermatozoa increased significantly with age. The same has been reported by Hahn et al. (1969b); Coulter et al. (1975); Carter et al. (1980). The study also demonstrates the adverse effects of low protein diets on semen production in young bulls. The latter are similar to the results of VanDemark and Mauger (1964) who reported poor semen production in bulls on low energy diets. The findings in this study are also in agreement with James (1950), Bratton et al. (1959) who indicated that under fed young bulls produced significantly lower sperm per ejaculate than over fed young bulls. Similar results in rams (Alkass and Bryant, 1982) have also shown that low level of feeding depressed progressively the numbers of spermatozoa voided out in the urine, scrotal circumference, sperm concentration and total spermatozoa in the ejaculate. However, other contrary reports have indicated reduced reproductive potential, poor seminal quality in Hereford and Angus

bulls fed with high energy diets than medium energy diets (Coulter and Kozub, 1984). Another report has shown that there was no effect of level of dietary energy on either daily sperm production or epididymal sperm reserves of 1 year Angus bulls (Wilsey, 1972).

The non-significant effect of dietary protein intake on seminal quality in this study is in accord with many reports (Wilsey, 1972, Sitarz et al., 1977; Breuer, 1980; Coulter and Kozub, 1984) who found no effect of high energy diets on seminal quality of bulls from weaning to 1 year of age. This study also confirms the recent work of Coulter and Kozub (1984) who reported that normal acrosomes were not affected by diet or breed.

VanDemark and Mauger (1964) demonstrated that underfeeding for an extended period of time up to 46 months of age lead to low sperm producing capacity and attempts to correct the damage became irreversible. The effect of high plane of nutrition on puberty, optimum sperm output and scrotal growth has been reported (Barber and Almquist, 1975). Hentges (1967) however, reported that low and high protein diets had no effect on endocrine changes, sperm production and semen quality. Generally, it appears that these varying observations might be due to period of time under investigations as has been reported by VanDemark and Mauger (1964). The findings in this study also agree with the work of Melrose (1962) who reported that differences in semen quality attributed to level of feeding were not significant.

The percentage proximal dropets and sperm head defects significantly decreased with age. This is in accord with the work of Rao (1971), Salisbury et al. (1978) and Sekoni (1979) who have reported high numbers of sperm defects especially proximal droplets and narrow sperm head defects in young bulls.

This has been said to be indicative of regenerative processes of the spermatogenic epithelium in the testes. The high percentage proximal droplets in young bulls and the significant reduction of such defects as bulls mature mimics the striking morphological changes taking place in the sperm during their passage through the epididymis. The latter is characterized by the migration of such droplets from a proximal position to a distal one until they are completely lost. Generally, no significant breed differences in sperm defects were observed.

Adequate protein supplementation is thus recommended for optimum sperm producing capacity and good fertility even though low protein of 8.51% crude protein as fed in this study did not appear to be critical for semen defects. Feed formulation should be made to contain adequate protein, mineral and energy components for optimum bull performance. This would particularly be important in areas of low quality herbage in the dry season that can result in loss of body weight and corresponding low levels of reproduction. Since sperm defects are higher at early age, it is recommended that yearling bulls should not be used until at the age of 17 months and above. At this time most of the sperm defects must have reduced to appreciable levels. The present study also shows that optimum sperm production can be achieved by adequate nutritional intakes.

Table 3.1: Mean postpubertal semen output of Bunaji bulls and their Friesian crossbreds on two levels of protein

Breed	Ration	No. of ejaculates	Semen volume (ml)	Sperm concentration ($x10^6$/ml)	Total Sperm ($x10^6$)	Sperm motility (%)
FRxBJ	HP	275	4.10 ± 1.24^b	127.11 ± 46.68^c	521.15 ± 57.88^c	59.79 ± 16.84^c
FRxBJ	LP	150	3.08 ± 1.14^a	88.50 ± 26.50^b	316.83 ± 30.21^b	49.50 ± 16.60^b
BJ	HP	231	4.19 ± 1.04^b	114.43 ± 40.66^c	479.46 ± 42.29^c	51.27 ± 22.70^b
BJ	LP	210	2.98 ± 0.94^a	58.00 ± 18.60^a	172.84 ± 18.08^a	45.14 ± 15.68^a

^{a,b,c}Data with different superscripts within columns are significantly different (P(0.05).

Table 3.2: Mean postpubertal sperm defects of Bunaji bulls and their Friesian crossbreds on two levels of protein

Characteristic	FRxBJ LP	FRxBJ HP	BJ LP	BJ HP
Number of ejaculates	150	275	210	231
% Live spermatozoa	66.87±4.33	68.83±4.96	68.51±5.28	66.03±4.07
Detached heads (%)	2.64±1.39	2.69±1.24	2.14±0.90	1.20±0.96
Proximal droplets (%)	21.54±4.34	20.73±18.13	11.17±10.23[a]	23.85±15.06
Distal droplets (%)	1.66±0.90	1.71±0.71	2.92±1.32	2.85±1.27
Rough midpiece (%)	0.45±0.40	0.39±0.21	0.37±0.32	0.33±0.33
Abaxial " (%)	0.37±0.28	0.45±0.41	0.44±0.37	0.48±0.30
Swollen " (%)	0.46±0.40	0.33±0.33	0.34±0.19	0.68±0.44
Coiled tails (%)	1.18±0.67	1.06±0.85	1.78±1.16	1.19±0.66
Reverse tails (%)	3.15±1.37	2.43±1.17	2.72±1.03	2.52±0.84
Rough acrosomes (%)	0.64±0.32	0.31±0.24	0.62±0.26	0.31±0.26
Irregular " (%)	0.28±0.16	0.22±0.18	0.30±0.26	0.30±0.23
Swollen acrosomes (%)	0.15±0.17	0.16±0.16	0.12±0.21	0.25±0.18
Micro heads (%)	0.41±0.38	0.34±0.22	0.39±0.33	0.44±0.35
Narrow heads	3.09±1.02	3.06±1.01	3.04±1.00	3.01±0.85
Pyriform heads (%)	1.24±0.83	1.02±0.65	1.08±0.65	1.01±0.71
Short broad heads (%)	1.31±0.75	1.49±0.77	1.14±0.72	1.01±0.71
Giants heads (%)	0.25±0.35	0.06±0.09	0.15±0.34	0.18±0.28

[a]Data with different superscripts within rows are significantly different (P(0.05).

