COMPARATIVE EVALUATION OF SEMEN QUALITY OF THE NORWEGIAN (N), TANZANIA LOCAL (L) AND N X L CROSSBRED BUCKS

BY

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DECLARATION

I, ALI AHMED OTHMAN ABOUD do hereby declare to the Senate of the Sokoine University of Agriculture that this dissertation has not been submitted for a higher degree award in any other University.

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ABSTRACT

The Tanzanian local (L) bucks were compared with the Norwegian (N) and Norwegian half - cross (N x L) bucks for their semen characteristics and for seasonal influences on variation in semen quality. The bucks were divided into two age groups (Group 1, n = 8, Group II, n = 24). For group I bucks observations were made for the period of six months (Jan. - June) falling in two seasons of three months each (SI = Jan. - March & SII = April - June) while group II bucks were observed for three months only (SII). Ejaculates were collected from the bucks by the use of electro - ejaculator once per week and twice on each day of collection.

Positive correlations (59.4% and 41.1%) between semen volume and respectively liveweight and testicular circumference were observed. Semen volume increased from 0.42 ml and 0.32 ml by approximately 0.02 ml and 0.03 ml respectively per each kilogram increase in liveweight and each centimeter increase in testicular circumference. Liveweight accounted for 35% of all variation in semen volume among individual bucks. Significant variation among bucks was observed for semen density ($P < 0.01$), semen volume ($P < 0.01$), wave - motion score ($P < 0.01$) and total number of livespermatozoa per ejaculate ($P < 0.01$).

Norwegian bucks in group II exhibited significantly ($P < 0.05$) higher semen volume (1.06 $\pm$ 0.17 ml) than both the locals (0.67 $\pm$ 0.03 ml) and the crossbreds (0.84 $\pm$ 0.03 ml). In group I breed effect was non - significant with respect to semen volume but local bucks were significantly.

superior in semen density $\times 10^7$/ml (350.83 $\pm$ 46.43 vs. 244.89 $\pm$ 18.8) wave - motion score (2.56 $\pm$ 0.38 vs. 1.98 $\pm$ 0.6) total number of spermatozoa /ejaculate $\times 10^7$ (410.99 $\pm$ 56.05 vs. 311.38 $\pm$ 13.13) and total number of livespermatozoa/ejaculate $\times 10^7$ (275.23 $\pm$ 54.4 vs. 201.48 $\pm$ 10.48).

Semen density, % livespermatozoa and wave - motion score showed significant monthly variations in all breed groups. Higher values of % livespermatozoa were recorded in March (75.05 $\pm$ 5.6%) for local bucks and in January (79.06 $\pm$ 3.5%) for Norwegian bucks. Monthly variation in semen volume among the 3 breeds were incosistent and insignificant. Lowest volumes were recorded in May (0.93 ml for local and 1.10 ml for Norwegian bucks) whereas highest values were recorded between February and March in both breeds (1.2 ml and 1.56 for local and Norwegian bucks respectively).

Body weight and testicular measurements can serve as indicators of sperm producing capacity in bucks. It is suggested that these parameters should provide basis for setting appropriate male : female ratios in planned matings. From the observations on monthly and seasonal variations in the semen attributes, it is concluded that annual rythms in spermatogenic activity do exist in all the three breeds. This however, does not exclude the possibility of using males from any of three breeds to serve throughout the year.

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INTRODUCTION

Since the advent of Artificial Insemination in the early 1950's, considerable research has been directed towards evaluating semen characteristics with the dual aim of maximising the use of superior sires and identifying constraints obstructing production of good quality ejaculates. Ample evidence has been shown suggesting that potential fertility of males can be determined at an early age from examination of semen characteristics. The differences noted among males in respect to their potential capacity for sperm production, suggest that effective selection of males for their ability to produce sperms or to develop strains with higher daily sperm production is quite possible.

In recent years, breeds comparison with respect to semen quality has attracted considerable attention (Zerfas et al 1982, Bordoloi et al 1983, El - Fouley et al 1980). Likewise, seasonal influence on reproduction activity of bucks and rams is a current subject of great controversy particularly for tropical breeds (Muhunyi et al., 1982; Greyling and Grobbelaar 1983). Some disagreement pertains among workers in respect to both the influence of breed and the effect of the climatic factors on semen quality and reproductive patterns of males (Davidenko et al. 1983; Johari , 1973, Igboeli 1974). However, a general consesus does exist in respect to seasonal rythms of reproductive activity of males, but the direction and magnitude of these rythms exhibit wide variations (Gomes and Joyce, 1975; Hoffman et al. 1972). Whereas some workers contend that seasons affect only the functional interrelationships of androgens, accessory glands and seminal plasma content (Hoffman et al. 1972) others have demonstrated that depending, upon the breed, climatic elements directly affect the spermatogenic activities and semen quality in rams

(Malikov, 1963).

A survey of literature suggests that no argument in respect to either the breed factor or the seasonal rythms can be universally affirmative. The reported contradictions may infact be due to environmental diversity. Furthermore, most conclusions were based on comparisons made between breeds that have evolved within more or less the same environmental conditions. It is imperative that comprehensive comparative studies are made on breeds of diverse origins. Such a need is further amplified in the tropics where most breed improvement programmes involve the use of exotic temperate breeds, and almost always an importation of males. The situation is more critical in small ruminants, where Artificial Insemination through the use of imported semen in virtually inconcevable in the near future. There is a paucity of information with regard to the sexual competence and semen quality of temperate breeds of goats imported into the tropics. The present study attempts to assess the semen quality and its seasonal changes in a temperate goat breed (Norwegian) imported into the tropics relative to that of the indigenous goats.

CHAPTER 2

LITERATURE REVIEW

2.1 The two components of semen

As defined by Mann (1964), the semen ejaculate is a suspension of spermatozoa in a fluid medium - "The seminal plasma". The two components differ in their origin, composition and function. The ratio between the two components varies widely among species and is largely determined by the size, storage capacity and output of the seminal plasma and spermatozoa. Freshly ejaculated semen usually is creamy, slightly yellowish or greyish and is often highly viscous. The volume of the ejaculated semen and the concentration of spermatozoa vary widely from one species to another. Table 1 summarizes some species differences in volume and density of ejaculated semen. It should also be noted that variations in volume, colour and density of ejaculates within the same species or individuals is not uncommon (Table 2). Mukherjee (1964) reported variations in colour of different ejaculate samples drawn from the same individual bull, ram or buck. In bucks and rams, the average volume has been reported to range between 0.2 mls and 2.2 mls (Vinha & Megale 1974, Prasad *et al*., 1970; Rathore, 1970; Katsyak, 1970; Tewari *et al*., 1968; Juma & Dessouky, 1969), whereas most reports on density give values lying between 1.2 - 3.75 x 10^9 sperms/ml. (Iritani *et al*., 1964; Austin *et al*., 1968; Smyth *et al*., 1967; Tewari *et al*., 1968).

Table 1. : Species differences in volume and sperm density of ejaculated semen

Species	Volume of single ejaculate(ml)	Sperm density in semen (sperm/μ 1)
Bull	2 - 10	$30 \times 10^4 - 2 \times 10^6$
Boar	150 - 500	$2.5 \times 10^3 - 30. \times 10^4$
Buffalo	0.5 - 4.5	$20 \times 10^4 - 80 \times 10^4$
Ram	0.7 - 2.0	$2 \times 10^6 - 5 \times 10^6$
Goat	0.2 - 2.5	$1 \times 10^6 - 5 \times 10^6$

Source : Mann (1964)

A close association between volume and density has been noted (Prasad et al., 1970). Goerke et al (1970) have reported a genetic correlation of 0.21 ± 1.15 between sperm concentration and semen volume in Southdown rams. Phenotypically a negative correlation exists between volume and concentration as exhibited by the large volume with low concentration in the boar, stallion and ass, and a small volume associated with high concentration in goat, ram, cock and Turkey. Laurans and Negriere (1964) noted that semen volume increased significantly with age and that there was a highly significant positive correlation (r = 0.73) between age and concentration of sperms in bulls. Katsyak (1970) showed that an increase with age in volume and concentration was notable in Polish Merino rams aged between 1 and 2 and 5 and 6 years, but a considerable decline was experienced for rams aged between 9 - 10 years. Similarly, Maskeev (1971) observed that in rams aged 1½, 3½, 4½ and 5½ to 6½ years, average ejaculate volumes were respectively 1.4, 2.2, 2.2, 2.0 and 1.8 mls, while sperm concentrations in milliards/ml were 2.36, 3.15 and 2.70 for respectively 1½, 4½ and 6½ years rams. In Barbari bucks, Prasad et al. (1970) have reported a linear increment in volume of ejaculate from 0.18 ± 0.02mls to 0.92 ± 0.07 mls between 4½ months to 36 months of age. Reports by Corteel (1975), Sinha et al. (1981) and Davidenko et al. (1983) conform with the above observations in other breeds of goats and sheep. Tiwari and Sahni (1982) reported that ejaculate volume and sperm numbers were significantly correlated with age (r = 0.64 and 0.63 respectively) and with body weight (r = 0.64 and 0.65 respectively) in Ramboullet x Malpura crossbred rams.

The diversity and the range of values reported for the association of ejaculate volume and sperm concentration with age of the animal are indicative of other possible confounding factors (Table 3). More generally accepted are the influences of liveweight (Bouillon, 1973), testicular size (Lino, 1972) and that of the frequency and method of collection (Colas et al., 1975; Tomkins et al. 1976 and Allison, 1975).

Amman (1966) observed that ejaculate volume and sperm concentration in rabbits were significantly lower ($P < 0.01$)at once every 12 hours than at either once every 24 hours or twice every 48 hours frequences of collection. Gregoire et al . (1958) found that increasing the ejaculation frequences of rabbits from once weekly to once daily resulted in a decrease of 50% in sperm concentration and 40% in ejaculate volume. In a series of studies by McWeeney (1976) and by Jennings and Jennings (1976) it was shown that excessive ejaculations significantly depress ejaculate volume and sperm concentration in Suffolk rams. Sahni et al. (1975) reported significantly higher volume and density for ejaculates collected on alternate days than those collected once daily in Ramboillet rams. Igboeli and Rakha (1971) noted higher volume of ejaculates for collections made after 4 days rest than those taken after 3 days in Angoni bulls. Similar, observations have been reported when rams were subjected to high mating pressure (Crocker, 1974; Salamon, 1962; Gibson and Jèwell, 1982). Fulkerson et al. (1982) and Mattner and Braden (1967) from their studies on rate of conception in naturally mated Merino ewes concluded that continuously mating rams may be depositing insufficient number of spermatozoa at a single insemination to ensure good conception. The frequency factor has however, been rejected by other workers. Prasad et al. (1970) noted no significant deterioration in semen characteristics by increasing the frequency of semen collection among Barbari bucks. Desjardins et al. (1965) on the other hand, reported an average weekly sperm output of 273 x 10^6/ml with one ejaculte per week and an increasing concentration with either one ejaculate per day (519 x 10^6/ml) or two successive ejaculates collected on alternate days (619 x 10^6/ml). Kurian and Raja (1965) observed no detrimental effect of interval between collections on the semen characters among Malabari bucks. The influence that frequency of collection exerts on the composition of individual samples of semen is illustrated in Table 4.

The association between the dimensions of external genitalia and both the volume and concentration of ejaculate has been widely reported (Bongso et al., 1982; Daudu, 1984; and Bongso et al.,1981). Carew and Egbunike (1980) reported highly significant correlation between daily sperm production and external scrotal length (r = 0.78), width (r = 0.73) and circumference (r = 0.61).Similarly, Borgohain et al. (1983), observed significant correlation between scrotal circumference and ejaculate volume (r = 0.26) and between scrotal circumference and sperm concentration (r = 0.77). Testis weight has been shown to have a significant linear correlation (r = 0.83) with sperm output (Lino, 1972).