Fig 3.1

VOLUME (ML) OF SEMEN OF FR x BJ AND BJ BULLS ON LOW AND HIGH PROTEIN DIETS

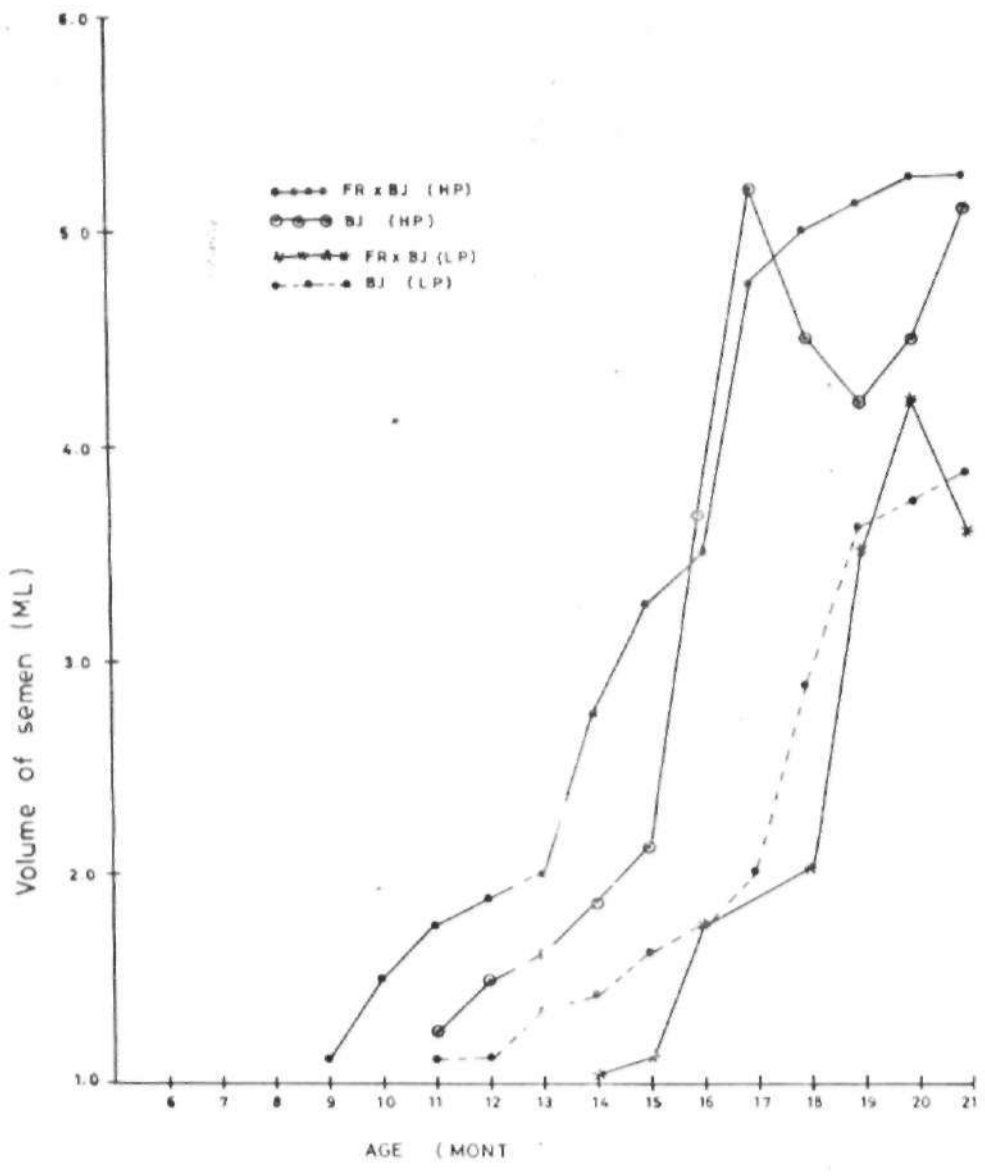


Fig 3.2

PERCENTAGE SPERM MOTILITY FOR FR x BJ AND BJ BULLS ON LOW AND HIGH PROTEIN DIETS

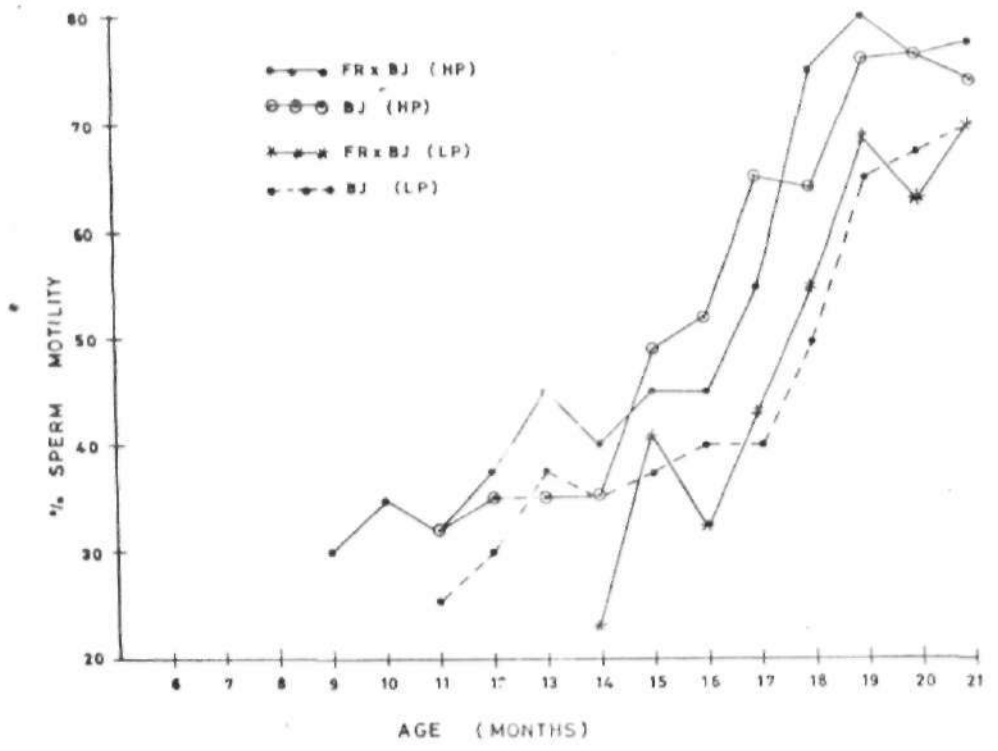


FIG 3.3

SPERM CONCENTRATION (x10⁶/ML) FOR FR x BJ AND BJ BULLS ON LOW AND HIGH PROTEIN DIETS

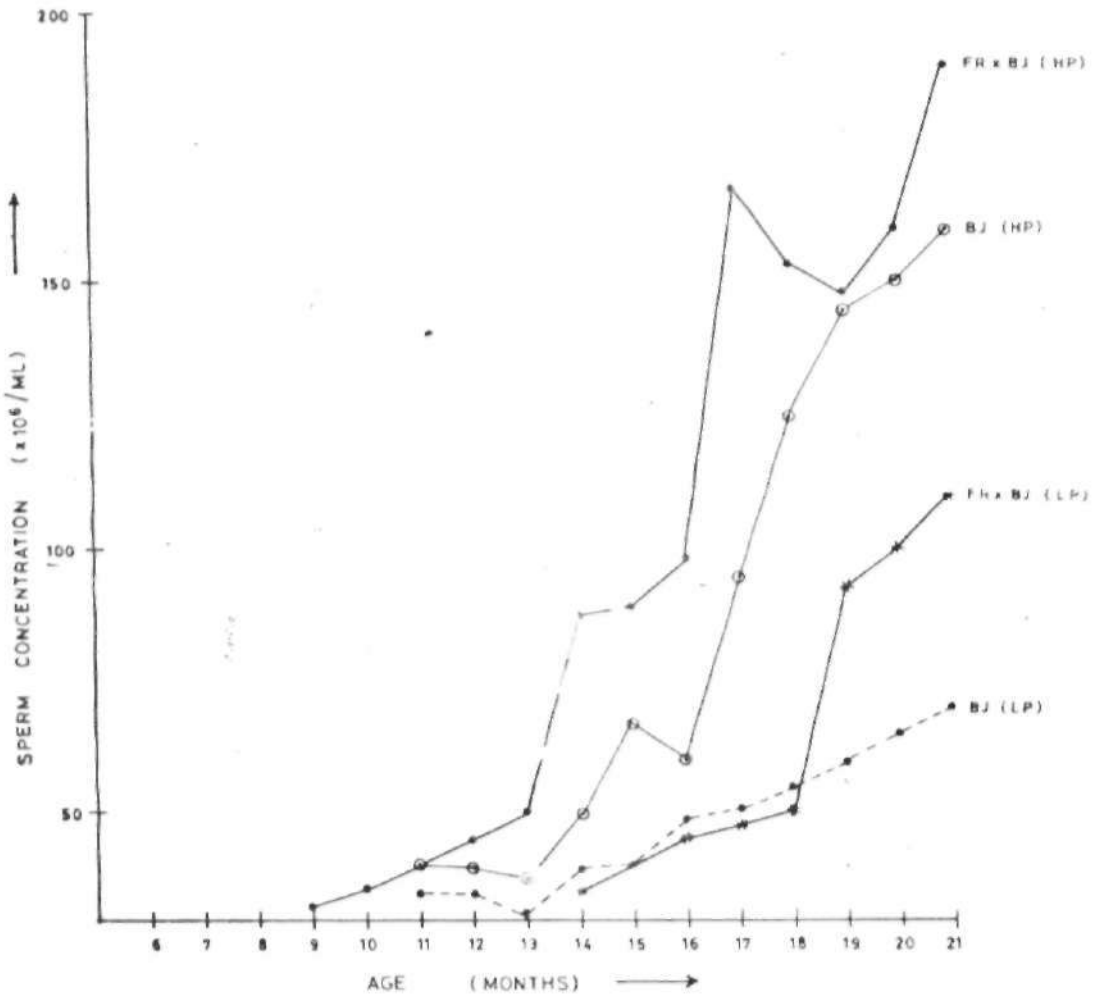


Fig 3.4

TOTAL SPERMATOZOA OF FR x BJ AND BJ BULLS ON LOW AND HIGH PROTEIN DIETS

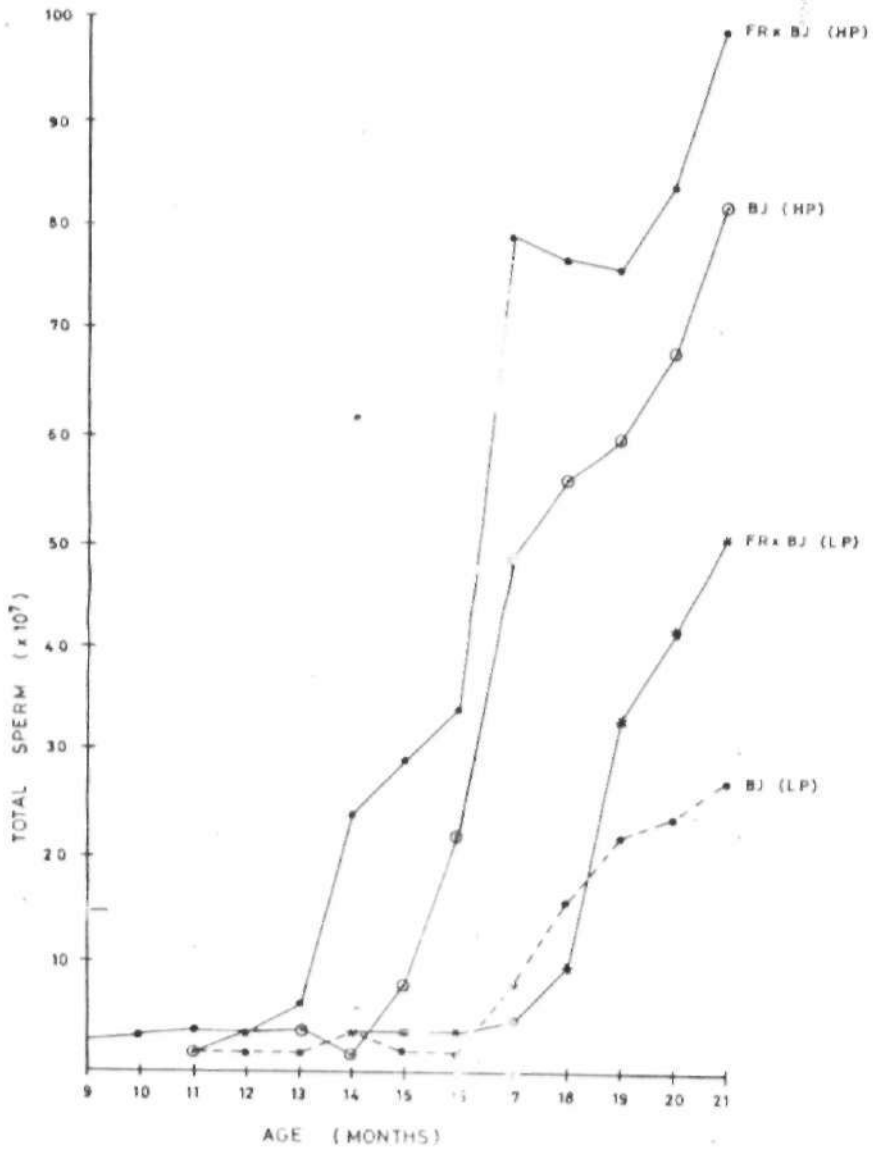


Fig. 3.5

PERCENTAGE PROXIMAL DROPLETS OF FR×BJ AND BJ BULLS ON TWO LEVELS OF PROTEIN DIETS

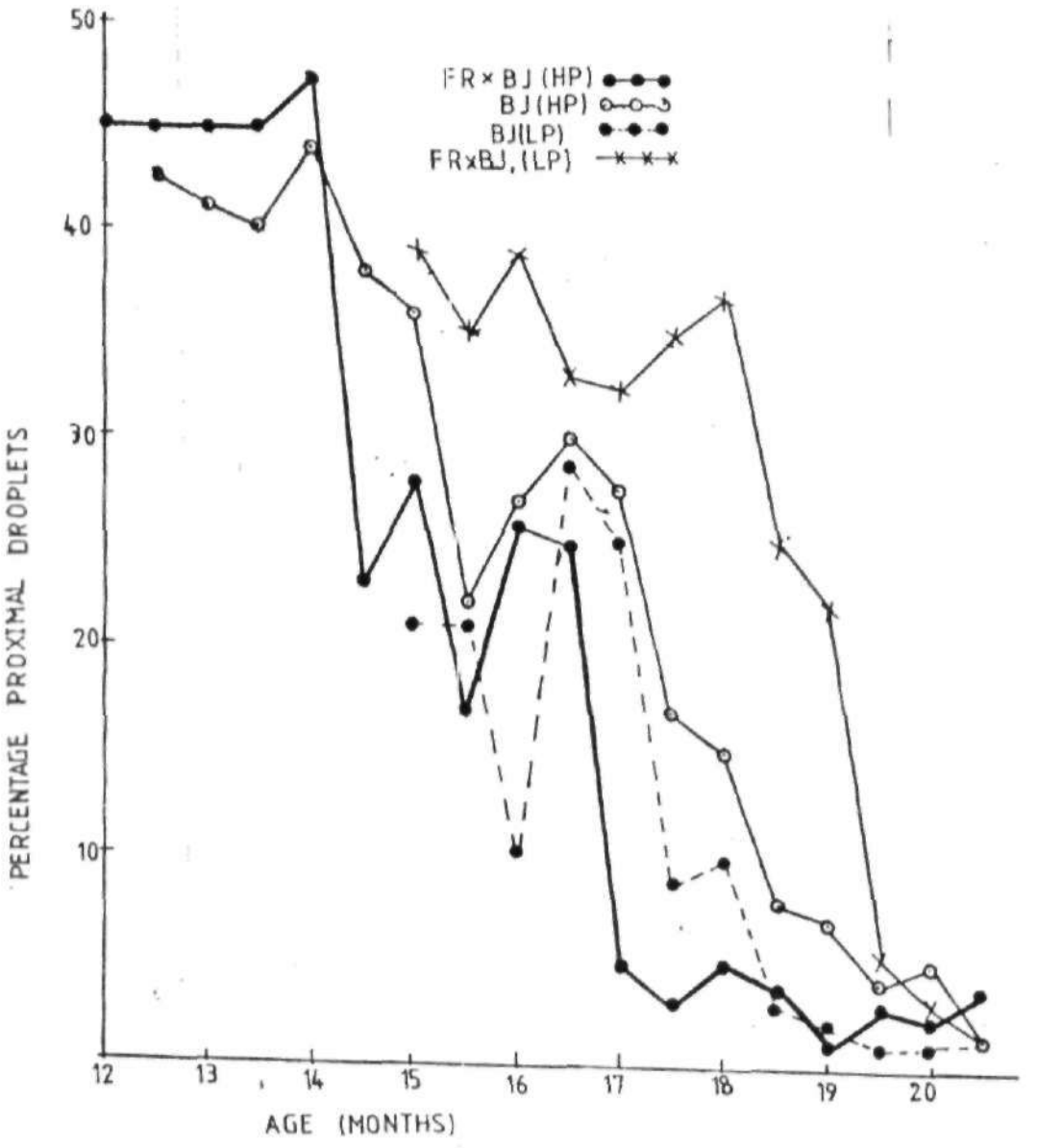
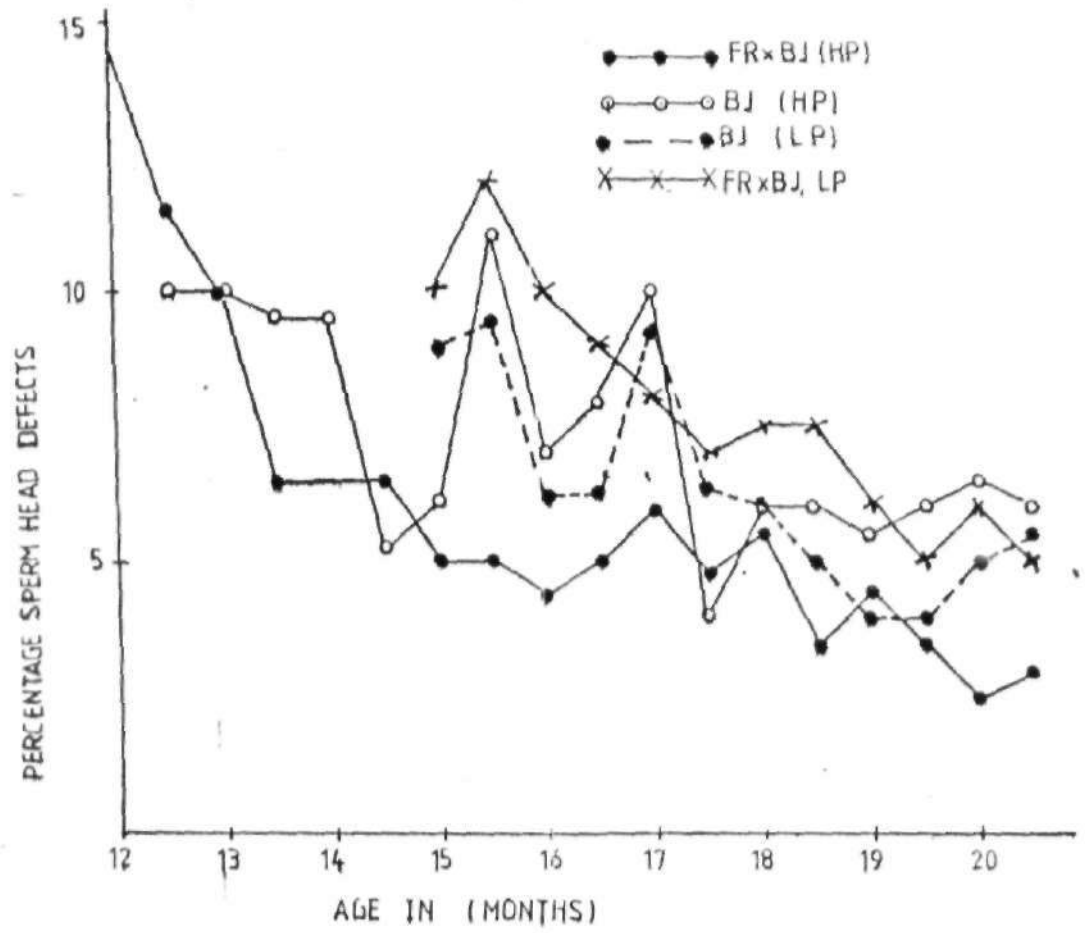