Table 2 : Average values of the characteristics of the semen collected from Suffolk rams

(October 1957 - September, 1958)

Month	Volume (ml)	Concentration spermatozoa (x 10^6/ml)	Motility (%)	Live spermatozoa (%)	Abnormal spermatozoa (%)	Fructose mg/100 ml	Citric acid mg/ 100 ml	Average maximum temperature ^oF
1957								
October	1.34±.	3.37±0.22	81.0±1.80	79±1.50	5.5±0.43	595±32.00	75±5.20	71.30
November	1.52±.11	3.32±0.18	79.0±2.30	77±1.40	7.2±0.71	524±6.90	104±6.90	64.40
December	1.40±.17	3.64±0.45	82.0±2.30	-	8.5±2.53	496±25.60	160±25.60	52.50
1958								
January	1.12±.08	3.14±0.14	68.0±3.00	39±4.00	14.6±1.74	387±12.00	26±9.10	52.60
February	1.04±.12	3.43±0.29	72.0±2.80	62±3.00	15.0±2.53	227±29.00	58±6.10	60.60
March	1.23±.08	3.36±0.14	73.0±2.0	61±2.10	14.5±1.44	262±57.	37±7.10	60.40
April	1.08±.05	3.08±0.12	71.0±1.70	60±2.50	18.1±1.87	199±25.00	43±2.70	71.90
May	0.89±.05	2.48±0.13	79.0±1.50	61±1.70	20.4±2.58	202±24.00	54±6.10	82.30
June	1.04±.05	2.39±0.14	75.0±1.50	64±1.90	9.5±1.47	393±32.00	70±7.30	86.30
July	1.09±.07	2.44±0.19	59.0±3.40	49±1.40	13.1±3.60	477±49.00	95±24.60	92.50
August	0.96±.04	1.94±0.19	35.0±2.90	25±3.00	31.5±1.50	673±13.00	44±5.60	97.80
September	0.91±.06	1.83±0.13	58.0±6.20	23±2.10	14.7±1.42	667±16.00	75±12.70	91.90

Source : Cupps (1960)

Table 3 : Statistical correlation between all semen characteristics

Semen characteristics correlations volume (ml)	Ossimi r	Rahmani r
1. Volume (ml) x initial motility	+ 0.0033	+ 0.0462
2. Volume (ml) x livesperm % in fresh	+ 0.0798	+ 0.0340
3. Volume (ml) x total abnormalities	- 0.0205	+ 0.1380
4. Volume (ml) x concentration	+ 0.3130*	- 0.2043
5. Volume (ml) x livesperm % in stored	+ 0.0961	+ 0.1455
Initial motility		
6. Motility x total abnormalities (%)	- 0.0983*	- 0.5143**
7. Motility x livesperm % in fresh	+ 0.1997**	+ 0.7249**
8. Motility x concentration	+ 0.1012	+ 0.6636**
9. Motility x livesperm % in stored	+ 0.0979	+ 0.4339**
Livesperm % in fresh		
10. Livesperm % in fresh x total abnormalities (%)	- 4212**	- 0.4650**
11. Livesperm % in fresh x concentration	+ 0.2142**	+ 0.1186
12. Livesperm % in fresh x live % in stored	+ 0.6088**	+ 0.6106
Total abnormalities (%)		
13. Abnormalities x concentration	- 0.1571**	- 0.2734**
14. Abnormalities x livesperm (%) in stored	- 0.3614**	
Concentration (x 10^6/ 1)		
15. Concentration x livesperm in stored	+ 0.0652	+ 0.0016

* Significant (P < 0.05)

** Significant (P < 0.01)

Source : Hafez (1955)

Table 4 : Characteristics of ejaculates of Angoni bulls.

	'Ejac. collected after 4 days rest.			Ejac. collected after 3 days rest.			Overall means	
Parameter	1^{st} ejac.	2^{nd} ejac.	Mean	1^{st} ejac.	2^{nd} ejac.	Mean	1^{st} ejac.	2^{nd} ejac.
Volume (ml)	3.6 ± 0.1	3.3 ± 0.1	3.5 ± 0.1	3.2 ± 0.1	2.9 ± 0.1	3.0 ± 0.1	3.4 ± 0.1	3.1 ± 0.1
Motility (%)	58.5 ± 1.0	59.5 ± 1.0	59.0 ± 0.7	57.2 ± 1.0	62.0 ± 1.0	59.6 ± 0.7	58.0± 0.7	61.0 ± 0.7
Sperm concentration x 10^7/ml	1.82 ± 1.0	1.60 ± 0.07	1.71± 0.05	1.82±0.07	1.70±0.07	1.76±0.05	1.82±0.05	1.65±0.05
Normal morphology (%)	75.3 ± 1.0	72.3 ± 1.0	7.40 ± 0.7	7.26 ± 1.0	72.5 ± 1.0	73.0 ± 0.7	74.0 ± 0.7	72.0 ± 0.7
Livespermatozoa (%)	81.1 ± 1.1	84.5 ± 1.1	83.0 ± 0.8	79.2 ± 1.1	82.0 ± 1.1	81.0 ± 1.8	80.0 ± 0.8	83.0 ± 0.8

'ejac. = Ejaculate

Mean pH value was 6.5

Source : Igboeli & Rakha (1971)

2.2 The physical, chemical and biochemical properties of semen

Much of the information in respect to the physical properties for example viscosity, specific gravity, osmotic pressure and pH of mammalian semen has been drawn from studies in bulls and rams. Summarising observations of different workers, Mann (1964) reports variable range of viscosity in semen of different species. A viscosity range of between 1.76 to 10.52 is said to be normal for bull semen depending upon the concentration of spermatozoa of a given sample. Osmotic pressure determined in terms of freezing - point depression has been noted to range (in centigrade) between 0.54 - 0.73 in bulls and 0.55 - 0.70 in rams (Mann, 1964).

In bull semen, a close association between low specific gravity and poor quality semen and that of high specific and good quality has been shown (Lindahl & Kihlström, 1952). Excessive initial alkalinity of semen in rams and bucks has been shown to accompany low fertility as reflected by low concentration of sperms and a correspondingly higher proportion of seminal plasma. Lopatko (1966) showed that semen pH in rams was negatively correlated with sperm motility (r = - 0.40), sperms concentration (- 0.49) and positively correlated with Methylene blue reduction time (r = 0.61).

Tables 5, 6 and 7 show observed quantities or proportion of various components of the whole semen of rams and bucks and their distribution. Obvious contrasts in composition can be noted between the two major fractions of semen. Acid - soluble phosphorus compounds are present in both the sperm and seminal plasma; but whereas the acid - soluble phosphorus of sperms is derived mainly from nucleotides, that of seminal plasma is due chiefly to glycerol - phosphorylcholine (Mann, 1964). Zŷvkov (1962) reported that the total phosphorus content in ram spermatozoa was about 27.10 $ug/10^9$ spermatozoa and that the phosphorus of adenine nucleotides was 12.2 $ug/10^9$ spermatozoa which was equivalent to 77.5% of Organic phosphorus. An average of 1.2 $\pm$ 0.10 g/100 g wet spermatozoa of phospholipids has been reported by Jain and Anand (1975) for goats spermatozoa. From the same work, the phospholipid content in the seminal plasma was reported to be 0.05 $\pm$ 0.03 g/100 ml plasma. Table 7 shows average quantities of various constituents of the seminal plasma of Barbari bucks as reported by Varshney et al. (1977). It has been observed that there is a close resemblance between rams and goats semen with respect to the main chemical characteristics. The goat seminal plasma has a high content of citric acid and glycerylphorycholine but lacks ergothionine. Fructose is the predominant sugar in ram and goat semen (Murdoch & White 1966). Substantial quantities of acetic and pyruvic acid has also been reported(Scott et al.,1962; and Scott et al., 1961). Brown et al., (1972), have reported on the free amino acids concentrations in the seminal plasma, rete testis fluid epididymal fluid and vesicular fluid in the ram, bull and rat.

Table 5 : Ram semen : Main components (average volume : 1.2 ml, average density 2,940,000 sperm/ ml)

Dry weight µg	14,820
Chloride (mg./100 ml)	87
Sodium (mg./100 ml)	103
Potassium (mg./100 ml)	71
Calcium (mg./100 ml)	9
Magnesium (mg./100 ml)	3
Inorganic phosphorus (mg/100 ml)	12
Total nitrogen (mg./100 ml)	875
Non protein nitrogen (mg./100 ml)	57
Urea (mg./100 ml)	44
Uric acid (mg./100 ml)	11
Ammonia (mg./100 ml)	2
Fructose (mg./100 ml)	247
Lactic acid (mg./100 ml)	36
Citric acid (mg./100 ml)	137
Co_2 content (mg./100 ml)	16
Ascorbic acid (mg/100 ml)	5

Source : Mann, (1964).

Table 6 : Goat semen : distribution of sodium, potassium and calcium in accessory secretions (mg./100 ml.)

	Sodium	Potassium	Calcium
Epididymal (cauda) semen (mg/100ml)	128	148	5
Ampullar semen (mg/100ml)	112	120	6
Vesicular secretion (mg/100ml)	200	238	15

Source : Salisbury & Cragle (1966)

Table 7 : : Semen constituents of Barbari bucks (seminal plasma)

Sodium (mg/100 ml)	178.05
Potassium (mg/100 ml)	184.26
Calcium (mg/100 ml)	16.70
Magnesium (mg/100 ml)	3.50
Chloride (mg/100 ml)	84.66
Inorganic phosphorus (mg/100 ml)	10.59

Source : Varshney *et al.*(1977)

Recent reports by Nair et al. (1982) suggest that there is a highly significant difference between bucks of the same breed in the level of sodium and potassium in the semen. Comparative studies on biochemical attributes of seminal plasma in Dorset horn, Suffolk and Muzaffarnagari rams affirm significant breed differences with respect to chloride, calcium and magnesium content in the semen (Saha & Sindhi, 1982). Pandey et al.(1982) reported significant differences between Barbari and Saanen bucks for levels of all ions except sodium and magnesium.

2.3 Chemical factors affecting semen quality

The biological significance of the semen chemical constituents in general and that of cations concentration in particular has been extensively researched (Dott and White, 1964; Quinn et al., 1965; Quinn, 1970; Breddeman and Foote, 1971; and McGrady and Nelson, 1972). Quinn and White (1966) noted a significant correlation between sperm numbers/ml with sodium (r = - 0.697), potassium (r = 0.538) and calcium (r = - 0.48) in semen and with sodium in spermatozoa (r = 0.704). In the same work the percentage live spermatozoa was reported to be negatively correlated with calcium ions (r = - 0.507) in semen and in the spermatozoa. Positive correlation exists between percent live sperms and potassium (r = 0.513). Similar positive relations for percent motility with potassium (r = 0.481) but with calcium a negative correlation (r = -0.441) pertains. Tables 8 and 9 show results reported by Quinn et al. (1965) for respective correlation coefficients between cations concentrations and semen quality; and variations in semen quality and cations in the semen of rams. Reporting on bulls, Roussel and Stallcup (1966) showed that alkaline phosphatase activity was significantly correlated with the percent motile spermatozoa and percent live spermatozoa in bull semen. An association between the concentration of glutamic acid in semen and conception rate among inseminated females has also been reported (De Vryst *et al*., 1964). A reciprocal relationship between potassium and calcium content in ram semen with respect to percent unstained cells has been reported by Quinn *et al*. (1965). A high percent of unstained cells/ spermatozoa was observed to be associated with high intracellular potassium and low calcium levels. Recently, Marinov and Dacheva (1984) have observed an association between low sperm motility and high concentration of potassium, sodium and citric acid in the seminal plasma of Pleven Blackhead and Isigari rams.

The influence of cations on semen quality is principally associated with their role on the semen metabolism. Murdoch and White (1966) observed that potassium and magnesium concentrations of suspending medium influence the relative ease with which ram spermatozoa oxidize acetate and glucose. They also noted a suppressive effect of potassium on glucose metabolism in the ram semen. They conclude that the rate of oxidation of glucose and acetate is depended upon the relative levels of potassium and magnesium in the ram spermatozoa. Potassium and phosphate ions have been reported to significantly increase motility, resperation and fructolyois in ram semen (Wallace and Wales, 1964), whereas magnesium and calcium seem to exert only marginal influence.

Table 8 : Correlation coefficients between Na and K in rams spermatozoa and seminal plasma in 16 semen specimens collected by different techniques

Correlation	Artificial Vagina	Electro-ejaculation
Na^+ : K^+ in sperm	- 0.41	- 0.091
Na^+ : K^+ in plasma	- 0,514	+ 0.72
Na^+ in sperm : Na^+ in plasma	+ 0.57	+ 0.39
K^+ in sperm : K^+ in plasma	+ 0.66	+ 0.78

Source : Quinn <u>et al</u> (1966)

Table 9 : Variation of semen quality and cations (mean mg./100 gm) in semen of individual rams ejaculated at weekly intervals

Ram	Semen quality		Na 3 week	K 4 week	Na 5 week	Mg 5 week
	* S. C.	5021 ± 559	135	119	8.6	12.0
1	* % M	66 ± 9.3	111	188	10.6	24.3
	* % U	91 ± 2.5	145	98	6.8	6.1
	S.C.	1969 ± 158	231	100	10.8	6.9
2	% M	62 ± 5.1	233	164	23.1	20.0
	% U	69 ± 7.0	261	85	9.8	5.3
	S.C.	2082 ± 428	210	96	13.7	7.5
3	% M	58 ± 78	176	143	47.7	16.3
	% U	45 ± 10.6	209	88	8.6	4.3
	S.C.	2635 ± 189	207	93	11.0	8.1
	% M	68 ± 6.0	167	193	22.6	23.5
	% U	83 ± 4.4	215	83	10.8	6.6

Source : Quinn *et al* (1966)

* S.C.=Sperm count (x 10^6/ml)

* % M = % motile spermatozoa

* % U = % percentage unstained spermatozoa

Figure 1 illustrates the depressive effect of calcium and phosphate ions on total oxygen uptake and fructose oxidation. Young and Nelson (1974) observed that both excess and insufficient calcium ions affected the "swimming" performance of spermatozoa. They suggest that sperm motility requires maintenance of calcium gradients, reversible sequestration and release of calcium ion dependent metabolic regulation of flagellar contractile system.

There have been occassional reports that calcium ions adversely affect mammalian sperm cell activity. Lardy and Phillips (1943) found that an increase in calcium content of suspension medium inhibited the respiration and glycolysis of bull spermatozoa. Quinn et al. (1970) reported that an excess of extracellular calcium was inhibitory to the motile activity of ram spermatozoa. Bredderman and Foote (1971) using cell volume as an index found that excess calcium caused both structural and permeability changes in bull's spermatozoa. McGrady and Nelson (1972) observed that excess calcium in the diluent reversed the polarity of the bull spermatozoa membrane from negative inside to positive inside. Influence of the major biologically active inorganic ions on viability and metabolism of spermatozoa has been extensively reviewed by Salisbury and Lodge (1962).

The flagellar contractile processes are coordinated by cation activated adenosinetriphosphatase (ATPase) in the tail. This process requires the presence of glycerol and magnesium (Bishop, 1962). The magnesium dependent ATPase has been shown to be confined almost exclusively to the mid - piece and tail of spermatozoa (Nelson, 1954) and to be intimately

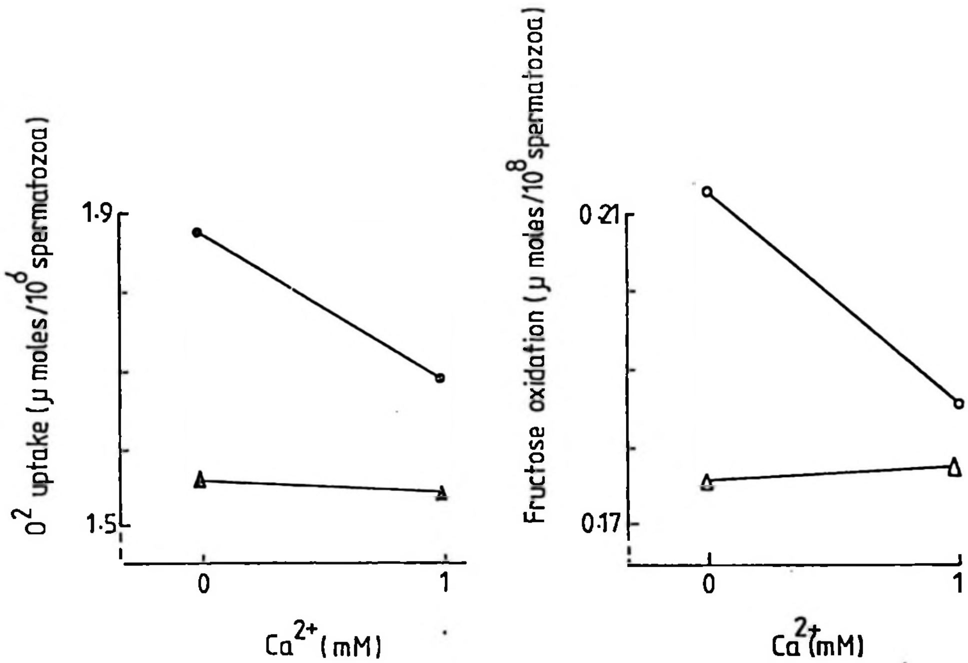


Fig. 1 : The interaction of calcium (1 mM) and phosphate (20 mM) ions on total oxygen uptake and fructose oxidation by ejaculated spermatozoa.

Source : Wallace and Wales (1964)

concerned with the contractile processes of the flagellar (Quinn and White, 1968).

A number of studies have demonstrated that high concentrations of carbondioxide inhibit metabolic processes in spermatozoa (Salisbury, 1959; Salisbury et al. 1960; Lodge & Salisbury, 1965; and Jones & Salisbury, 1962) while low concentrations have a stimulatory effect (Lodge & Salisbury, 1963; Hammer & Williams 1964; Shellby & Foley 1966; Foley & Williams 1967; Murdoch & White 1968). Wales and O'shea (1966) were unable to detect a stimulating effect of respired carbon-dioxide on the oxygen uptake of bull spermatozoa, but did find a statistically significant stimulation of lactate accumulation.

The role of bicarbonate in sperm metabolism is not well known. High concentration of bicarbonate has been shown to facilitate sperm capacitation *in vitro* (Bavister, 1969; Mounib & Chang 1964; Hammer & Williams; 1963; Murdoch & White, 1967). The secretions of the female genital tract contain substantial amounts of bicarbonate (Lutwak-Mann 1962; Vishwa- Karma, 1962;) and have been observed to stimulate sperm metabolism (Olds & VanDemark 1957; Wales & Restall, 1966, Iritani et al . 1969; Black et al. 1968). Murdoch et al (1971) reported that the stimulatory effect of bicarbonate on sperm metabolism is more marked on glycolysis than on oxygen uptake. In their earlier work, Murdoch & White(1970) demonstrated that the principal site of bicarbonate action is on the reactions catalalysed by pyruvate - kinase in ram spermatozoa.

2.4 Major factors influencing semen quality

2.4.1 Breed

Variation in semen characteristics attributable to differences among breeds is a subject of extensive controversy. Some of the reported contradictions have been briefly outlined in the introductory part of this work.

Studies such as those of Napier (1961) and Beaty (1970) have shown that significant variations in sperm phenotype are genetically based rather than caused by the external environment. Purse (1973) as cited by Carr and Land (1982) contend that a considerable proportion of the variation even in the time of onset of the breeding season within a population may be of genetic origin. This proportion has been estimated to be 35% in a stock of Welsh Mountain Sheep.

In a comparative study between two breeds of sheep, Ulyanov and Kovalenko (1972) reported that semen quality was higher and undergoing fewer seasonal changes in Caucasian and 3/4 Lincoln-Longwool rams than in pure Lincolu-Longwool rams through the summer months. It was also noted that during the cold season Lincoln-Longwool semen improved although not to the level of Caucasian rams. Sahni and Roy (1972) observed a contrasting seasonal incidence of abnormal spermatozoa in the semen of Bikaneri, Mandya and Corriedale x Bikaneri on one hand, and that of Corriedale and Romney-Marsh on the other. The incidence of abnormal spermatozoa ranged between 1 - 2% in the first group and showed no seasonal variations, whereas for the second group it ranged between 0 - 48.8% for Corriedale and 1.6 - 63.7% for Romney - Marsh. Significant breed differences in the percent live spermatozoa and sperm concentration has been reported by Johari (1973) among Polworth, Ramboillet, Bikaneri and Rampur - Bushair rams. In this study it was observed that Ramboillet and Polworth rams had significantly lower sperm concentration(2122.9 x 10^6 & 1957.5 x 10^6/ ml, respectively) and percent live spermatozoa (80.42% & 79.13%, respectively), than Bikaneri (3620.2 x 10^6/ ml & 90.13%) and Rampur - Bushair (3450.0 x 10^6/ml & 89.66%) rams. During autumn the percent live spermatozoa was noted to be significantly lower in Ramboillet rams than that of all other breeds.

Studies involving both the temperate and tropical breeds of sheep and goats as reported by several workers (Zerfas et al., 1982; Davidenko et al., 1983; El-Fouly et al., 1980; Galal, et al. 1982; and Sahni et al., 1972) show little agreement on whether or not breed differences with respect to semen quality do exist. Contrary to those reporting breed differences in semen characteristics, Galal et al.(1978) on comparing the German Mutton Merino Aussimi and Merino backcross rams, observed that except for percent abnormal spermatozoa and interval to first mount, no other attribute of semen quality and libido was affected by breed group. El-Fouly et al., (1980) reported significant breed differences only for semen pH between Ossimi and Rahmani rams, whereas in Beetal and Assam bucks Borgohain (1983) noted a significant breed difference in percent mid piece abnormalities only. A comparison between Dorset-horn and Suffolk rams has shown a significant breed difference only in motility, with Dorset-horn rams producing semen of superior motility (Boland *et al*. 1984)

2.4.2 Nutrition

Among factors controlling the generation and output of sperm and accessory fluids in males, nutrition assumes a paramount role. Nevertheless, specific nutrient requirement for this process is yet to be precisely determined. The complexity of the problem arises from the fact that the processes involved are subject to fluctuations, according to climate and other environmental conditions, food habits and age of sexual maturation. In addition, other non - specific factors such as nervousness can complicate nutrient utilization to such an extent that"pseudo-malnutrion" results inspite of adequate composition of food.

A brief review on the experimental and clinical studies shows that chronic and acute starvation, caloric restriction, quantity and quality of protein, and also vitamins and mineral deficiences can precipitate to deleterious effects on testicular functions. So also is the effect of over nutrition (Meiles & Nelson 1960; Leatheum 1961).

A series of studies by Davies et al. (1957) on monozygotic twins calves demonstrate the impact of under-nutrition on spermatogenic and endocrine activity of the gonads. It was shown in this work, that restriction of food intake to one - half the normal intake markedly delayed the secretory activity of the accessory organs. Spermatogenesis was however, delayed by a lesser extent.