FIG. 3.6

PERCENTAGE SPERM HEAD DEFECTS OF FR×BJ BULLS ON TWO LEVELS OF PROTEIN DIETS



CHAPTER FOUR

EFFECTS OF TWO LEVELS OF PROTEIN INTAKE ON THE HAEMATOLOGY OF BUNAJI AND FRIESIAN x BUNAJI (CROSSBRED) BULLS

4.1. INTRODUCTION

Haematologic parameters can provide useful information on the health status, etiology and pathogenesis of low reproductive function of Zebu cattle indigenous to tropical Africa (Saror and Coles, 1973a,b,c). This may be due to a combination of one or more of environmental, genetic, physiologic and nutritional influences, whose effects may be expressed in the blood picture (Roubicek et al., 1968). Poor growth rate is brought about by limitation in dietary intake of a particular nutrient which may affect the blood chemistry (Payne et al., 1970). Rowland and Manston (1976) established normal values of blood chemistry for dairy cattle and identified some potential uses of blood parameters.

An association between nutrition, blood profile and infertility has been reported (Greig and Boyne 1956; Coles, 1967; Hewett, 1974a,b). Correlations between blood components and rate of weight gain have been reported (Schultze, 1955; McDonald et al., 1960; Stufflebeam et al., 1969). It has also been reported that haemoglobin and packed cell volume are influenced by feeding levels and improved management practices (Saror and Coles, 1975; Oyedipe, 1981). Whether these variations are large enough to influence the reproductive performance (early attainment of puberty) of Bunaji and Friesian x Bunaji bulls-calves indigenous to the tropics, has not been fully investigated. The present work was undertaken to:

evaluate the influence of different levels of nutrition on haemotologic parameters of Bunaji and Friesian x Bunaji bull calves.

4.2. MATERIALS AND METHODS

4.2.1. Animals and Nutrition

This has been described as in Chapter 2 and 3.

4.2.2. Blood collection and analysis

Before commencement of study, blood, faecal and serum samples were screened for possible diseases and effective vaccination and treatment were done accordingly, Blood samples were collected from individual animals one month before commencement of study, at the beginning of study, and then twice a month till the end of the study. The blood samples were collected via jugular vein puncture into tubes containing disodium salt of ethylene diaminetetraacetic acid (EDTA) as an anti-coagulant.

Haemoglobin (Hb), packed cell volume (PCV), red blood cells (RBC), white blood cells (WBC) and differential white blood cell count were determined using routine laboratory procedures (Coles, 1967; Saror and Coles, 1973).

4.2.3. Statistical Analysis

A statistical package (Nie et al., 1975), comprising analysis of variance (ANOVA), Schieffe multiple range test was used to test for differences in the blood parameters between the four treatment groups. Correlation analysis (Steel and Torrie, 1960; Nie et al., 1975) were done within groups to check the relationships between different parameters. The influence of ration, breed and age on all blood parameter was analysed by standard ANOVA procedures (Steel and Torrie, 1960).

4.3 RESULTS

Results on mean blood values are presented in Tables 4.1 and 4.2. Monthly serial sampling are presented in Tables 4.3 to 4.12.

4.3.1. Packed cell volume

Bulls on high plane of nutrition had significantly higher PCV values than those on low plane (P(0.001). Mean PCV values for FRxBJ on low and high planes were 28.86 ± 2.12% and 37.21 ± 1.90% respectively, while PCV for Bunaji on low and high planes were 32.33 ± 1.58 and 35.96 ± 1.93% respectively.

4.3.2. Haemoglobin

The influence of ration and age on haemoglobin values were highly significant (P(0.001). Bulls on high planes had significantly higher haemoglobin values than those on low plane (P(0.05). Mean haemoglobin values (gm/dl) for FRxBJ on low and high planes were 10.08 ± 1.00 and 11.69 ± 0.71 respectively while values for Bunaji on low and high planes were 10.06 ± 0.56 and 12.07 ± 0.64 respectively.

4.3.3. Total Protein

Ration and age had significant influence on total protein (P(0.001); while breed had no significant influence. Animals on high protein diets had significantly higher total protein than animals on low protein (P(0.001). Mean total protein (gm/dl) for FRxBJ on low and high protein diets were 6.97 ± 0.43 and 7.60 ± 0.38 respectively while values for Bunaji on low and high protein diets were 7.14 ± 0.33 and 7.60 ± 0.37 respectively.

4.3.4. Red blood cell

Bulls on high plane had significantly higher RBC values than animals on low plane with no significant breed differences. Mean RBC values ($x10^6$/ml) for FRxBJ on low and high planes were 5.10 ± 0.57 and 6.43 ± 0.58 respectively, while values for Bunaji on low and high planes were 5.54 ± 0.48 and 6.84 ± 0.51 respectively.

4.3.5 White blood cell

The influence of breed, age and ration on total white blood cell count were highly significant (P<0.01). Mean total WBC values ($x10^3$/ml) for animals on high plane (FRxBJ, 11.04 ± 0.93 and BJ, 12.94 ± 0.95) had significantly high total WBC values than animals on low plane (FRxBJ, 10.67± 1.28 and BJ, 11.25 ± 0.95).

4.3.6 White blood cell differential count

The influence of breed, ration on WBC differential count are presented on Table 4.2. Breed and age had highly significant effects on neutrophils, lymphocytes, eosinophils, monocytes, basophils (P<0.01). Ration had no significant effect on WBC differential count . Mean neutrophil values for FRxBJ on low and high planes were 31.00 ± 2.98% and 30.58 ± 2.71% respectively, and were significantly (P<0.01) lower than the values for Bunaji on low plane (32.09 ± 2.27%) and high plane (32.30 ± 2.60%). FRxBJ bull-calves had significantly higher lymphocyte count than Bunaji bull-calves (P<0.001). Mean lymphocyte count for FRxBJ on low and high planes were 61.92 ± 2.91% and 61.90 ± 3.04% respectively, while values for Bunaji on low and high planes were 58.58 ± 2.57 and 59.17 ± 2.54% respectively.

Age effect on lymphocyte count was highly significant (P(0.001), with variations at different sampling periods. Generally, the Bunaji had higher percentage eosinophils than the FRxBJ bull-calves (P(0.01). Age and ration had no significant effect on eosinophils (P)0.1). Mean eosinophils on low and high planes for FRxBJ were 4.70 ± 1.36% and 5.16 ± 1.64% respectively and for Bunaji bulls the values were 6.58 ± 1.86% and 5.49 ± 1.53% respectively.

The Bunaji bulls had significantly (P(0.01) higher monocyte value than FRxBJ animals. Mean monocyte values for FRxBJ on low and high planes were 1.99 ± 0.68% and 1.95 ± 0.64% respectively and for Bunaji the values were 2.48 ± 0.88% and 2.33 ± 0.68% for low and high planes respectively. Age had significant influence on monocyte values (P(0.001) with inconsistent variation at different sampling periods.

The Bunaji bull-calves on low and high protein diets had significantly higher basophils values thnn FRxBJ on similar levels of nutrition. Age also had significant influence on basophil values with varying values throughout the period of study. Ration effects were not significant (P)0.1). Mean basophil values for FRxBJ on low and high planes were 0.15 ± 0.18% and 0.16 ± 0.19% respectively, while Bunaji on low and high planes were 0.33 ± 0. 30% and 0.22 ± 0.20% respectively.

4.3.7. Relationship between haematologic parameters

PCV was significantly (P(0.01) correlated to haemoglobin, red blood cell and total protein for the four treatment groups (Appendices 4.3-4.6). Haemoglobin was also significantly correlated to red blood cell and total protein (P(0.01) for all the groups.

Correlations between PCV, haemoglobin, red blood cell and white blood cell were found to be consistent among the treatment groups. Significant positive correlations (P(0.01) were found between, packed cell volume, haemoglobin, red blood cell and total plasma protein.

There were significant negative correlations among the components of differential blood count (P(C.01).

4.4. DISCUSSION

The values for blood parameters in this study are within the normal range reported for temperate breeds (Schalms, 1965; Coles, 1967), tropical breeds (Saror and Coles, 1973a,b). The haematologic data obtained in this study are in agreement with the reduced haemoglobin, red blood cell, hematocrit and serum protein values for Hereford and Zebu cows when placed on different levels of protein (Bedrak et al., 1956; Oyedipe et al., 1984). The significantly higher values of packed cell volume, red blood cell, haemoglobin, white blood cell and total plasma protein recorded for animals on high protein diets in this study are in accord with those of Hewett (1974), Oyedipe et al. (1984). These workers observed that haemoglobin and PCV were influenced by feeding levels. The higher PCV, Hb, red blood cell, white blood cells and total protein values for high protein diet in this study are in agreement with observations by Saror and Coles (1973a,b, 1975) who have indicated that haemoglobin and packed cell volume were lower in nomadic Zebu cattle than those under improved management husbandry practices. The results indicate that there were significant breed differences in PCV, RBC, WBC, Hb and total protein values. These findings are similar to the works of Saror and Coles (1973a,b; 1975) who reported that nomadic Zebu

cattle had consistently lower PCV, Hb, values than FRxBJ and BJ cattle managed in institutional and Government farms. The authors explained these differences to be due to nutrition and husbandry practice.

The effect of ration on white blood cell differential count was insignificant. Breed had a significant influence on neutrophil, lymphocyte, eosinophil, monocyte and basophil counts. The BJ bulls had significantly higher neutrophils, eosinophil, monocyte and basophil values than FRxBJ bulls. The only exception was lymphocyte count, in which FRxBJ had higher values.

Significant correlations between haematologic parameters existed for packed cell volume, haemoglobin, plasma total proteins and red blood cell for all the four treatment groups. This latter observation tends to confirm that level of protein intake is closely associated with PCV, Hb, total protein and RBC (Oyedipe et al., 1984).

It can be concluded that values for PCV and Hb, total protein obtained under field conditions may serve to monitor the nutritional status of our indigenous animals. This monitoring of blood values and total serum proteins under different nutritional levels may provide a useful tool in setting out criteria for evaluating the production potentials of our livestock, particularly under field conditions.

Table 4.1: Means ±s.e.m. of some blood parameters of FRxBJ and BJ bull-calves on two level of protein diets.

Breed	Ration	Packed cell volume (PCV) (%)	Haemoglobin (Hb) g/100ml	Red blood cell (RBC) x10^6/ml	White blood cell (WBC) x10^3/ml	Total Protein
FRxBJ	Low Protein	28.86±2.12^{a}	10.08±1.00^{a}	5.80±0.11^{ab}	10.67±1.28^{b}	6.97±0.43^{a}
FRxBJ	High Protein	37.21±1.90^{d}	11.69±0.71^{b}	6.43±0.11^{c}	11.04±0.97^{b}	7.60±0.38^{b}
BJ	Low Protein	32.33±1.58^{b}	10.06±0.56^{a}	5.86±1.69^{a}	11.25±0.95^{b}	7.14±0.33^{a}
BJ	High Protein	35.96±1.93^{c}	12.07±0.64^{b}	6.04±0.10^{b}	12.94±0.95^{a}	7.60± .37^{b}

a,b,c,d Data within columns with different superscripts are significantly different (P<0.05).

Table 4.2: Means ±s.e.m. of White blood cell differential count of Bunaji and Friesian x Bunaji bulls on two level of protein diet

Breed	Ration	Neutrophils (%)	Lymphocyte (%)	Eosinophils (%)	Monocytes (%)	Basophils (%)
FRxBJ	Low Protein	30.00±2.98	61.92±2.91	4.70±1.36	1.99±0.68	0.15±0.18
FRxBJ	High Protein	30.58±2.71	61.90±3.04	5.16±1.64	1.95±0.64	0.16±0.19
BJ	Low Protein	32.09±2.27[a]	58.58±2.57[a]	6.58±1.86[b]	2.48±0.83	0.33±0.30
BJ	High Protein	32.30±2.60[a]	57.07±2.54[a]	5.49±1.53[a]	2.33±0.68	0.21±0.20

[a,b]Data within columns with different superscripts are significantly different (P(0.05).

Table 4.3: Means ± s.e.m. of percentage packed cell volume (PCV) of FRxBJ and BJ bulls on two levels of protein diets.

Age (months)	Bunaji		Friesian x Bunaji	
	LP	HP	LP	HP
6	29.25±1.54	30.59±1.26	29.45±1.05	33.54±1.70^{a}
7	31.70±0.95^{a}	35.58±1.83^{a}	29.55±1.83^{a}	37.77±1.43^{c}
8	33.75±0.89^{a}	37.00±1.33^{c}	30.45±1.32^{b}	39.73±1.09^{d}
9	34.20±1.57^{b}	39.59±1.01^{d}	30.78±1.39^{a}	37.60±1.64^{c}
10	33.35±0.73^{b}	34.68±0.97^{b}	28.25±1.74^{a}	38.72±1.16^{d}
11	35.70±1.17^{b}	39.59±1.26^{c}	28.88±1.25^{a}	36.50±1.39^{b}
12	31.35±0.77^{b}	36.57±1.42^{c}	28.69±1.76^{a}	35.72±0.80^{c}
13	32.55±0.94^{b}	37.18±1.07^{c}	28.00±1.55^{a}	36.50±0.86^{c}
14	33.00±1.14^{b}	37.68±1.43^{c}	27.50±1.55^{a}	36.56±0.61^{c}
15	30.90±1.10^{a}	35.00±0.79^{b}	28.86±1.04^{a}	34.53±1.02^{b}
16	30.30±1.13^{a}	37.86±1.24^{b}	28.56±1.20^{a}	42.33±1.31^{c}
17	32.70±1.12^{b}	35.23±1.24^{c}	30.43±1.18^{a}	35.81±1.34^{c}
18	31.50±1.11	29.54±1.41	28.79±1.54	35.44±1.07^{b}
19	31.55±0.92^{ab}	32.14±1.86^{b}	28.93±1.78^{a}	37.53±1.06^{c}
20	31.90±1.19^{a}	38.64±2.04^{b}	29.71±2.44^{a}	41.63±2.00^{c}

^{a,b,c,d}Data in rows with different letter superscripts are significantly different ($P<0.05$).

Table 4.4: Means ± s.e.m. of haemoglobin (gm/100ml) and BJ bulls on two protein diets.

Age (months)	Bunaji		Friesian x Bunaji	
	LP	HP	LP	HP
6	10.24±0.39^{a}	12.11±0.39^{b}	12.03±0.80^{b}	10.01±0.56^{a}
7	10.94±0.29	11.70±0.37	12.06±0.78	12.20±0.43
8	11.74±0.30	12.51±0.45	9.94±0.67	12.66±0.34
9	11.82±0.54	12.89±0.38	10.62±0.64^{a}	12.36±0.58
10	12.09±0.35	11.87±0.33	8.79±0.73^{a}	12.60±0.43
11	11.29±0.28	12.56±0.49	9.94±0.52^{a}	12.00±0.62
12	10.69±0.31^{b}	12.30±0.59^{c}	8.81±0.47^{a}	11.20±0.21^{b}
13	10.99±0.35^{ab}	12.09±0.41^{c}	9.55±0.54^{a}	11.89±0.44^{b}
14	10.79±0.33	11.05±0.30	9.55±0.61^{a}	12.02±0.30^{b}
15	11.39±0.35	11.73±0.38	9.34±0.51^{a}	12.40±0.39^{b}
16	10.72±0.36	11.62±0.40	8.16±0.56^{a}	10.05±0.54^{b}
17	11.60±0.37	12.45±0.30	11.26±0.67	12.65±0.38
18	10.03±0.44^{a}	12.01±0.57^{b}	9.73±0.49^{a}	10.85±0.46^{a}
19	10.84±0.24^{a}	12.10±0.80^{b}	9.47±0.65^{a}	10.88±0.49^{a}
20	10.16±0.66^{a}	12.11±0.81^{c}	11.46±1.23^{b}	10.81±0.84^{a}

^{a,b,c,d}Data in rows with different superscripts are significantly different ($P<0.05$).

Table 4.5: Means ± s.e.m. of FBC ($x10^6$/ml) of FRxBJ and BJ bulls on two protein diets.

Age (months)	Bunaji		Friesian x Bunaji	
	LP	HP	LP	HP
6	5.19±0.38^{a}	5.62±0.38^{b}	6.13±0.29^{c}	6.77±0.33^{d}
7	5.47±0.38^{ab}	5.09±0.22^{a}	5.10±0.36^{a}	5.79±0.33^{b}
8	5.59±0.28	5.60±0.34	6.01±0.33^{a}	7.03±0.32^{a}
9	5.98±0.36^{a}	6.34±0.41^{b}	5.82±0.41^{a}	6.23±0.47^{b}
10	7.76±0.37^{c}	6.12±0.35^{a}	6.00±0.42^{a}	7.20±0.38^{b}
11	5.66±0.34^{a}	6.65±0.35^{b}	7.93±0.42^{c}	7.53±0.38^{c}
12	6.06±0.34^{a}	6.77±0.46^{b}	5.52±0.36^{a}	7.11±0.35^{c}
13	5.89±0.32^{a}	6.34±0.35^{b}	6.29±0.38^{b}	6.88±0.39^{c}
14	5.71±0.27^{a}	6.68±0.32^{b}	5.82±0.36^{a}	6.69±0.32^{b}
15	5.74±0.35^{a}	6.31±0.23^{b}	6.06±0.40^{b}	6.69±0.36^{c}
16	4.02±0.37^{a}	6.72±0.35^{b}	6.51±0.37^{b}	5.45±0.43^{b}
17	4.96±0.41^{a}	6.26±0.30^{c}	5.12±0.33^{b}	6.66±0.50^{c}
18	5.23±0.26^{b}	5.75±0.35^{c}	6.04±0.31^{d}	4.04±0.30^{a}
19	5.50±0.22^{c}	4.95±0.31^{b}	3.85±6.23^{a}	4.83±0.42^{b}
20	5.44±0.47	5.19±0.49	5.66±0.97	5.36±0.31

^{a,b,c,d}Data in rows with different superscripts are significantly different (P(0.05).

Table 4.6: Mean ± s.e.m. of WBC (10^3/ml) of FRxBJ and BJ bulls on two protein diets.

Age (months)	Bunaji		Friesian x Bunaji	
	LP	HP	LP	HP
6	9.90±0.52^{b}	10.64±0.63^{c}	9.74±0.04^{b}	8.27±0.82^{a}
7	13.70±1.30^{c}	12.65±0.76^{b}	12.12±1.02^{b}	11.24±0.58^{a}
8	10.37±0.38^{a}	11.55±0.63^{b}	10.47±0.46^{a}	11.10±0.43^{ab}
9	9.93±0.54^{a}	11.47±0.57^{b}	10.48±1.13^{a}	12.96±0.66^{c}
10	10.76±0.43	11.56±0.79	11.27±0.96	11.34±0.58
11	10.37±0.35	12.05±0.56^{a}	10.60±0.41	10.54±0.46
12	11.50±0.62	14.27±0.81	10.13±0.31	10.86±0.58
13	12.53±0.90	12.25±0.60	10.08±0.52	10.98±0.49
14	10.68±0.39^{a}	11.20±0.43^{b}	10.16±0.72^{a}	11.03±0.54^{b}
15	11.88±0.67	11.81±0.86	11.08±0.90	10.96±0.41
16	11.11±0.55	10.82±0.66	8.11±1.80^{a}	9.31±0.79^{b}
17	11.92±0.80	11.71±0.50	9.11±1.08	11.90±0.70
18	12.18±0.53	12.65±0.68	9.77±1.09^{a}	12.14±0.56^{b}
19	12.57±0.31	11.90±0.61	13.31±0.85^{a}	11.74±1.02
20	9.27±0.56^{a}	12.85±1.02^{c}	16.53±1.82^{d}	12.19±0.89^{b}

^{a,b,c,d}Data in rows with different letter superscripts are significantly different ($P<0.05$).

Table 4.7: Means ± s.e.m. of % total protein of FRxBJ and BJ bulls on two levels of protein diet.

Age (months)	Bunaji		Friesian x Bunaji	
	LP	HP	LP	HP
6	6.89±0.20	7.96±0.24^{a}	7.10±0.19	7.09±0.15
7	7.86±0.33^{c}	8.75±0.16^{d}	6.85±0.35^{a}	7.33±0.17^{b}
8	7.60±0.23^{a}	8.18±0.23^{c}	6.81±0.16^{a}	7.17±0.17^{b}
9	7.37±0.24^{a}	8.05±0.31^{b}	7.27±0.23^{a}	7.78±0.23^{b}
10	7.15±0.24^{a}	7.50±0.17^{b}	7.31±0.26^{ab}	7.16±0.18^{ab}
11	7.05±0.15	5.58±0.25^{a}	7.33±0.41	7.26±0.32
12	7.35±0.09	7.17±0.31	7.36±0.36	8.52±0.21
13	7.44±0.17^{a}	7.96±0.21^{b}	7.54±0.11^{a}	8.84±0.18^{c}
14	7.34±0.20^{a}	7.99±0.32^{b}	7.06±0.21^{a}	8.35±0.34^{c}
15	6.81±0.18^{a}	7.72±0.24^{b}	7.07±0.16^{a}	8.44±0.30^{c}
16	6.75±0.13	7.20±0.33	6.24±0.47	7.02±0.17
17	6.93±0.23	6.90±0.07	5.61±0.38^{a}	7.44±0.27
18	6.17±0.24	6.82±0.09	6.42±0.48	7.75±0.29^{a}
19	6.69±0.21	7.03±0.17	7.19±0.13	6.69±0.14
20	7.65±0.31	6.79±0.30	7.60±0.40	6.89±0.32

^{a,b,c,d}Data in rows with different superscripts are significantly different (P(0.05).