VanDemark et al(1964) working on bulls, observed that in addition to reducing semen volume and sperm numbers, underfeeding from 8 weeks to 46 months of age caused the bulls to be slower in replenshing sperm reserves. They also observed that the level of Total Digestible Nutrient (TDN) intake showed less effect on semen volume than on sperm numbers. Changing the TDN intake had little effect on semen replenishment rate; and only improved slightly the replenishment of the originaly underfed bulls as they were increased to 100% TDN. Hiroe et al (1964) reported that semen of bulls receiving 70% of National Research Council (NRC) TDN standard and 50% of NRC Digestible Crude Protein (DCP) standard, was inferior in volume, sperm concentration and concentration of fructose, total nitrogen, ascorbic acid, acid soluble phosphorus and calcium, compared with those given 95% and 113% of Standard TDN with 130 and 96% of standard DCP. Similarly, Flipse and Almquist (1961) observed that average motile sperm output per ejaculation by the low-fed animals was only 50% of that of bulls receiving 100 - 130% of the NRC recommended TDN allowance. They suggest that bulls on lower level of TDN intake before puberty may continue to exhibit below normal performance for a year after puberty.

A significantly earlier age of semen production (39 weeks) as a result of feeding high levels of TDN has been reported by Foote and Trimberger (1968). Working on bulls, Aliev (1964) noted that inclusion of skim milk in bull ration has a beneficial effect on reaction time, ejaculate volume, sperm motility, number of spermatozoa per ejaculate, concentration and semen pH. Optimum results were obtained with 20% skim milk in the ration with a concomittant increase in conception rate by 13 - 18%. Arbeiter (1963) reported that a change-over from poor quality to good quality hay resulted in a significantly longer sperm survival both in the whole and diluted semen of goats. An increase in percentage forward motility was also noted. However, this improved feeding had no effect on ejaculate volume or density, percent abnormal spermatozoa, pH and percent mass motility. In rams, Aliev (1965) reported that rams fed grain ration exhibited significantly superior ejaculate volume, sperm motility, concentration and sperm survival time than those on solely green forage. In the same work it was'noted that rams on grain rations had a reaction time three times shorter than that of the controls. Semenov and Koretskii (1971) reported that rams given more concentrates showed greater sexual activity, higher sperm concentration by 6.4 - 8.3% and higher sperm resistance by 23.7% than those under a standard diet. The conception rate and lambing rate following inseminations with semen of supplemented rams were respectively 10.4 and 15.1%

higher than after inseminationa with semen of control rams.

Extensive restricted energy intake has been observed to delay time of puberty in rams, boars and stallion; as well as decrease in libido, semen volume, sperm numbers per ejaculate, percent live spermatozoa, motility and an increase in percent abnormal spermatozoa (Hiroe & Tomizuka, 1965). However, energy restriction in the adults does not impart as severe changes as those observed in the young. Marked reduction in calorie intake will reduce semen volume in adult rams (Tilton *et al*. 1964) without reducing fertility. Extended undernutrition can cause infertility in the rams, but reallimentation will restore normal fertility (Mori, 1959). Most perceptibly pronounced effect of under-nutrition in adults is on gonadal endocrine activity rather than on its gametogenic function as illustrated by Mann (1964). Inadequate stimulation of the gonads by the hypophysis, and not an inability of the testis to produce testosterone, has been suggested to be the main effect of under-nutrition in causing delay in the onset of androgenic activity (Davis *et al* 1957).

Okolski *et al*. (1972) observed that a considerable decrease in semen production , sperm motility, fructose levels in the semen and an increase in the proportion of spermatozoa with primary and secondary abnormalities, resulted as a consequence of feeding rations containing sub-maintenance levels of protein. Braden *et al*.(1974) have reported results indicating that a high protein intake is not essential for high sperm production in rams; suggesting that a level of 12 grams Crude Protein (CP) digested in the intestine per 100 grams Digestible Organic Matter

(DOM) does not appear to be limiting for sperm production. Goettsch (1960) estimated the minimum need of dietary protein to support reproduction at 16.7% for rats and 13.6% for mice. Flipse and Almquist (1963) on the other hand, observed that bull calves fed rations containing 10% protein attain sexual maturity at the same time as those given higher level of protein. This differential dietary requirements of protein for reproduction between ruminants and non ruminants, seems to follow the pattern similar to that of requirements for general maintenance. Adequate levels of lysine, tryptophan, tyrosine and arginine, are equally as important in non-ruminants as in ruminants. Severe protein restrictions have been reported to reduce semen volume and total sperm numbers (Meacham et al 1963). In a latter work. Meacham et al., (1964) have demonstrated that a low protein diet reduces seminiferous tubule diameter in the bull. A markedly lower fructose and citric acid content as well as the activity of 5 - nucleotidase was reported for bulls maintained on a diet containing 1.6% protein when compared to those fed a normal diet containg 13.8 - 14.3% protein (Shirley et al. (1963). Limited work has been reported in respect to effect of protein on semen attributes in ruminants in general and in small ruminants in particular. Most studies on dietary protein requirements for testicular functions are mainly confined on monogastrics (Ewing et al. 1966; Shettles, 1960; Harpner 1964; Bujard et al.1964; Biswas & Deb, 1966; and Goldberg et al.,1961).

Regressive changes in the male accessory organs as well as general testicular dysfunction consequent to inadequate intake of vitamins A, E and B-complex have been extensively reported. (Dukelow,1967, Arscott &

Parker,1967; Bunyan _et al._; 1967 and Bieri & Prival, 1966). Considerable species differences exist in respect to response to vitamins deficiency. In rats, guinnea pigs and birds, vitamin E deficiency results into irreversible testicular damage whereas little or no effect has been noted in bulls, rams and goats. The use of tocopherol for treatment of low fertility in male farm animals has provided inconclusive results (Dukelow, 1967). Involvement of vitamin E in rats testicular metabolism and semen output has received critical examination by several workers (Bieri & Prival 1966; Griesbach _et al_.1957; Sinha _et al_. 1964 and Pecora & Arata 1964).

Subnormal sexual behaviour and subsequent reduction in the rate of spermatogenesis resulting from avitaminosis - A in young bulls has been reported by Ghannam _et al_. 1966. Adult bulls are however, not severely affected but produce a poor quality semen (Dixon _et al_ 1965). Vitamin A deficiency amplifies the seasonal changes in ram semen production with severe deficiencies precipitating into retarded testicular development reduced sperm production and quality as well as complete ceasation of spermatogenesis (Johnson _et al_. 1970). Induction of metaplastic keratinization of the epithelium lining the male accessory sex organs (Thompson _et al_ 1964), alteration of testis composition(Buttler _et al_., 1968; Bieri & Prival, 1966; and Gambal, 1966) and inhibition of spermatogenesis (Biswas & Deb, 1965) are among the major manifestations of vitamin A deficiency.

Retardation of testicular growth and accessory sex organs, reduction in testis weight, tubular degeneration, cryptorchidism and other anatomical and functional imparement of the testis are among the most common manifestations of vitamin B-complex deficiencies in males. These manifestationa are more pronounced among monogastrics than in ruminants.

Notwithstanding the seasonal limitations on energy, protein and vitamin intakes, mineral deficiencies have been reported to be among the major causes of infertility in domestic ruminants in Tanzania (Kategile et al 1978). Most limiting minerals include cobalt, magnesium, zinc, phosphorus, iron, manganese, iodine, calcium, copper and potassium. Numerous reports have affirmed the role and importance of minerals on the physical, morphological and biochemical properties of semen in sheep and goats (Hilderbrandt 1967; Hartel, 1967; El-Wishy et al 1968; Sadykov & Arifov 1969; Chernova & Aslanyan, 1971 and Dariush, 1971). Assumption by Simkiss (1967) that farm animals under practical feeding conditions do not exhibit infertility related to mineral deficiencies may not hold true under Tanzania conditions. Recent studies in Tanzania have shown that there exist distinct seasonal variations in mineral content in pastures which is also associated with reproductive patterns of grazing ruminants (Kidunda, 1981).

Grozevskaya (1964) reported that daily addition of 20 milligrams cobalt chloride or zinc sulphate at the rate of 0.25 - 0.5 mg/kg body weight increased ejaculate volume and improved semen quality in bulls. The addition of manganese chloride did not affect semen production, but had a favourable effect on general spermatozoan metabolism. In the same work, it was observed that a combination of the three minerals or of cobalt plus manganese or zinc was less effective than zinc or cobalt alone. Three out of every ten semen samples (i.e. 30%) from various breeds of rams were reported to be of substandard quality as a consequence of phosphorus deficiency in the diet (Bereznev, 1966). Rams given 20 g sodium phosphate daily for 30 days showed an increase in ejaculate volume, sperm concentration and total number of spermatozoa (Cernova 1969). An increase of semen volume by 8.9 - 29.1% consequent to feeding ram 0.5 - 1.0 mg calcium iodide per day has been reported (Sadykov & Arifov 1969). In the same work, a more pronounced effect of calcium iodide was noted on sperm concentration which increased by between 13.1 - 44.6%. Aslanyan and Dariush (1973) have shown that semen quality of rams given supplement containing copper, cobalt and zinc was higher than that of rams receiving no supplements. In their earlier studies, Aslanyan and Dariush (1972) demonstrated that a supplement of 0.15 mg cobalt sulphate, 0.45 mg copper sulphate, and 0.5 mg zinc sulphate per kilogram bodyweight per day to Askanian rams resulted in a signfiicantly higher sperm concentration, and sperm survival rate, a higher sperm count and a higher conception rate as compared with non - supplemented rams.

Reporting on the influence of feeding nitrate on semen quality of bucks, Harlet (1967) noted that percent forward motility was greater and lasted longer in bucks fed 11 grams of nitrate per day than those fed 0 - 8 g/day. Similar Hilderbrandt (1967) observed that daily doses of 11 grams of nitrate included in the concentrates fed to bucks improved their semen density and reduced the percent abnormal spermatozoa. Results presented by Bereznev (1966) Cernova (1969), Baicoianne et al (1964) and Wallace and Wales (1964) have all shown positive effects of dietary sodium zinc, iodine, potassium and phosphorus on semen quality and quantity.

2.4.3 Seasonal variations

In many seasonal breeders complete aspermatogenesis occurs during the non-breeding season, but in other species there is only a partial depression in sperm production rate (Fig. 2 and 3).

Seasonal influences on reproductive activity in bucks and rams have been extensively reviewed (Muhunyi et al.,1962; Greyling and Grobbellaar 1983; Mittal 1982; Vinha 1980; Sinha et al. 1981; Fischer & Mann (1979). A survey of literature shows that much attention has been focused on the influence of changing patterns of light for studies on seasonal breeders, whereas temperatûre has received most attention for those species which breed and reproduce throughout the year. As an overview, reproductive patterns of males is largely influenced by gaographical locality and the associated variations in climatic conditions. Photoperiod (Day-length) and atmospheric

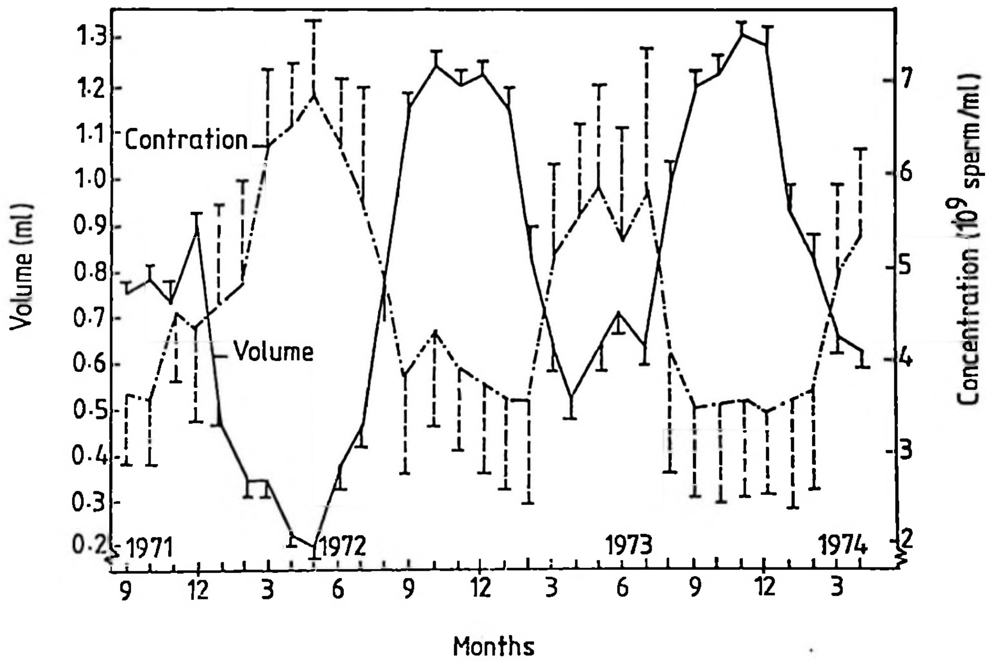


Fig. 2 : . Seasonal variations in volume and sperm concentration of ejaculates (m ± s.d.) poitevine males.