Table 4.8: Means ± s.e.m. percentage neutrophils of FRxBJ and BJ bulls on two protein diets.

Age (months)	Bunaji		Friesian x Bunaji	
	LP	HP	LP	HP
6	33.20±1.48[a]	27.00±1.42	28.60±1.30	28.86±1.24
7	32.20±1.58[c]	34.00±2.07[c]	26.65±1.70[a]	29.95±2.15[b]
8	28.90±1.80[a]	31.36±1.51[b]	29.70±1.36[ab]	30.59±1.44[ab]
9	31.90±1.78	32.68±1.52	28.61±2.07	29.20±1.51
10	30.60±1.99[a]	36.77±2.06[b]	35.06±2.67[b]	31.28±1.91[a]
11	30.80±1.72	33.27±1.91[a]	29.63±1.44	31.17±2.21
12	27.45±1.47	28.43±1.37	34.43±2.21[a]	29.22±2.32
13	32.80±1.43	31.00±1.41	34.50±2.02[a]	30.89±1.61
14	32.50±1.35[a]	28.00±1.32	29.00±2.06	28.00±1.73
15	34.90±1.38[c]	31.23±1.59[b]	27.71±2.12	29.12±1.69[ab]
16	37.20±2.14[a]	32.90±1.47	32.71±2.50	31.13±2.38
17	34.40±1.51	37.00±1.94[a]	33.36±2.94	32.13±2.31
18	30.70±1.74[a]	33.73±1.78[b]	36.36±1.56[c]	35.75±2.22[c]
19	31.65±1.29[a]	35.43±2.63[b]	31.29±2.41[a]	33.41±1.97[b]
20	37.20±1.65[a]	31.82±3.38	27.57±1.30	28.25±2.67

[a,b,c,d] Data in rows with different superscripts are significantly different (P<0.05).

Table 4.9: Means ± s.e.m. of percentage lymphocytes of FRxBJ and BJ bulls on two protein diets.

عمر (months)	Bunaji		Friesian x Bunaji	
	LP	HP	LP	HP
6	55.00±2.24[a]	61.86±1.71	62.90±1.06	62.00±1.46
7	60.60±1.41	59.22±1.90	65.95±2.00[a]	62.18±2.35
8	63.45±1.64[ab]	62.59±1.70[a]	64.70±1.60[b]	61.73±1.83[a]
9	58.95±1.65	59.55±1.53	60.11±1.86	60.15±2.04
10	61.05±2.14	56.04±2.06[a]	58.69±2.04	63.72±1.58
11	60.60±1.50	60.32±2.08	64.88±2.78[a]	61.00±2.67
12	58.10±2.20	59.26±2.02	57.13±2.19	60.89±2.36[a]
13	54.95±1.57[a]	59.64±1.74[b]	58.44±2.35[b]	56.94±2.03[ab]
14	61.05±1.25	61.36±1.54	65.38±1.74[a]	67.39±1.84[a]
15	60.15±1.32	62.45±1.38	66.86±2.21[a]	64.59±2.01[a]
16	57.30±2.25	61.73±1.49	58.71±2.90	62.06±2.78
17	62.20±1.72	58.05±2.01	60.36±2.52	60.56±2.63
18	54.60±2.28[a]	59.09±1.81	59.71±1.28	60.75±1.95
19	52.15±1.01[a]	57.62±2.09	60.92±1.73	60.29±1.64
20	57.30±1.53[c]	61.54±1.89[a]	65.43±1.41[b]	65.25±3.75[b]

[a,b,c,d] Data in rows with different superscripts are significantly different (P<0.05).

Table 4.10: Means ± s.e.m. of percentage eosinophils for FRxBJ and BJ on two levels of protein diet.

Age (months)	Bunaji		Friesian x Bunaji	
	LP	HP	LP	HP
6	8.60±1.81[a]	8.41±1.04[a]	5.45±0.61	5.36±0.83
7	5.15±0.70	5.04±0.96	5.05±0.73	4.50±0.80
8	5.70±1.09	5.14±0.92	3.90±0.50[a]	5.23±0.62
9	6.05±0.77[a]	5.91±0.93[a]	7.39±1.10[b]	7.15±1.08[b]
10	5.45±1.28	5.09±0.61	4.63±1.04[b]	3.56±0.97[a]
11	7.25±1.00[c]	1.95±0.86[b]	3.88±1.94[a]	6.44±2.03[d]
12	10.90±1.82	9.61±1.14	4.06±1.00[a]	5.72±1.15[b]
13	7.00±1.01	5.55±0.89[b]	3.81±1.04[a]	9.00±1.47[d]
14	5.30±1.25[b]	8.41±1.59[c]	3.88±0.78[a]	3.22±0.60[a]
15	3.25±0.48[a]	4.59±1.28[b]	3.71±0.62[a]	4.66±0.85[b]
16	4.30±1.40	3.45±0.68	3.50±1.71	5.93±1.26
17	2.50±0.73[a]	3.68±0.70[b]	4.93±1.00[c]	5.75±1.87[d]
18	10.65±1.94[c]	5.27±1.10[b]	3.50±1.00[a]	2.44±0.58[a]
19	10.35±1.09[a]	3.95±1.17	4.64±0.96	3.94±0.85
20	3.70±0.76[ab]	6.45±1.96[c]	4.00±0.81[b]	2.75±0.90[a]

[a,b,c,d] Data in rows with superscripts are significantly different (P(0.05).

Table 4.11: Means ± s.e.m. of percentage monocytes for BJ and FRxBJ bulls on two levels of protein diet.

Age (months)	Bunaji		Friesian x Bunaji	
	LP	HP	LP	HP
6	2.95±0.51	3.23±0.38	2.65±0.41	3.23±0.45
7	2.70±0.45	2.14±0.44	2.10±0.40	2.00±0.39
8	1.85±0.41	1.64±0.36	2.10±0.39	2.00±0.25
9	2.40±0.60	2.64±0.71	3.44±0.60	2.30±0.45
10	2.30±0.45	1.73±0.30	1.75±0.38	1.67±0.34
11	1.25±0.34	0.86±0.22	0.88±0.58	1.11±0.32
12	2.30±0.62	2.91±0.54	2.88±0.72	3.06±0.64
13	4.80±0.71	3.77±0.64	3.06±0.58	3.06±0.51
14	0.95±0.28	1.54±0.28	1.69±0.41	1.28±0.31
15	1.55±0.31	1.77±0.43	1.74±0.42	1.38±0.28
16	0.33±0.21	1.86±0.61	1.29±0.32	0.80±0.26
17	0.77±0.25	1.36±0.31	0.93±0.30	1.50±0.45
18	3.45±0.68[a]	1.64±0.47	0.43±0.17	1.06±0.39
19	5.40±0.54[a]	2.62±0.48	1.07±0.24	1.82±0.55
20	1.70±0.54	2.27±0.65	2.71±0.56	2.50±0.90

[a,b,c,d] Data in rows with different superscripts are significantly different (P(0.05).

Table 4.12: Means ± s.e.m. of percentage basophils of BJ and FRxBJ bulls on two levels of protein diet.

Age (months)	Bunaji		Friesian x Bunaji	
	LP	HP	LP	HP
6	0.40±0.15	0.55±0.16	0.25±0.12	0.90±0.06
7	0.05±0.05	0.05±0.05	0.60±0.24	0.55±0.30
8	0.40±0.30	0.27±0.13	0.30±0.13	0.32±0.13
9	0.65±0.16	0.23±0.11	0.05±0.06	0.20±0.12
10	0.80±0.27	0.91±0.36	0.06±0.06	0.06±0.06
11	0.25±0.12	0.27±0.11	0±0	0.28±0.14
12	0.10±0.05	0±0	0±0	0±0
13	0.05±0.05	0.05±0.04	0.19±0.14	0.11±0.08
14	0.10±0.10	0±0	0.13±0.13	0±0
15	0.25±0.17	0.09±0.09	0±0	0±0
16	0±0	0.05±0.04	0.07±0.07	0.33±0.23
17	0.35±0.17	0±0	0.07±0.07	0.06±0.06
18	0.30±0.15	0.09±0.09	0±0	0±0
19	0.90±0.55	0.38±0.14	0.14±0.14	0.18±0.12
20	0±0	0.27±0.20	0±0	0±0

Data in rows with no superscripts are not significantly different (P(0.05).

The results in this study indicate that bulls on high protein diet attained puberty at significantly earlier ages than those on low protein diet. This finding is in agreement with reports in bulls (Joubert, 1954; Barber and Almquist, 1975) and more recently in heifers (Oyedipe, 1981) who have reported delayed puberty and retarded development when animals were placed on low plane of nutrition. The FRxBJ bulls reached puberty earlier than BJ when placed on high protein and the reverse was observed when the bulls were fed on low level of crude protein. This observation could be partly due to certain genetic traits inherent in the exotic breeds of bulls.

The observed pubertal parameters between 9 and 18 months in this work is in accord and within the range reported by Igboeli and Rakha (1971), Fields et al. (1982), Wildeus and Entwistle(1982), Wildeus et al. (1984). These workers have highlighted the delayed puberty and slower rate of sexual maturation of Bos indicus breeds. It is known for example that the indigenous cattle are more resistant to tropical environmental conditions of which nutrition is part.

Average daily gains were significantly higher for FRxBJ than BJ on both the low and high protein diets, indicating the slower growth rate and sexual development of Bos indicus breeds. The lighter body weights obtained at first ejaculated sperm and at puberty by animals on high protein diets as compared to those on low protein is in accord with the work of Dufour (1975) who showed that fast growing heifers were younger and lighter at puberty than moderately growing heifers. The finding on chest girth is in accord with the work of Oyedipe et al. (1981) who reported that chest girth for Zebu bulls and their crosses were not different at puberty.

Body condition score of animals on higher protein diet were significantly higher than for those on low protein diet without any breed differences. Significant association between plane of nutrition and condition score has been reported (Elliot and Topps, 1963; Alkass and Bryant, 1982). The latter indicated that body condition in reproduction has application in ensuring improvement in fertility.

FRxBJ bulls on high protein diet attained puberty at significantly smaller scrotal circumference than those on low protein diet, but this was not true for the Bunaji bulls. The FRxBJ had significantly larger scrotal circumference than Bunaji at both first appearance of spermatozoa and at puberty. This latter finding contradicts findings by Oyedipe et al. (1981) who reported non-significant differences in scrotal circumference for Zebu bulls and their crosses at puberty. However, this latter study (Oyedipe et al., 1981) examined bulls under routine management conditions. The mean scrotal measurement of 22.5 cm at puberty obtained in this study compares very well with the 21.5 cm and 24.5 cm circumference at puberty for Bos indicus bulls as reported by Oyedipe et al. (1981) and Wildeus et al. (1984) respectively.

The influence of age on withers height and chest girth indicates that there was an increase in these parameters with age. Withers height for the Bunaji on high protein did not differ significantly from those of low protein while withers height for the FRxBJ on high protein were significantly higher than those on low protein. The FRxBJ had higher withers height than BJ. The FRxBJ bulls on high protein diet had significantly larger chest girth than any of the other treatment groups. The animals on high protein diet had significantly heavier body weights, higher growth rates than animals on low protein. The FRxBJ were significantly better in terms of growth rate and body weight than the Bunaji..

Results in the present study indicate that age, breed and ration had significant influences on scrotal growth. Animals on high protein had significantly larger scrotal circumference than those on low protein diets. This finding is in accord with the works of Wilsey (1972), Pruitt (1983), Coulter and Kozub (1984) who have reported greater scrotal circumference in young bulls fed high energy diets.

Bulls on high protein diets had significantly higher volume of semen than those on low protein diets. Volume of semen also tended to increase with age. These findings agree with the report of VanDemark and Mauger (1964) who reported that volume of semen of underfed bulls was 65% to 75% of the control bulls. Barber and Almquist (1975) also reported significant increase in volume of semen with age. The significant higher percentage motility for animals on high protein diets than those on low protein diets and also the increased sperm motility with age is in agreement with reports by many workers (Flipse and Almquist, 1960; VanDemark and Mauger, 1964).