Source : Gall, (1970)

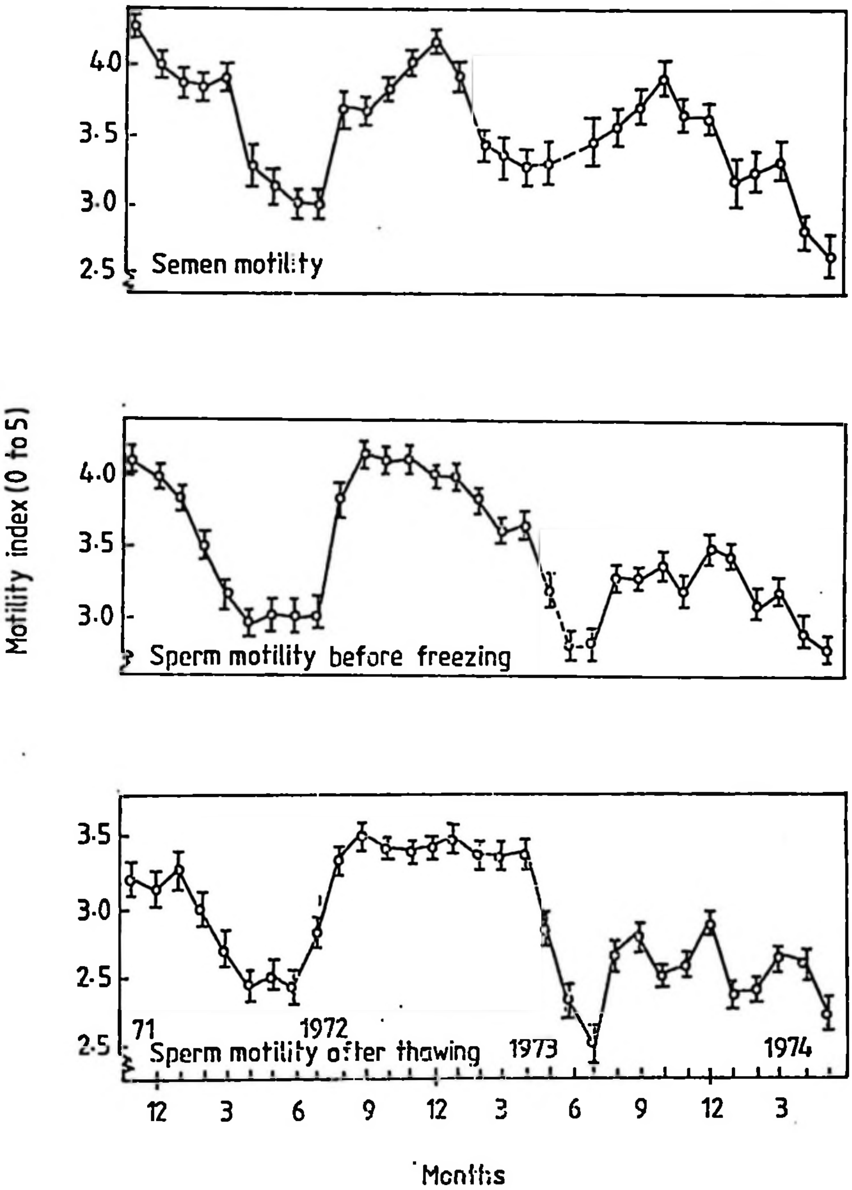


Fig. 3 : Monthly variations in semen and sperm motilittes (m± sm) in alpine bucks.

Source : Gall, (1970)

temperatures are the major climatic elements that have been shown to influence seasonal reproductive patterns in general and testicular function, spermatogenesis and semen quality in particular (Moule & Waites 1963; Erwing & VanDemark, 1963; Erwing & VanDemark 1960; Waites & Setchell 1964; Amann et al. 1965; and Almquist & Amann 1961). The perceptive impact of other factor is a function of geographical locality. Photoperiodic effects are more markedly manifested in the higher latitudes (Thwaites, 1965; Jackson & Williams, 1973) whereas atmospheric temperatures and relative humidity play a major role in and around the equator (Radford, 1961).

Corteel (1976) reported a markedly decreased motility accompanied by a decrease in fertilizing ability throughout the summer months in the semen of french-Alpine bucks. In India, observation by Vinha (1975) on Anglo-Nubian bucks revealed that semen volume was greater in autumn (1.65 mls) and smallest in summer (1.3 mls). The reverse order applies in the case of sperm concentration. Aslanyan & Lisovaja (1963) reported no appreciable difference in rams ejaculate volume during the year, but noted that there was a tendency for it being greater in summer and winter than in spring and autumn. They also observed greater sperm concentration and higher number of sperms per ejaculate in winter and spring, associated with greater sperm resistance and longer survival time. Lowest sperm motility was observed during the summer.

In a series of studies on goat semen, Iritani *et al.* (1964) have reported that ejaculate volume and the concentrations of citric acid; fructose and proteins were significantly higher during the breeding season than at other times. Sperm density was however, noted to be lowest during the breeding season. Observations made by Hoffman *et al.* (1972) on goats and by Galil and Galil (1982) in Sudan Desert - sheep are suggestive of the fact that hyper-activation of vesicular glands and the general functional interrelationships of androgens and accessory glands, follows a seasonal rythm and that this is markedly manifested during the mating season.

In Awassi and Border-Leicester rams, ejaculate volume and sperm numbers were reported to be highest in autumn and lowest in spring (Amir *et al* 1965). Similar pattern was observed for fructose content in rams semen (Moule *et al* , 1966; and Cupp *et al.*,1960), lipids, phos-pholids and cholestrole content in goats semen(Bilaspuri & Guraya 1980). The converse applies for sperm density. In the same study it was found that the seasonal fluctuations in fructolysis activity of spermatozoa was associated with the seasonal changes in sperm density. A fall in the ejaculate volume, sperm motility and concentration, and an increase in percent abnormal spermatozoa accompanied with a decline in libido throughout the summer to early autumn has been observed in the semen of bulls, rams (Table 10), goats and rabbits (Hiroe & Tomizuka, 1965; Sahni & Roy 1967; Misra & Sengupta, 1965; Holmberg, 1968; Smyth & Gordon 1967; Ashmawy 1979; and Sahni *et al* 1981). In South Africa Lamont (1964) observed that although there indeed exists a seasonal fluctuation in

Table 10 : Seasonal differences in semen characteristics of the (A) Ossimi Breed (B) Rahmani Breed

(A)	Seasons				
Parameter	Spring	Summer	Autum	Winter	Significance
Volume (ml)	1.06	0.92	0.95	0.87	*
Initial motility[1]	7.30	6.70	7.30	5.60	**
Concentration($\times 10^6$/ml)	9.940	3.235	3.162	2.806	**
Total abnormalities (%)	9.23	21.52	12.17	12.41	
Live % in fresh	70.84	55.85	64.67	55.07	
Live % in stored*	47.41	34.14	46.36	45.46	
(B)					
Volume (ml)	1.13	1.10	1.29	1.17	NS
Initial motility[1]	6.20	6.00	6.70	5.40	NS
Concentration($\times 10^6$/ml)	3.376	3.607	3.370	2.961	*
Total abnormalities(%)	9.78	23.92	13.81	17.39	
Live % in fresh	64.67	51.85	59.92	46.83	
Live % in stored	49.59	29.19	54.74	41.43	

* Significance ($P < 0.05$)

** Significance ($P < 0.01$)

[1]Stored for 48 hours at $4^{o}C$

Source : Hafez (1955)

the semen characters of Merino rams, the depression in quality during the summer is nevertheless still within the limits of good quality semen. He further suggests that the high environmental summer temperatures are of primary importance in controlling fluctuations in semen quality. Galil and Galil (1980) reported that in Sudan Derset sheep ejaculate volume, average wave-motion score, percent forward motility and average percent live spermatozoa were lowest during winter months. Contrary to other workers, Juma and Dessouky (1969) observed that a general fall in ejaculate volume and increase in percent dead as well as abnormal spermatozoa, is a phenomenum observed during winter months in Awassi rams.

Michelsen et al.(1982) reported that there is a marked seasonal variations in scrotal circumference, libido and serving capacity in Suffolk, Lincoln, Columbian and Polypay rams. Both serving capacity and percent normal spermatozoa were observed to correspond with the seasonal variations in scrotal circumference. Simplicio et al.(1982) also observed seasonal variation in testicular measurements associated with changes in semen attributes in Somali rams. However, they contend that the magnitude of the seasonal effects was not sufficient to prevent the rams being used for breeding throughout the year. In tropical bulls, the seasons have been shown to influence the sperm dimensions as well (Mukherjee & Singh,1966; Pant & Mukherjee,1972; and Roychoudhry, 1969). A correlation between testis weight with testis diameter ($r = 0.62$, $P < 0.001$) and scrotal circumference ($r = 0.86$) has been reported by Daudu (1984) in Red Sokoto goats and by Drymundssen et al.(1982) who also observed that the testis diameter was greatest in autumn and lowest in spring in Icelandic rams. Islam and Land (1977) have reported a genetic covariance between seasonal changes in testicular size and seasonal changes in the incidence of ovulation in rams of different breeds.

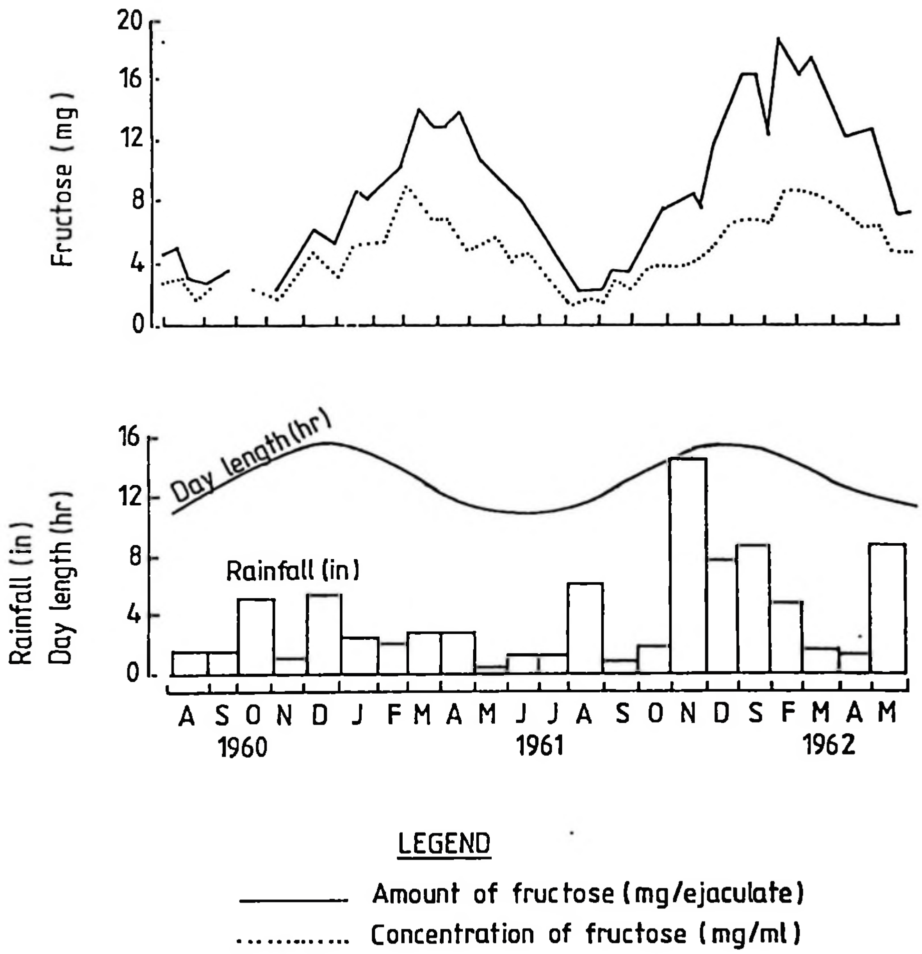
Studies on the mechanisms through which animals manifest seasonality in reproductive activity and in semen quality have attracted considerable attention. Ravault (1976) as cited by Carr and Land (1982) suggests that the concentration of prolactin in peripheral blood could be the possible criterion of seasonality, because hyper-prolactineaemia is a characteristic of rams during non breeding season. However other workers have shown that there is no clear relationship of seasonal variation in the concentration of plasma prolactin and the expected period of reproductive function (Carr & Land, 1982, Howles et al 1980). Lincoln and Kay (1979) noted maximal Luteinizing Hormone (LH) levels just prior to mating season and maximum testosterone levels during mating season coinciding with peak testicular activity in Red deer Stag.