Sperm concentration and total spermatozoa were significantly higher for bulls on high protein diets than for those on low protein diet. Sperm output also increased with age. This finding is in agreement with earlier observations by Hahn et al. (1969b), Coulter and Foote (1976), Carter et al. (1980). The low ejaculate characteristics reported for the low protein groups in this study are similar to the findings of VanDemark and Mauger (1964) who reported that bulls on restricted energy diets produced poorer quality semen than those on medium and high energy diets.

The influence of protein intake on sperm defects in this study was non-significant. This finding is in accord with those reported by Sitarz et al. (1977), Coulter and Kozub (1984) who found no effect

of high energy diets on some sperm defects of bulls from weaning to one year of age. Most sperm defects tended to decrease with age, especially proximal droplets. The larger numbers of sperm defects especially proximal droplets are indicative of regenerative processes of the spermatogenic epithelium in young prepubertal bulls.

Packed cell volume (PCV), haemoglobin (Hb), red blood cell (RBC), white blood cell (WBC) and total protein, and indicators of growth were significantly higher for animals on high protein diet than those on low protein diet. The finding is in agreement with the works of Hewett (1974) and Manston et al. (1975), who observed that Hb, PCV were influenced by feeding levels.

The monitoring of blood and total protein values under different nutritional levels may provide a useful tool in setting out criteria for evaluating the production potentials of our livestock particularly under field conditions.

This investigation also demonstrates significant associations between body and scrotal growth and level of protein intake in bull-calves which is desirable for attainment of sexual function. Adequate protein supplementation and good management of the young sire has been shown to be necesaary for early and optimum sperm cell production. Attainment of early puberty by improved protein intake would lead to reduction in time interval between generations which is of genetic advantage in cattle improvement programmes. Adequate protein supplementation should be recommended in any successful cattle management, especially in the tropical regions where marked seasonality of rainfall results in extremely low availability of pasture and herbage conditions. Thus the young sire should be fed and managed adequately so as to bring him into early and optimum production of spermatozoa.

With adequate protein supplementation, age at puberty of the sire can be shortened and such a sire could be used for breeding at an earlier age. This would help to economise the cost of keeping a bull. Crossbreeding of of Friesian with our indigenous cattle has been practised over the years in order to achieve genetic improvement. Growth rate and age at puberty could be influenced by level of nutrition and this could be important in planning of management programmes especially for maximising the reproductive efficiency of Bunaji and their Friesian crossbred bulls.

REFERENCES

Aire, T.A. and Akpokodje, J.U. (1975). Development of puberty in White Fulani (Bos indicus) bulls calf. British Veterinary Journal 131, 146-151.

Alkass, J.E. and Bryant, M.J. (1982). Some effects of level of feeding and body condition upon sperm production and gonadotropin concentrations in the ram Animal Production Journal 34, 265-277.

Almquist, J.O. and Amann, R.P. (1961). Reproductive capacity of dairy bulls. II. Gonadal and extragonadal sperm reserves as determined by direct counts and depletion trials, dimensions and weight of genitalia Journal of Dairy Science 44, 1668-1674.

Almquist, J.O. and Amann, R.P. (1962). Effect of a high ejaculatory frequency on sperm output and semen characteristics of Holstein bulls from puberty to 2 years of age. Journal of Dairy Science 45, 688 (Abst.)

Almquist, J.O. and Barber, K.A. (1974). Pubertal characteristics and early growth of Charolais bulls on high nutrient allowance. Journal of Animal Science 38, 831-834.

Almquist, J.O., Branas, R.J. and Barber, K.A. (1976). Postnatal changes in semen production of Charolais bulls ejaculated at high frequency and the relationship between testicular measurements and sperm output. Journal of Animal Science 42, 670-676.

Almquist, J.O. and Cunningham, D.C. (1967). Reproductive capacity of beef bulls. I. Postnatal changes in semen production of different ejaculation frequencies. Journal of Animal Science 26, 174-178.

Amann, R.P. (1970). Sperm production rates. In: The testis Ed. A.D. Johnson, W.R. Gomes, N.L. VandDemark. Academic Press, N.Y.

Arije, G.F. and Wiltbank, J.N. (1971). Age and weight at puberty in Hereford heifers. Journal of Animal Science 33, 401-406.

Asdell, S.A. (1955). Nutrition and Reproduction. In: Cattle Fertility and Sterility. Ed. Asdell, S.A. 2nd. Ed. Little, Brown and Company Boston, 180-221.

Ashdown, R.R. (1960). Development of penis and sheath in the bull calf. Journal of Agricultural Science 54, 348-352.

Ball, L., Nelson, L.D., Furman, J.W. and Seidel, G.E. (1974). Semen collection and evaluation of bulls for breeding soundness. Presented at the Annual Meeting AVSSBS Columbia Missouri Sept. 6-7.

Bane, A. (1954). Sexual functions of bulls in relation to heredity, rearing intensity and somatic conditions. Acta Agricultural Scandinavica 4 97-208.

Barber, K.A. and Almquist, J.O. (1975). Growth and feed efficiency and their relationship to pubertal traits of Charolais bulls. Journal of Animal Science 40, 288-301.

Bedrak, E., Warnick, A.C., Hentges, J.F., Cunha, T.J. and Feaster, J.P. (1956). The effect of varying protein intake on reproduction, blood composition and weight changes of beef heifers. Journal of Animal Science 15, 1283 (Abst.).

Berry, JG., Brinks, J.S and Russell, W.C. (1983). Relationship of seminal vesicle size and measures of libido in yearly beef bulls. Theriogenology 19, 279-285

Blocky, M.A. (1975). Studies on social and sexual behaviour of bulls. Ph.D. Thesis, University of Melbourne Victoria Island, Australia.

Blom, E. (1959). A rare sperm abnormality, "Corkscrew sperm" associated with sterility in bulls. Nature 183, 1280-1281.

Blom, E. (1966). A new sterilizing and hereditary defect, the "Dag defect" located in the bull sperm tail. Nature (London) 209, 739-740.

Blom, E. (1973). The ultrastructure of some characteristic sperm defects and a proposal for a new classification of bull spermiogram. Proceedings 7th Simposio Internazionale di Zootechnia Milan pp 9-12.

Blom, E. and Birch-Aderson (1968). The ultrastructure of the "pseudo droplet" defect in the bull sperm. 6th International Congress Animal Reproduction and Artificial Insemination 1, 117-119. Paris.

Bongso, T.A., Hassan, M.D. and Nordi, W. (1984). Relationship of scrotal circumference and testicular volume to age and body weight in the Swampo Buffalo (Babalus bubalis) Theriogenology 22, No.2, 513-524.

Bongso, T.A., Jainudeen, M.A. and Zahrah, S. (1982). Relationship of scrotal circumference to age, body weight and spermatogenesis in goats. Theriogenology, 18: 513-524.

Bratton, R.W., Hisgrave, S.D., Dunn, H.O. and Foote, R.H. (1959). Cause and prevention of reproductive failure in dairy cattle. II. Influence of underfeeding and overfeeding from birth to 60 weeks of age on growth, sexual development and semen production of Holstein bulls. Cornell University Agricultural Station Bulletin 940-941.

Breuer, D.J. (1980). Effects of 140-day feed test on some fertility parameters in beef. Ph.D. Dissertation University of Missouri, Columbia pp 41-48.

Carter, A.P., Wood, P.D.P. and Penelope, A.W. (1980). Association between scrotal circumference, liveweight and sperm output in cattle. Journal of Reproductive Fertility 59: 447-451.

Chenoweth, P.J., Farin, P.W. and Mateos, E.R. (1984). Breeding soundness and sex drive by breed and age in beef bulls used for natural breeding. Theriogenology 22 No.4, 431-349.

Coles, E.H. (1967). Veterinary Clinical Pathology W.B. Saunders, Philadelphia. pp. 8-31.

Coulter, G.H. and Foote, R.H. (1979). Bovine testicular measurements as indicators of reproductive performance and their relationship to productive traits in cattle. Theriogenology 11, 297-311.

Coulter, G.H. and Kozub, G.C. (1984). Testicular development, epididymal sperm reserves and seminal quality in two-year old Hereford and Angus bulls. Effects of two levels of dietary energy. Journal of Animal Science 59 No.2, 432-440.

Coulter, G.H. Larson, L.L. and Foote, R.H. (1975). Effect of age on testicular growth and consistency on Holstein and Angus bulls. Journal of Animal Science 41, 1383-1388.

Dott, H.M. (1975). The estimation of the production of motile bull spermatozoa and a comparison with the proportion eosinophilic in various diluents. Journal of Reproductive Fertility 45, 47-55.

Dott, H.M. and Foster, G.C. (1972). A technique for studying the morphology of mammalian spermatozoa which are eosinophilic in a differential live/dead ratio. Journal of Reproductive fertility 29, 443-446.

Elliot, R.C. and Topps, J.H. (1963). Voluntary intake of low protein diets by sheep. Animal Production Journal 5, 269-274.

Fagerlin, P.T., Carrol, E.J. and Brink, J.S. (1971). Testicular growth and semen traits in beef bulls. Journal of Animal Science, 33 253 (Abstract).

Fasko, J. (1974). Fertility, semen quality, body conformation and reasons for culling of Slovankan bred bulls. Animal Breeding Abstracts 44, 488.

Faulkner, L.C., Hopwood, M.L., Masken, J.F., Kingman, H.E. and Stoddard, H.L. (1967). Scrotal frost bite in bulls Journal of American Veterinary Medical Association 151, 602-605.

Fields, M.J., Burns, W.C. and Warnick, A.C. (1979). Age, season and breed effects on testicular volume and semen traits of young beef bulls. Journal of Animal Science 48, 1299-1304.

Flipse, R.J. and Almquist, J.O. (1960). Effect of total Digestible nutrient intake from birth to four years of age on growth and reproductive development and performance of dairy bulls. Journal of Dairy Science 44, 905-913.

Foote, R.H., Hahn, J. and Larson, L.L. (1970). Testicular measurements as predictors of sperm output and semen quality. Proceedings 3rd Technical Conference on Artificial Insemination and Reproduction p. 31.

Gustafson, B., Grabo, R. and Rao, A.R. (1972). Two cases of bovine epididymal dysfunction. Cornell Veterinary 62(3) 393-402.

Greig, W.A. and Boyne, A.W. (1956). The effect of high and low planes of nutrition in the haematology of Monozygous calves. Journal of Animal Science 47, 150-153.

Hafez, E.S.E. (1980). Physiology of male reproduction In: Reproduction in Farm Animals 4th Ed. Lea and Fabiger Philadelpha.

Hahn, J., Foote, R.H. and Crauch, E.T. (1969a). Tonometer for measuring testicular consistency of bulls to predict semen quality. Journal of Animal Science 29, 483-489.

Hahn, J., Foote, R.H. and Seidel, G.E. (1969b). Testicular growth and related sperm output in dairy bulls. Journal of Animal Science 29, 41-47.

Hancock, J.L. (1955). The disintegration of bull spermatozoa. Veterinary Record: 67, 825-826.

Harasymowycz, J.L., Ball, L. and Seidel, G.E., Jr. (1976). Evaluation of bovine spermatozoa morphological features after staining or fixation. American Journal of Veterinary Research 37, 1053-1057

Hentges, J.F. (1967). Level of feeding and bull performance. In: Factors affecting calf crop. Edited by Cunha, Warnick, Koger, Gainesville University of Florida of Florida Press.

Hewett, C. (1974a). The effect of type and intensity of feeding on blood profile. Acta Veterinaria Scandinavica 50, 113-125.

Hewett, C. (1974b). The relationship between level of fertility and variations in the blood profile. Acta Veterinaria Scandinavica 50, 126-140.

Hultnas, C.A. (1959). Studies on variation in mating behaviour and semen picture in young bulls of Swedish Red and White breed and on causes of this variation. Acta Agricultural Scandinavica Supplementary 6, 1.

Igboeli, G. and Rakha, A.M. (1971). Puberty and related phenomena in Angoni (short horn zebu) bulls. Journal of Animal Science 33, 647-650.

Ivankov, M.F. (1975). Variation in semen quality in relation to age of bulls and haematological parameters Animal Breeding Abstract 44, 532.

James, J.P. (1950). The effect of level of nutrition on the sexual capacity of dairy bulls. Proceedings 10th Annual Conference New Zealand Society Animal Production. pp. 84-88.