2.4.3.1 Effect of temperature on semen attributes

The effect of heat, either environmental or applied, on semen quality in the ram and bull has been investigated in a number of studies (Cupps et al.,1960, Collins et al.1968 McDowel, 1970; Austin et al.,1961 and Howarth, 1969). Degeneration of germinal epithelium of the testis of animals with scrotal testis as a result of exposure to temperatures higher than those normally found in the scrotum has long been known.

Malikov(1963) reported that periods of low atmospheric temperature were related with good quality semen, while those of high temperature were related with production of poor quality semen in rams. Similar observations were made by Hiroe and Tomizuka (1965b,)who suggest that high environmental temperature resulted in the so called "summer sterility" in rams and goats. By subjecting rams to 38°C for 24 hours. Djanuar (1965) and Simpson (1966) found that sperm motility declined by about 60%. Continuous exposure to 27°C - 43°C resulted into irreversible depression of semen quality and reaction time in Leicester rams (Lindsay, 1969). Observation made on Merino rams exposed for 3 days to two 6 hours periods in a climate - chamber at 40.5°C; 8.5 mm Hg vapour pressure and 40.5°C; 31 mm Hg respectively; showed a decrease in semen quality in all rams after the treatment (Moule & Waites, 1963). In the same study, it was noted that the change was related to the rise of temperature of the subcutaneous tissue of the scrotum. A comparative study on the effect of direct impact of air temperature on semen quality revealed that semen of rams reared indoors exhibited superior sperm motility score, concentration and percent live spermatozoa than that of rams on outdoor rearing (Dwirvedi, 1977).

The seminal degeneration that follows exposure of rams to high air temperatures appears to be due to the direct effects of heat on the testis; for when temperature stress is severe, local thermo-regulation fails and testicular temperature rise(Moule & Knapp, 1950). Assuming that the cooling mechanism of the scrotum plays an essential role in the regulation of spermatogensis and testicular



Source: Moule G.R. et al (1966); Aust. J. Agric. Res. Vol.17: 923

Fig. 4 : . Seasonal fluctuations in the concentration (mg/ml) and amount (mg/ejaculate) of fructose in the semen of rams at pasture. Monthly rainfall and seasonal changes in day length are also shown.

metabolism, one might expect that abnormal increases in temperature would result in changes in metabolic activity of the testicular tissue. Evidence has been presented suggesting occurence of absolute change in metabolism in testicular tissue after exposure to elevated temperature (Ewing & VanDemark 1969, 1961; VanDemark & Ewing 1963; Waites & Setchell, 1964; Gomes et al . 1971; Sod-Moriah, 1974 and Gomes & Joyce, 1975). Ewing and VanDemark (1963) further suggest that the spermatogenic arrest which results from exposure of the testis to elevated temperatures may be caused by reduced levels of substrate (especially glucose and lactic acid) in the tissue.

2.4.3.2 The effect of Photoperiod on semen attributes

In seasonally breeding species, the controlling effect of changing photoperiod on reproduction has been well documented. As early as 1937, Marshal (1937) propounded that photoperiod is the principale environmental cue which times the reproductive cycle of the domestic ram. Ten years later, Yeates (1947) demonstrated that decreasing day-length stimulates reproductive activity in the ram. Numerous reports during the last decade conform with these earlier assertions. Johnson and Desjardins (1973) have reported on the coincidence of maximal spermatogenic and steroidogenic activity with the decrease in photoperiod in Suffolk and Hmapshire rams. A gradual decline was associated with increase in photoperiod. Jackson and Williams (1973) also noted response to light as reflected by changes in semen attributes consequent to changes in light regime among Suffolk rams. Similar changes were observed by Cupps et al.(1960) for seasonal changes in ejaculate volume, percent live spermatozoa and % percent abnormal spermatozoa. Figure 4 shows the changes in both amount and concentration of fructose in rams ejaculates consequent to changes in day - length.

The review by Symington and Oliver (1966) summarizes the contradictory reports on the photoperiodic effects on sexual activity of sheep and goats in the tropical and subtropical latitudes. A series of reports by Beaty and Williams (1971) and by Williams (1972) draw attention to the considerable variation in the reproductive efficiency of seven British breeds in an equatorial location. Thwaites (1965) postulates that since day - length at the equator varies from the mean value of 12 hours 50 minutes by only $\pm$ 2 min. then the equatorial environment must eliminate normal photoperiodic response. From a study on Mutton Merino in Israel, it was observed that the short - day photoperiodic theory is not applicable to all breeds of sheep (Goot, 1969). It is further suggested that in sheep with a long sexual season, genetic heterozygosity may be responsible for regulating the breeding season by allowing other environmental stimuli besides light to trigger - off sexual activity. In the Sudan, Halima & Brudieux (1980) working on Sudan Desert sheep, concluded that the short - day photoperiodic theory is not applicable to all breeds of sheep or to all environmental conditions. By alternating photoperiod between 8 hours and 16 hours of light, Boland et al.(1984) observed no significant change in semen volume, sperm motility and percent dead or abnormal cells in Dorset - Horn and Suffolk rams. Similarly Fowle (1965) could not determine if the daily photoperiod exerted a direct or indirect effect on the semen quality of Merino rams.

A number of studies have been conducted to determine the mechanism by which the photoperiod exerts its influence on reproductive cyclicity in general and semen quality in particular. Pelletier and Ortavant (1975) have shown that changes in photoperiod affect reproductive physiology by influencing the release of gonadotrophins from the anterior pituitary gland (APG). Decrease in day length stimulale both synthesis and release of Luteinizing Hormone (LH) and Follicle Stimulating Hormone (FSH) resulting in enhanced spermatogenesis and testosterone production by the testis (Lincoln, 1976). The mechanism by which the photoperiod regulates hypothalamic L-RH activity is still unknown. A number of recent studies indicate that at least part of the photic - induced change in pituitary gonadotrophins release may be due to alteration in the sensitivity to steroid feedback of gonadotrophins control centre as suggested by Hoffman (1973). In rams, it has been shown that an exposure to non - stimulatory photoperiod renders the hypothalamic - hypophyseal axis sensitive to the negative feed back effect of steroid hormones (Pelletier & Ortavant 1975). Other studies however, suggest that the photoperiod can alter hypothalamic-pituitary Gonadal activity independent of steroid hormone (Gibson _et al_. 1975; Davis & Meyer, 1973). Turek and Campell (1979) conforming to this line, suggest that two mechanism, one steroid dependent and the other steroid independent, are involved in the photoperiodic control of neuro - endocrine - gonadal activity.

MATERIALS AND METHODS

3.1 The experimental animals

The Norwegian bucks used in this study were drawn from among bucks acquired by the Department of Animal Science (S.U.A.) from Norway in 1983 and 1984 (for the old and the young bucks respectively). The local (Tanzanian) bucks were among bucks born and reared at the department's goat unit. Crossbred bucks were obtained from a group of first generation kids sired by the Norwegian bucks acquired in 1983.

The Norwegian bucks belong to the typical Norwegian milking goats, commonly known as "Telemark white goats". These goats are said to have descended from Capra aegagrus (French, 1970). Characteristically, they are white in colour with long sabre horns and a dense growth of long hairs. Mature males weigh about 35 kg on average.

The Tanzanian Local bucks are a representative of the large group of meat goats collectively known as a Small East African goat. They posses short straight horns, have a short shiny hair coat of variable colours and stand about 60 cm at withers. Males are well musceled and weigh about 25 - 30 kg. They have a prominent ridge of long coarse hair running the full length of the back.

3.2 Description of the environment

The Sokoine University Farm and Magadu Dairy Unit are situated at around 6^{o} - 7^{o}S, 37^{o}E - 38^{o}E, about 550 meters above sea level. The two units are sandwiched between Uluguru mountains to the east and Mindu - Lugala flood plains to the west.

The area experiences a bimodal rainfall regime with short rains falling between November and January, while the long heavy rains fall between March and May. The annual precipitation ranges between 600 mm - 1000 mm (average 908 mm) with the peak normally received in April. This rainfall is adequate for pastures which require 400 - 1000 mm of precipitation. The most common natural pasture species include Hyperrhania rufa, Pennisetum purperium and and Chloris gayana

The temperature ranges between 15^{o}C - 35^{o}C with the hottest months being between October to January (20^{o}C) while the cool months are April to July (15^{o}C minimum) in a normal year.

3.3.1 The experimental procedure

A total of 32 bucks were used in this experiment. The bucks were categorized into two major groups described here as group I (GI) and group II (G II).

Group I comprised of two subgroup (A_o) and (B_o). Subgroup A_o consisted of 4 pure local bucks of 3 years of age, while subgroup B_o consisted of 4 pure Norwegian bucks of 2½ yrs. old.

Group II comprised of three subgroups, A, B and C. Bucks in all subgroups were of about similar age ranging between 12 - 14 months at the beginning of the experiment. Subgroup A consisted of 9 pure local bucks, that of B was of 6 pure Norwegian bucks and subgroup C consisted of 9 Norwegian half - crosses.

Two periods, each of 3 months were described:

1st January - March (hot season prior to long rains)

2nd April - June (cool season; during the long rains)

For group I, comparison of semen attributed was done for the period from January to June. Semen collection was suspended during the mating season of January - March for those bucks that got involved in the mating. For group II, observations were made for the period from April to June when all bucks had attained between 12 - 14 months of age.

3.3.2 Housing and feeding

All bucks were kept indoors and were stall - fed throughout the experimental period. Local bucks that were previously being grazed, were kept indoors and stall-fed with similar diets as the Norwegian bucks 21 days before the beginning of sampling.

Fresh Guatamala grass (*Tripsicum laxam*), Rhodes grass (*Chloris gayana*) hay and standard dairy meal concentrates were provided *ad libitum*. The concentrate component constituted 30% of the total ration. The proximate compositions of the principal roughages used are given in the Table 11.

In addition to this, mineral supplements were given mixed together with the concentrates. Water was provided ad libitum.

3.3.3 Semen collection and evaluation

All bucks were accustomed to the Electro-ejaculator one month prior to the commencement of collection period. Semen was collected once weekly, taking two ejaculates at an interval of 8 hours on each day of collection. A bipolar electrode of Blackshaw was used. A maximum stimulation of 10 volts at 40 cycles per second was given and the ejaculum was collected in a graduated test tube. Care was taken to prevent sudden changes in temperatures by placing the tubes with samples in a thermos flask (pre-warmed to 37°C by a hot wet cotton swarb) immediately after collection. Throughout observation time, samples were maintained at 36.5°C - 37°C in a water bath.