Joubert, D.M. (1954). The influence of winter nutritional depression on the growth, reproduction and production of cattle. Journal of Agricultural Science, 44, 5-10.

Kumi-Diaka, J., Nagaratnam, V. and Ruwuan, J. (1981). Seasonal and age related changes in semen quality and testicular morphology of bulls in a tropical environment. Vet. Rec. 137 156-161.

Kunkel, H.O., Green, G., George, R.K., John, S.R.L. and Myrtis, C. (1957). Relationship between serum protein bound iodine and other blood constituents to rates of gain in beef cattle. Journal of Animal Science 16, 1030 (Abstract).

Lagerlof, N. (1934). Morphological studies of changes in the spermiogram and the testes of bulls with lower fertility and infertility. Acta Pathologic et microbiologica Scandinavica Supplementary 19, 254.

Lamond. D.R. (1970). The influence of undernutrition on reproduction in the cow. Animal Breeding Abstract 38, 358-372.

Lardy, H.A., Philips, P.H. and Rupel, W.I. (1942). A preliminary report on the effect of the ration on the semen production of young dairy bulls. Journal of Animal Science 1, 79-84.

Larson, B.L. and Kendal, K.A. (1957). Changes in specific blood serum protein levels associated with parturition in the bovine. Journal of Dairy Science 40, 659-662.

Leland, S.E.(Jr). (1961). Blood and plasma volume, total serum protein and electrophoretic studies in helminthic diseases. Annals of the New York Academy of Sciences 94(1) 163-182.

Linford, E., Glover, F.A., Bishop, C. and Stewart, D.L. (1976). The relationship between semen evaluation methods and fertility in the bull. Journal of Reproductive Fertility 47, 283-291.

Lowman, B.G., Scott, N. and Somerville, S. (1973). Condition scoring of cattle. East of Scottland College of Agriculture Bulletin No.6

Lunstra, D.D., Ford, J.J. and Echternkamp, S.E. (1978). Hormone concentrations, growth, testicular development, sperm production, sexual agressiveness in bulls of different breeds. Journal of Animal Science 46, 1054-1062.

Mann, T. and Rowson, L.E.A. (1950). Effect of different planes of nutrition on the composition of bull semen. 3rd International Congress of Animal Production 1, 21-22.

Manston, R.; Russells, A.M.; Dew, S.M. and Payne, J.M. (1975). The influence of dietary protein upon blood composition in dairy cows. Veterinary Record 96, 497-502.

McDonald, L.E. (1975). Male reproduction and Endocrinology In: Mcdonald, L.E. (ed.). Veterinary Endorrinology and Reproduction 2nd Ed. Lea and Febiger, Philadelphia.

McDonald, M.A., Krueger, H. and Bogart, R. (1960). Rate and efficiency of gains in beef cattle IV: Blood haemoglobin, glucose, urea, amino acid, nitrogen, creatinine and uric acid of growing Hereford and Angus calves. Oregon Agricultural Experimental Station Technical Bulletin No.36 .

Melrose, D.R. (1962). Artificial Insemination in cattle. In: The Semen of animals and artificial insemination pp. 1-181. Ed. J.P. Maule Commonwealth Agricultural Bureaux.

Melrose, D.R. and Laing, J.A. (1970). The characteristics of normal semen In: Fertility and infertility in the domestic animals. pp. 128-160. Ed. J.A. Laing, Baillere Tindal and Cassel, London.

Meyerhoeffer, D.C., Wetterman, R.P., Wells, M.E. and Turman, E.J. (1976). Effects of elevated ambient temperature on bulls. Journal of Animal Science 43, 297-337.

Miller, W.J. (1970). Zinc nutrition of cattle. A review. Journal of Dairy Science 53, 1123-1135.

Morrow, D.A. (1980). Current therapy in Theriogenology. W.B. Saunders Co., Philadelphia pp. 878-950.

Monsoor, M., Latif, M., Masood, A. and Qazi, M.H. (1984). Age related changes in body weight, scrotal size and plasma testosterone levels in Buffalo bulls (Bubalus bubalis). Theriogenology 22, 651-656.

Mudra, K. (1974). The effect of rearing on semen production of young bulls. Animal Breeding Abstract 410 (1976).

Munro, I.B., Stewart, D.L. and Melrose, D.R. (1961). Middle piece defect in bovine spermatozoa. Veterinary Record 73, 577-578.

Nie, H.H., Hull, C.B., Jenkins, G.J., Steinbrenner, K. and Bent, D.H. (1975). Statistical package for social Sciences. McGraw-Hill Book Co., New York, 2nd Ed.

Oloufa, I. (1956). Some factors affecting the semen of Egyptian cattle and Buffaloes. Journal of Animal Science 17, 610-614.

Osinowo, O.A. (1979). Testicular growth and semen quality of West African bulls. Ph.D. Thesis Ahmadu Bello University, Zaria, Nigeria.

Oyedipe, E.O. (1981). Effect of protein intake on growth, blood composition and reproduction in Nigeria Cattle. Ph.D. Thesis, Ahmadu Bello University, Zaria, Nigeria.

Oyedipe, E.O., Kumi-Diaka, J. and Osori, D.I.K. (1981). Determination of onset of puberty in Zebu bulls under tropical conditions of Northern Nigeria. Theriogenology 16, 419-431.

Oyedipe, E.O., Saror, D., Osori, D.I.K. and Akerejola, O. (1984). Haematologic parameters of Zebu cattle on different protein levels and their relation to rate of gain. Bulletin of Animal Health and Production in Africa Vol. 32(2) pp. 129-136.

Payne, J.M., Dew, S.M., Manston, R. and Faulks, M. (1970). The use of of a metabolic profile test in dairy herds. Veterinary Record 87, 150-158.

Pfander, W.H. (1971). Animal nutrition in the tropics, problems and solutions. Journal of Animal Science 33, 843-849.

Pilat, Z. and Pindak, J. (1974). The effect of different nutrition during rearing on semen production of young bulls. Vliu rozdilnych krymnych davek behem odchovu na produkci spermatu roomch byku Vyzkum V choru skotu 16, 30-32.

Pruitt, R.J. (1983). Effect of energy intake on the sexual development of yearling beef bulls. Ph.D. Dissertation Kansas State University, Manhattan.

Pullan, N.B. (1978). Condition score of White Fulani cattle. Tropical Animal Health and Production 10, 118-120.

Pursley, G.R. and Herman, H.A. (1950). Some effects of hypertonic and hypotonic solutions on the livability and morphology of bovine spermatozoa Journal of Dairy Science 33, 220-227.

Rao, A.R. (1971). Changes in the morphology of sperm during their passage through the genital tract in bulls with normal and impaired spermatogenesis Ph.D. Thesis Royal Veterinary College Stockholm.

Rathore, A.K. (1970). Acrosomal abnormalities in ram spermatozoa due to heat stress. British Veterinary Journal 126, 440-443.

Reeves, K.R. and Johnson, B.H. (1976). Energy intake and testis function in prepubertal bulls. Journal of Animal Science 42, 264 (Abstract)

Roberts, S.J. (1971). Reproduction and Infertility in male animals. In: Veterinary Obstetrics and Genital diseases. 2nd Edition. Ann. Arbor, Michigan: Edwards Brothers, Roberts, S.J. Inc.

Rollinson, D.H.L. (1951). Studies on the abnormal spermatozoa of bull semen. British Veterinary Journal 107, 203-209.

Ross, J.G. (1960). Normal serum albumins values in Nigerian Zebu cattle. Veterinary Record 72(9) 159-161.

Roubicek, C.B., Taylor, R.L., Pahnish, O.F. and Ray, D.E. (1968). Plasma phosphorus and blood haemoglobin concentration in unsupplemented range cattle. Journal of Animal Science 27, 1487-1494.

Rowlands, G.J. and Manston, R. (1976). The potential uses of metabolic profiles in the management and selection of cattle for milk and beef production Livestock Production Science 3, 239-256.

Salamon, S. (1964). The effect of nutritional regimen on the potential semen production of rams. Australian Journal of Agricultural Research 15, 645-656.

Salisbury, G.W., VanDemark, N.L. and Lodge, J.R. (1978). Physiology of reproduction and artificial insemination of cattle p. 286-328, 733-787 2nd Ed. W.H. Freeman and Company, San Francisco.

Saror, D. and Coles, E.H. (1973a). The blood picture of White Fulani and White Fulani x Friesian cattle. Bulletin of Epizootic Diseases of Africa 21, 495-497.

Saror, D. and Coles, E.H. (1973b). The blood picture of White Fulani (Zebu) and White Fulani x Friesian (Crossbred) dairy cows. Bulletin of Epizootic Diseases of Africa 21, 485-487.

Saror, D. and Coles, E.H. (1973c). Some serum biochemical parameters in White Fulani (Zebu) and White Fulani x Friesian (Crossbred) cattle in Nigeria. Bulletin of Epizootic Diseases of Africa 21, 489-493.

Saror, D. and Coles, E.H. (1975). Haematologic parameters of Nigerian Zebu cattle under native husbandry practices. Nigerian Veterinary Journal 4, 89-92.

Schalms, O.W. (1965). Veterinary Haematology 2nd Ed. Lea and Febiger, Philadelphia.

Schultze, A.B. (1955). Changes of certain characters of blood of dairy calves during one year of life and their possible relation to rate of gain in body weight. Growth 19, 141-144.

Sekoni, V.O. (1979). The incidence of abnormal spermatozoa in bull semen and some causes of variation. M.Sc. Thesis University of Minnesota.

Sekoni, V.O. and Gustafson, B.K. (1980). The incidence of sperm abnormalities in dairy bulls and effects of age and season 9th International Congress Reproduction and Artificial Insemination Volume, III, p. 284-289.

Sekoni, V.O., Gustafson, B.K. and Mather, E.C. (1981). Influence of Wet fixation, staining techniques and storage time on bull spermatozoa morphology. Nordian Veterinary Medicine 33, 161-166.

Silvada, P. (1976). Influence of high environmental temperature on some semen characteristics of Zebu semen. 8th International Congress on Animal Reproduction and Artificial Insemination 1, 241.

Sitarz, N.E., Erb, R.E., Martin, T.G. and Singleton, W.L. (1977). Relationship between blood plasma testosterone, weaning, treatment, daily gains and certain physical traits of young Angus bulls. Journal of Animal Science 45, 342-348.

Spitzer, J.C., Wiltbank, J.N. and Lefever, D.G. (1975). Increase beef cow productivity by increasing reproductive performance. Colorodo State University Experimental Station General Series 949.

Steel, R.G.D. and Torrie, J.H. (1960). Principles and Procedures of Statistics, McGraw-Hill Book Co., Inc., New York.

Stufflebeam, C.E., Blakely, J.E., Lasley, J.F., Thomson, C.B. and Mayer, D.T. (1969). Effect of energy intake upon the levels of certain blood components in young beef heifers. Journal of Animal Science 29, 992-996.

Topps, J.H. (1977). The relationship between reproduction and under-nutrition in beef cattle. World Review of Animal Production 13, 43-49.

VanDemark, N.L. and Mauger, R.E. (1964). Effect of energy intake on reproduction of dairy bulls. I. Growth of reproductive organs, semen production and puberty. Journal of Animal Science 47, 798-802.

Ward, H.K. (1968). Supplementation of beef cows grazing on veld. Rhodesian Journal of Agricultural Research 6, 93-96.

Warnick, A.G., Meacham, T.N., Cunha, T.J., Roggins, P.E. Hentges, J.F. and Shirley, R.L. (1961). Effect of source of level of nitrogen on semen production and libido in rams. International Congress on Animal Reproduction and Artificial Insemination Hague 2, 202.

Wells, M.E., Awa, O.A. and Fancy, S.S. (1972). Effect of season on acrosome status in the bull. Journal of Dairy Science 55, 1174-1178.

Wildeus, S. and Entwistle, K.W. (1982). Postpubertal changes in gonadal and extragonadal sperm reserves in Bos indicus strain bulls. Theriogenology 17, 655-667.

Wildeus, S., Holroyd, R.G. and Entwistle, K.W. (1984). Patterns of pubertal development in Sahiwal and Brahman Cross bulls in tropical Australia. I. Growth and semen characteristics. Theriogenology 22, 361-373.