The spermatozoa were counted with a heamocytometer in duplicate samples diluted with 1% Eosin B in 3% (w/v/ Sodium Chloride Solution. Mass motility was scored as described by Zemjannis (1970) with score values ranging between 0 - 5 in ascending order of activity. The percent motile spermatozoa was estimated under high power after the semen was diluted in Isotonic (0.08 m) sodium phosphate buffer of pH 7.0. The percent livespermatozoa was determined after differential staining with 1% Eosin B in 2.6% sodium citrate dehydrate containing 5% Nigrosin as described by Quinn and White (1966).

Atomic absorption spectrophotometer was used for the determination of levels of sodium, potassium, calcium, magnesium, copper and zinc in the seminal plasma. The seminal plasma was obtained by centrifugation of the samples at 3000 revolutions per minute(r.p.m.) for 30 minutes as suggested by Garbers and First (1971).

Samples were diluted in distilled water for sodium and potassium determinations, whereas for calcium and magnesium 0.78% EDT Na_2 solution was used as a diluent. For copper and zinc, the supernantant was used after centrifugation of seminal plasma samples diluted in Trichloroacetic acid (TCA). The standards containing 2.5 - 25.0 ppm of calcium, 0.5 - 3.0 ppm of copper, 0.1 - 0.8 ppm of magnesium, 0.4 - 6.0 ppm of zinc, 0.25 - 4.0 ppm of sodium and 0.5 - 6.0 ppm of potassium were used for the determinations of the unknown samples. The seminal plasma used in all determinations was drawn from pooled samples from each respective group.

Additional measurements taken included:-

- Liveweight (kg) of bucks taken monthly
- Body measurements:- Chest circumference, height at withers and body length - (values given in appendix)
- Scrotal dimensions: - length and circumference measured as described by Igboeli (1974)
- Meteorological data:- Monthly averages for maximum and minimum temperatures. Relative humidity, solar radiation and sunshine hours

Table 11 : Proximate composition of Guatamala grass (*Tripsicum laxam*), Rhodes grass hay (*Chloris gayana*) and concentrates (wheat bran + cotton seed cake) fed to the experimental bucks

	Expressed as percentage dry matter						
	% DM	% CP	% CF	% EE	% Ash	% NFE	ME (MJ/kg)
Guatamala grass	35	11.5	26.6	2.2	5.7	54.0	9.75
Rhodes grass	34.5	9.1	25.0	2.0	6.6	57.3	9.79
Concentrates	90.25	15.96	6.9	-	-	-	-

NB : Determination of EE, NFE, ME and Ash in the concentrates were not done

Parameters observed and derived include :-

1) semen volume (mls) - (P_1)
2) semen density (no. of sperms/ml) - (P_2)
3) percent live spermatozoa (%) - (P_3)
4) mass motility score (wave - motion) - ranging from 0-5 -(P_4)
5) total number of spermatozoa per ejaculate - derived as semen volume x semen density - (P_5)
6) total number of live spermatozoa per ejaculate - derived as total number sperm/ejaculate x % live spermatozoa - (P_6)

3.3.4.1 <u>Statistical analysis</u>

For analysis of results, a mixed model was assumed. The bucks and breeds, were considered as fixed, while months and seasons were regarded as random efeects. The following statistical model was used to described the effect of the variables studied:

$$Yijklm = U + A_i + B_j + (AB)_{ij} + C_{ik} + D_{jl} + E_{ijklm}$$

where Y_{ijklm} = observation on the m^{th} ejaculate of the k^{th} buck of i^{th} breed in the l^{th} month of j^{th} season.

U = general mean

A_i = effect of i^{th} breed

B_j = effect of j^{th} season

$(AB)_{ij}$ = interaction of i^{th} breed with j^{th} season

C_{ik} = effect of k^{th} buck of i^{th} breed

D_{jl} = effect of k^{th} month of j^{th} season

E_{ijklm} = random element

The procedure for analysis of nested factorial experiment as outlined by Becker (1964) was followed, except that in this case account of unequal "cell" numbers was taken. Due to the computer limitations, the analysis was performed in two steps. In step 1 effects of the bucks (regardless of breed) and months (regardless of season) were computed (in a two-way classification). In step 2, effects of breed and season and their interactions were analysed. The breed effect (SS_B) was substracted from the buck effect (SS_b) in step 1 to estimate effect of the buck within breed (SS_{bB}). Similarly the season effect was extrapolated from the month effect in step 1 to estimate the effect of the month within season. Finally the interaction (SS_I) was substracted from the residual (SS_R) in step 1 to estimate a new residual sum of square.

3.3.4.2 Tests of significance

- Mean square for breeds was tested against mean square for bucks within breed.
- Mean square for season was tested against mean square for months within seaso .
- Mean square for bucks was tested against residual mean square
- Mean square or months was tested against interaction (Bucks x months) mean square where the latter was significant - residual mean square was used where the case was otherwise.
- Interaction mean square was tested against residual mean square.

The standard deviations for all mean values given were calculated as suggested by Henderson (1960). Due to the small number of bucks per breed group it was thought to be unnecessary to compute the variance components for bucks.

Partial regressions were calculated for association between testicular dimensions, body measurements and semen attributes. Unless otherwise stated, the asteriks *, ** and *** have been used to denote statistical significance ($P < 0.05$), ($P < 0.01$) and ($P < 0.001$) respectively.

RESULTS

4.1 Effect of the bucks within breeds

Tables 12, 13 and 14 show significant variations among bucks within breeds in respect to semen volume, ($P < 0.01$), density ($P < 0.01$), wave motion score ($P < 0.05$) and total number of livespermatozoa per ejaculate ($P < 0.05$). Table 13 shows that a considerable proportion ($r^2 = 35\%$) of all variation in semen volume was attributable to the difference in liveweight. By standardizing liveweight into metabolic body weight ($W^{0.75}$) it could be noted that variation in body size accounted for nearly one half (48.7%) of all factors influencing semen volume in bucks (Table 15).

Although a significant variation among bucks was noted for density and semen volume, variation in total number of spermatozoa per ejaculate was non - significant (Table 14). Similarly variation in percent livespermatozoa was not significant (Table 13).

When each ejaculate (within buck) was considered as a possible source of variation it was noted that except for sperm density, variations within bucks for all other parameters were non - significant. However, no attempt was made to compute correlations among the different ejaculate attributes.

Table 12 : Mean ± SE.[1] of semen volume (mls) and percent livespermatozoa among bucks in group 1

Parameter	Breed	Bucks 1	Bucks 2	Bucks 3	Bucks 4	F - ratio
Semen volume (mls)(P_2)	Norwegian	1.06 ± 0.13	1.20 ± 0.12	1.27 ± 0.08	1.73 ± 0.12	4.81^{**}
	Local	0.97 ± 0.09	1.49 ± 0.56	1.01 ± 0.11	1.27 ± 0.18	
% Livespermatozoa (P_2)	Norwegian	62.68 ± 4.79	68.14 ± 5.14	63.51 ± 5.19	61.82 ± 7.80	0.88 NS
	Local	59.55 ± 6.66	78.04 ± 5.96	64.59 ± 4.78	59.53 ± 2.16	

[1]SE. = standard error

Table 13 : Mean ± S.E. of semen density and wave - motion score among bucks in group 1

Parameter	Breed	Bucks 1	2	3	4	F - ratio
Wave motion (P_3)	Norwegian	1.55 ± 0.63	2.00 ± 0.95	2.06 ± 1.25	2.32 ± 1.02	20.38**
(0 - 5)	Local	1.97 ± 0.84	3.08 ± 1.05	3.21 ± 1.40	1.97 ± 0.96	
Semen density (P_4)	Norwegian	259.53 ±20.50	271.18±19.75	259.79±21.34	189.07±16.07	23.46**
(x 10^7 / ml)	Local	305.77±25.34	354.4±29.56	478.75±38.75	264.4 ±19.65	

** Significant ($P < 0.01$)

Table 14 : Mean ± S.E. of total number of spermatozoa/ejaculate and total number of livespermatozoa/ejaculate among bucks in group 1

Parameter	Breed	Bucks 1	2	3	4	F-ratio
Total number of spermatozoa per ejaculate	Norwegian	275.10±23.55	325.42±26.08	329.93±20.17	327.10±18.38	1.85 NS
($x\ 10^7$) (P_5)	Local	296.59 ±19.35	528.06±46.64	483.54±40.60	335.79±29.52	
Total number of livespermatozoa/ejaculate	Norwegian	172.43±12.56	221.74±20.12	209.53±17.56	202.20±18.27	34.56^{**}
($x\ 10^7$) (P_6)	Local	176.62±9.37	412.09±32.40	312.32±24.30	199.89±20.00	

Table 15 : Simple and multiple regression coefficients and correlation (r) between semen volume and liveweight, metabolic body weight and testicular measurements in bucks

Parameter	Regression line	r
Testicular circumference (cm)/liveweight (kg)	$13.48 + 0.3168 X_o$	0.775
Testicular length(cm)/ liveweight (kg)	$6.015 + 0.1532 X_o$	0.707
Testicular circumference (cm)/testicular length (cm)	$4.598 + 1.704 X_1$	0.902
Volume(ml)/testicular circumference (cm)	$0.3224 + 0.025 X_2$	0.411
Volume (ml)/liveweight (kg)	$0.4198 + 0.0185 X_o$	0.594
Volume (ml)/metabolic body weight	—	0.698
Volume (ml)/X_1, X_2	$-214.8713 - 0.107 X_1 + 10.38 X_2$	
Volume (ml)/X_o, X_2	$0.414 + 4.88 \times 10^{-3} X_o + 0.0154 X_2$	

X_o = Liveweight (kg)

X_1 = Testicular length (cm)

X_2 = Testicular circumference (cm)

Table 15 summarizes results from computation of simple and multiple coefficients of regression between semen volume and liveweight, metabolic body weight and testicular measurements in bucks. Computations were based on average values of variables of each individual buck. Distinction of bucks into their respective breed groups was not done for these computations.

4.2 Effect of the breed

Tables 16, 17, 18 and 19 show that, breed of the buck had a significant effect on the wave motion-score ($P < 0.05$), density ($P < 0.01$), total number of spermatozoa per ejaculate ($P < 0.01$). Local bucks in group 1 exhibited superior values in all these parameters. No significant breed effect was observed in respect to semen volume for bucks in group 1 (Table 16).

Table 16 : Effect of the breed of buck in group 1 on mean ± S.E. of semen volume, percent livespermatozoa and wave - motion score

	Buck breed		
Parameter	Norwegian	Local	F- ratio
Semen volume (ml)	1.32 ± 0.11	1.18 ± 0.12	0.83 NS
% livespermatozoa	64.03 ± 1.40	64.69 ± 4.75	0.17 NS
Wave - motion score	1.98 ± 0.16	2.56 ± 0.38	4.42*

Table 17 : Effect of breed of the buck in group 1 on sperm density, total number of spermatozoa per ejaculate and total number of livespermatozoa per ejaculate (mean ± S.E.)