Willet, E.L. and Ohms, J.I. (1957). Measurement of testicular size and its relationship to production of spermatozoa. Journal of Dairy Science 40, 1559-1569.

Wilsey, C.O. (1972). The effect of high levels of energy intake on growth and seminal quality of Angus bulls. M.Sc. Thesis Colorado State University, United States of America.

Wiltbank, J.N. (1978). Puberty in Brahman type of cattle. In Proceedings Annual Conference of the Society for Theriogenology, Oklahoma pp.118-127.

Wolf, F., Almquist, J.O. and Hale, E.B. (1965). Prepubertal behaviour and pubertal characteristics of beef bulls on high nutrient allowance. Journal of Animal Science 24, 761.

Wright, P.L., Pope, A.L. and Phillips, P.H. (1962). Effect of protein and energy intake on lamb production and certain blood constituents of ewe. Journal of Animal Science 21, 602-610.

Zemjanis, R. (1970). Male reproductive function. In: Diagnostic and Therapeutic Techniques in Animal Reproduction. 2nd Ed. p. 70-150. Baltimore: The Williams and Wilkins Company.

Appendix 2.1: Analysis of variance (ANOVA) for the effect of ration, age and breed on withers height, chest girth of FFxBJ and BJ bull calves.

Source of variation	DF	Mean square values for growth traits	
		Withers height	Chest girth
Main effects	17	2998.76***	10550.90***
Age	15	3028.65***	11146.37***
Breed	1	5945.68***	10269.25***
Ration	1	753.13*	4058.31***
2-way interactions	31	285.80*	228.39^{NS}
Age x Breed	15	356.84*	284.98^{NS}
Age x Ration	15	243.91^{NS}	74.46^{NS}
Breed x Ration	1	0.85^{NS}	1604.63**
Explained	48	1246.65***	3884.28***
Residual	1134		
Total	1182		

*P(0.05
**P(0.01
***P(0.001
NS = Nonsignificant

Appendix 2.2: Analysis of variance for the effect of ration, age and breed on condition score, scrotal circumference and body weight of FRxBJ and BJ bull calves.

Source of variation	DF	Mean square values for growth traits		
		Condition score	Scrotal circumference	Body weeight
Main effects	17	48.92****	1398.02***	154229.77***
Age	15	22.71***	1388.49***	161584.36***
Breed	1	0.78^{NS}	2214.26***	171766.89***
Ration	1	485.49***	1089.04***	56649.36***
2-way interactions	31	2.42***	25.62***	4954.23***
Age x Breed	15	2.30***	31.29***	6676.68***
Age x Ration	15	2.64***	13.01^{NS}	2750.08^{NS}
Breed x Ration	1	0.71^{NS}	127.53***	11847.50*
Explained	48	18.89***	511.68***	57822.65***
Residual	1134			
Total	1182			

*P(0.05
**P(0.01
***P(0.001
NS = Nonsignificant

Appendix 2.3: Correlation coefficients between growth traits of Bunaji bull-calves on low protein diet.

Parameters	1	2	3	4	5	6
1. Age		.81*	.81*	.41*	.76*	.83*
2. Body weight			.92*	.42*	.76*	.99*
3. Scrotal circumference				.46*	.74*	.92*
4. Condition score					.42*	.44*
5. Withers height						.76*
6. Chest girth						

*P(0.01

Appendix 2.4: Correlation coefficients between growth traits of Bunaji bull-calves on high protein diet.

Parameters	1	2	3	4	5	6
1. Age		.96*	.91*	.63*	.73*	.80*
2. Body weight			.99*	.58*	.73*	.86*
3. Scrotal circumference				.64*	.72*	.85*
4. Condition score					.61*	.64*
5. Withers height						.80*
6. Chest girth						

*P(0.01

Appendix 2.7: Correlation coefficients between body growth and spermiogram of BJ on low protein diet

Parameters	1	2	3	4	5	6	7	8
Age		.98*	.97*	-.39*	.74*	.74*	.57*	.41%
Body weight			.98*	-.35*	.72*	.72*	.58*	.42*
Scrotal circumference				-.38*	.70*	.74*	.55*	.46*
Volume						.66*	.59*	.31*
Motility							.58*	.24
Concentration								.15*
Condition score								

*P(0.05

Appendix 2.8: Correlation coefficients between body growth and spermiogram of BJ on high protein diet

Parameters	1	2	3	4	5	6	7	8
Age		.98*	.83*	-.63*	.69*	.81*	.69*	.63*
Body weight			.99*	-.52*	.64*	.74*	.63*	.58*
Scrotal circumference				-.59*	.67*	.76*	.63*	.64*
Volume						.74*	.62*	.45*
Motility							.72*	.52*
Concentration								.37*
Condition score								

*P(0.05

Appendix 2.9: Correlation coefficients between body growth and spermiogram of FRxBJ on low protein diet

Parameters	1	2	3	4	5	6	7	8
Age		.98*	.99*	-.28*	.62*	.74*	.61*	.33*
Body weight			.98*	-.23*	.52*	.59*	.57*	.38*
Scrotal circumference				-.32*	.60*	.77*	.69*	.56*
Volume						.55*	.55*	.26*
Motility							.72*	.36*
Concentration								.30*
Condition score								

*P(0.05

Appendix 2.10: Correlation coefficients between body growth and spermiogram of FRxBJ on high protein diet

Parameters	1	2	3	4	5	6	7	8
Age		.98*	.98*	-.42*	.65*	.79*	.76*	.52*
Body weight			.96*	-.34*	.60*	.72*	.67*	.48*
Scrotal circumference				-.38*	.66*	.82*	.79*	.52*
Volume						.61*	.67*	.38*
Motility							.67*	.48*
Concentration								.37*
Condition score								

*P(0.05

Table 3.1: Analysis of variance (ANOVA) on the effect of ration, age, and breed on semen volume, and motility of spermatozoa of FRxBJ and BJ bull-calves

Source of variation	DF	Mean square value	
		Volume	Motility
Main effects	17	104.90***	32573.76***
Age	15	107.56***	2644.80***
Breed	1	9.99^{NS}	2644.80***
Ration	1	157.38***	38294.69***
2-way interactions	31	3.65***	1018.69***
Age x Breed	15	1.13^{NS}	510.78***
Age x Ration	15	5.95***	1447.36***
Breed x Ration	1	6.38*	2608.44***
Explained	48	39.51***	12194.45***
Residual	1134		
Total	1182		

*P(0.05
**P(0.01
***P(0.001
NS Nonsignificant

Appendix 3.2: Analysis of variance (ANOVA) of the effect of ration, age, and breed on scrotal circumference, sperm concentration and total sperm of FRxBJ and BJ bull-calves.

Source of variation	DF	Mean square values		
		Scrotal circumference	Concentration	Total sperm
Main effects	17	1398.02***	1154×10^{6}***	1.86×10^{10}***
Age	15	1388.49***	1181×10^{6}***	1.83×10^{10}***
Breed	1	2214.26***	2.686×10^{8}***	5.36×10^{9}***
Ration	1	1089.04***	15.79×10^{8}***	3.78×10^{10}***
2-way interactions	31	25.62***	86.97×10^{6}***	2.49×10^{9}***
Age x Breed	15	31.29***	34.60×10^{6}***	9.58×10^{8}***
Age x Ration	15	13.01^{NS}	138.13×10^{6}***	3.92×10^{9}***
Breed x Ration	1	127.53***	112.722×10^{6}**	2.82×10^{9}**
Explained	48	511.68***	464.89×10^{6}**	4.88×10^{11}***
Residual	1134			
Total	1182			

*P(0.05
**P(0.01
***P(0.001
NS Nonsignificant

Appendix 3.3: Analysis of variance (ANOVA) for the effect of ration, age and breed on live spermatozoa, detached heads, and cytoplasmic droplets for FRxBJ and BJ bulls

Source of variation	DF	Mean square values			
		Live Spermatozoa	Detached heads	Proximal droplets	Distal droplets
Main effects	3	866.08**	22.95^{NS}	12659.15***	50.27**
Breed	1	793.42^{NS}	4.45^{NS}	4006.46**	150.12***
Ration	1	710.25^{NS}	8.70^{NS}	467.34^{NS}	0.02^{NS}
Age	1	1172.51*	62.05*	32568.04***	0.01^{NS}
2-way interactions	3	308.36^{NS}	7.14^{NS}	925.06^{NS}	2.27^{NS}
Breed x Ration	1	46.87^{NS}	13.37^{NS}	1421.94^{NS}	0.23^{NS}
Breed x Age	1	903.87**	5.64^{NS}	133.59^{NS}	0.02^{NS}
Ration x Age	1	7.68^{NS}	0.09^{NS}	1216.72^{NS}	6.44^{NS}
3-way interactions	1	495.46^{NS}	1.30^{NS}	7.72^{NS}	6.23^{NS}
Breed x Ration x Age	1	495.46^{NS}	1.30^{NS}	7.72^{NS}	6.23^{NS}
Explained	7	574.11**	13.08^{NS}	5822.91***	23.40^{NS}
Residual	395				
Total	402				

*P(0.05
**P(0.01
***P(0.001
NS Nonsignificant

Appendix 3.4: Analysis of variance (ANOVA) for the effect of ration, age and breed on sperm mid piece and tail defects of FRxBJ and BJ bulls

Source of variation	DF	Mean square values				
		Mid piece defects			Tail defects	
		Rough	Abaxial	Swollen	Coiled	Reversed
Main effects	3	1.41^{NS}	0.17^{NS}	8.45***	17.51^{NS}	62.00***
Breed	1	0.03^{NS}	0.20^{NS}	1.74^{NS}	10.91^{NS}	1.40^{NS}
Ration	1	2.89^{NS}	0.09^{NS}	2.31^{NS}	19.26^{NS}	37.65^{NS}
Age	1	0.87^{NS}	0.28^{NS}	18.68***	25.06^{NS}	164.56***
2-way interactions	3	0.61^{NS}	0.41^{NS}	4.45^{NS}	5.08^{NS}	55.96^{NS}
Breed x Ration	1	0.49^{NS}	0.26^{NS}	7.39*	6.11^{NS}	8.51^{NS}
Breed x Age	1	1.42^{NS}	0.03^{NS}	0.00^{NS}	5.04^{NS}	6.72^{NS}
Ration x Age	1	0.06^{NS}	0.98^{NS}	5.18*	4.65^{NS}	151.85***
3-way interactions	1	0.06^{NS}	0.56^{NS}	7.13*	1.26^{NS}	37.01^{NS}
Breed x Ration x Age	1	0.06^{NS}	0.56^{NS}	7.13*	1.26^{NS}	37.01^{NS}
Explained	395					
Total	402					

*P(0.05
**P(0.01
***P(0.001
NS Nonsignificant

Appendix 4.5: Correlation coefficients between blood parameters of Bunaji bulls on low protein diets

Parameters	1	2	3	4	5	6	7	8	9	10
PCV		.49*	.20*	.02	.17*	-.05*	-.01	.09	-.09	.08
Hb			.50*	.04	.10*	-.08	.07	.02	-.06	.03
RBC				.11*	.13*	-.13*	.02	.11*	.01	.10*
WBC					-.07	.00	.02	-.07	.06	.00
Tp						.06	-.08	.03	.01	.07
Neutrophil							-.39*	.27	-.22*	-.09
Lymphocyte								-.53*	-.24*	-.08
Eosinophil									.18*	.10*
Monocyte										.13*
Basophil										

P/0.01

Appendix 4.6: Correlation coefficients between blood parameters of Bunaji bulls on high protein diet.

Parameters	1	2	3	4	5	6	7	8	9	10
PCV		.31*	.33*	.12*	.52*	.07	-.02	-.05	-.07	-.06
Hb			.15*	.18*	.44*	.01	.04	-.07	.01	.09*
RBC				.24*	.16*	.04	-.01	-.06	.00	-.02
WBC					-.11*	-.06	.03	.02	.02	.11*
Tp						-.04	.06	-.04	.07	-.02
Neutrophil							-.72*	-.32*	.18*	.03
Lymphocyte								-.31*	-.17*	-.12*
Eosinophil									.18*	.10*
Monocyte										.11*
Basophil										

P/0.01