Parameter	Buck breed		F - ratio
	Norwegian	Local	
Semen density(x 10^7/ml)	244.89 ± 18.8	350.83 ± 46.43	5.97*
Total sperm/ejaculate(x 10^7)	314.38 ± 13.13	410.99 ± 56.05	7.46*
Total livespermatozoa/ejaculate (x 10^7)	201.48 ± 10.48	275.23 ± 54.4	11.80**

Table 18 : Effect of breed of the buck on semen volume, % livespermatozoa and wave - motion score (mean ± SE .) (Group II)

Parameter	Buck breed			F-ratio
	Local	½ Norwegian crosses	Norwegian	
Semen volume (ml)	0.67 ± 0.03	0.84 ± 0.03	1.06 ± 0.17	5.99*
% livespermatozoa	58.89 ± 6.17	43.19 ± 3.55	54.88 ± 4.86	10.93**
Wave-motion score (0 - 5)	1.64 ± 0.31	1.56 ± 1.02	1.64 ± 0.94	0.05 NS

Table 18 show that contrary to observations in group 1 significant breed effect was noted for semen volume and percent livespermatozoa among bucks in experimental group II. Norwegian bucks exhibited significantly ($P < 0.05$) higher semen volume (1.06 ± 0.17 ml) than both the local and the Norwegian half crosses (0.67 + 0.03 ml and 0.84 ± 0.03 ml, respectively). Semen drawn from local bucks had significantly ($P < 0.05$) higher percent livespermatozoa (58.89%) than that of both the Norwegian (54.8%) and the crossbred bucks (43.19%).

In Table 18 it can also be noted that bucks in all breed group exhibited about the same wave-motion scores inspite of the significant breed differences observed for the proportion of livespermatozoa in ejaculates.

Table 19 : Mean ± S.E. of semen density, total number of spermatozoa/ ejaculate and total number of livespermatozoa/ejaculate among bucks in group II

	Buck breed			
	Local	½ Norwegian crosses	Norwegian	F-ratio
Semen density (x 10^7/ml)	203.64 ± 15.57	197.04 ± 20.33	193.06 ± 17.08	0.02 NS
Total number of spermatozoa/ejaculate (x 10^7)	136.43 ± 11.50	165.51 ± 10.25	204.64 ± 12.40	1.06 NS
Total number of live-spermatozoa/ejaculate (x 10^7)	80.34 ± 5.32	71.48 ± 6.87	112.31 ± 9.8	1.49 NS

Table 20 : Analysis of variance for semen characteristics in Group I

Source	df	Parameters[1] (F - ratio)					
		P_1	P_2	P_3	P_4	P_5	P_6
Bucks	7	4.81**	0.88	20.38**	23.46**	1.85	34.56
Breeds	1	0.83	0.167	4.42*	5.97*	7.46*	11.80**
Bucks/breed	6	4.93	1.00	19.23	16.47	1.37	30.95
Months	5	1.91	12.74	10.52	13.34	1.29	3.22
Seasons	1	4.27	1.92	0.14	4.35	0.99	1.80
Months/seasons	4	1.15	10.75	12.69	7.98	1.29	2.77

[1]Parameters P_1 - P_6 are as defined under materials and methods

Table 21 : Analysis of variance for semen characteristics in Group II

		Parameters (F-ratio)					
Source	df	P_1	P_2	P_3	P_4	P_5	P_6
Bucks	22	5.25	10.20	3.83	5.42	1.50	4.47
Breeds	2	5.99*	10.93**	0.05*	0.02	1.06	1.49
Bucks/breed	20	4.81	10.26	0.22	5.94	1.56	4.28
Months	2	8.55	1.85	0.55	11.93	4.17	9.79
Residual	138	132	101	114	114	108	
Total	184	178	147	160	160	154	

* Significant at ($P < 0.05$)

** Significant at ($P < 0.01$)

Table 22 : Liveweight and testicular measurements (mean ± S.E.) of the different breed groups

	Group I		Group II		
	Norwegian	Local	Norwegian	½ Norewegian	Local
Liveweight (kg)	42.58 ± 0.74	35.54 ± 1.78	30.08 ± 1.07	25.45 ± 0.78	14.74 ± 0.80
Testicular length (cm)	-	-	10.92 ± 0.61	10.0 ± 0.36	7.90 ± 0.35
Testicular circumference (cm)	-	-	23.75 ± 1.01	22.0 ± 0.42	16.98 ± 1.29

Table 23 : Effect of the month and breed of the buck on semen volume (ml), % livespermatozoa and wave - motion score in Local and Norwegian bucks in Group 1

	Months					
	January	February	March	April	May	June
Semen volume (ml)						
Local	1.16 ± 0.10	1.2 ± 0.05	1.16 ± 0.01	1.0 ± 0.50	0.93 ± 0.07	1.25 ± 0.01
Norwegian	1.16 ± 0.06	1.56 ± 0.04	1.56 ± 0.09	1.25 ± 0.02	1.10 ± 0.00	1.25 ± 0.02
% livespermatozoa						
Local	69.26 ± 4.30	62.16 ± 5.40	75.05 ± 5.60	63.7 ± 2.46	49.96 ± 6.50	59.15 ± 5.60
Norwegian	79.06 ± 3.50	73.56 ± 6.86	64.7 ± 3.04	72.13 ± 11.20	40.7 ± 3.30	42.8 ± 2.50
Wave - motion						
Local	1.79 ± 0.35	2.09 ± 0.42	2.97 ± 0.35	2.66 ± 1.08	2.33 ± 0.35	2.41 ± 0.30
Norwegian	1.80 ± 0.29	1.79 ± 0.16	2.08 ± 0.28	2.44 ± 0.30	1.25 ± 0.26	1.57 ± 0.25

A summary of variance analysis for the parameters observed in Group I and II is presented in Tables 20 and 21, respectively.

Table 22 summarizes the mean values and this standard errors observed for liveweight and testicular measurements among the different breed group in group 1 and group II. No testicular measurements were taken for bucks in group I. Much variation was observed in testicular circumference ($P < 0.01$) which was also shown to have a close correlation with liveweight ($r = 0.77$) and with semen volume ($r = 0.41$).

4.3 Effect of the month of semen collection

Tables 23, 24, 25 and 26 show results of the effect of the months and of the breed of the buck on semen characteristics among bucks in groups I and II, respectively. Significant monthly variations were noted for percent livespermatozoa ($P < 0.05$), wave- motion score ($P < 0.05$) and density ($P < 0.05$) for bucks in group I. Significantly higher values of percent livespermatozoa were recorded in March (75.05 $\pm$ 5.6%) for local bucks and in January (79.06 $\pm$ 3.5%) for Norwegian bucks.

Table 24 : Effect of the month and breed of the buck on semen density, total number of spermatozoa per ejaculate and total number of livespermatozoa per ejaculate in local and Norwegian bucks in group 1 (mean ± S.E.)

	Months					
	January	February	March	April	May	June
Density (x 10^7/ml)						
Local	304.7±22.46	299.8±18.63	264.3±9.42	397.5±21.6	325.2±19.07	508.7±30.43
Norwegian	214.9±17.19	272.2±20.23	226.10±12.59	252.16±13.44	285.0±8.55	237.9±11.92
Total number of spermatozoa/ejaculate (x 10^7)						
Local	353.45±25.54	359.76±20.69	306.58±18.08	397.58±29.51	302.4±33.11	635.6±52.63
Norwegian	249±11.48	424.63±34.26	352.71±31.72	315.2±21.25	313.5±30.05	297.38±19.73
Total number of live-spermatozoa/ejaculate (x 10^7)						
Local	244.79±14.74	223.62±13.62	230.10±18.03	253.25±20.00	149.99±7.35	376.10±29.56
Norwegian	197.18±13.74	312.10±21.10	228.19±16.92	227.35±14.37	127.59±11.7	124.89±9.93

For the Local bucks, a declining tendency in % livespermatozoa was noted towards both ends of the experimental periods after the peak in March. As for the Norwegian, a gradually falling overall proportion of livespermatozoa was observed towards June. In both breed groups' lowest % livespermatozoa was recorded in May.

Monthly variation in semen volume among bucks of both breeds in group I was inconsistent and insignificant. However, lowest volumes were recorded in May, (0.93 ml and 1.10 ml for Local and Norwegian bucks, respectively). Highest values were recorded between February and March in both groups (1.2 - 1.16 ml for local bucks and 1.56 ml for Norwegian bucks).

Wave - motion scores (Table 23) showed considerable monthly variation in both breed groups. A trend of increasing mass activity was noted between February and April with peak values recorded in March for the Local bucks and April for the Norwegian bucks. Mass activity showed a close correspondence with changes in percent livespermatozoa particularly among the Local bucks.

Considering most of the observed semen attributes (Tables 23 and 24) local bucks exhibited overall superior semen quality in June than in all other months, whereas for the Norwegian bucks,fairly good quality ejaculates were collected in January.

For bucks in group II, highly significant ($P < 0.01$) monthly variations were noted for semen volume, density and total number of livespermatozoa per ejaculate in all breed groups (Table 25). Contrary to observation in group I, monthly variation in semen volume for bucks in group II were significant though inconsistent. A linear increment in density was discernable in all breed groups. Crossbred bucks demonstrated a more remarkable increase in semen density than the other two breed groups.

Wave - motion score for crossbred bucks was observed to be considerably higher than that of Norwegian and Local bucks. This was particularly so in May and June. Except for the Local bucks, all other breed groups exhibited a reduction in proportion of livespermatozoa in ejaculates between April and June. Most remarkable reduction was recorded among Norwegian bucks which recorded a reduction nearly 40% between April and June.

In Local and crossbred bucks (Group II) significantly higher values for total number of livespermatozoa per ejaculate were noted in June. But for the Norwegian bucks, higher number of livespermatozoa was recorded in May. For all breed groups, highest values of total number of spermatozoa per ejaculate were recorded in June (Table 26).

Table 25 : Effect of the month on semen volume (ml), % livespermatozoa and wave-motion scores in Local, Norwegian and Crossbred (½N) bucks in group II

	Months		
	April	May	June
Semen Volume (ml)			
Local	0.80 ± 0.03	0.66 ± 0.04	0.73 ± 0.08
Norwegian	1.20 ± 0.75	0.95 ± 0.046	1.23 ± 0.97
½ Norwegian	0.71 ± 0.06	0.83 ± 0.067	1.10 ± 0.89
% Livespermatozoa			
Local	37.7 ± 2.43	42.8 ± 3.62	60.3 ± 5.73
Norwegian	56.1 ± 3.86	48.2 ± 3.38	34.12 ± 2.96
½ Norwegian	47.9 ± 3.67	38.0 ± 3.06	36.9 ± 4.60
Wave-motion score			
Local	0.87 ± 0.05	0.78 + 0.15	1.40 ± 0.92
Norwegian	1.18 ± 1.02	1.46 ± 0.94	1.11 ± 0.83
½ Norwegian	1.50 ± 0.85	1.72 ± 1.03	1.60 ± 0.93

Table 26 : Effect of the month on semen density, total number of spermatozoa/ejaculate and total number of livespermatozoa/ ejaculate in Local, Norwegian and crossbred bucks (Group II)

	Months		
	April	May	June
Semen density(x 10^7/ml)			
Local	76.55±6.23	168.4±12.73	163.4±9.38
Norwegian	100.33±11.42	215.66±29.25	197.0±14.72
½ Norwegian	139.05±9.30	198.7±12.81	343.6±39.62
Total number of spermatozoa/ejaculate(x 10^7)			
Local	62.8±5.11	111.14±10.05	119.2±12.39
Norwegian	121.15±15.37	204.87±19.44	242.31±20.00
½ Norwegian	98.72±8.34	164.92±13.64	377.30±26.75
Total number of livespermatozoa/ejaculate (x 10^7)			
Local	23.67 ± 6.90	47.56 ± 3.84	71.87 ± 5.88
Norwegian	67.96 ± 4.13	98.74 ± 8.11	82.30 ± 7.21
½ Norwegian	47.28 ± 2.33	62.66 ± 6.30	135.82 ± 9.55

Table 27 shows mean monthly values for the various climatic factors as recorded during the experimental period (January - June). Highest maximum and minimum temperatures were recorded in January, whereas lowest values were noted in June. January also had the highest level of radiation (19.88 $MJ/m^2/day$) and amount of sunshine hours (8.7 hours/days).

It can be observed that although the range in maximum and minimum temperatures was only 4.8^oC and 5.8^oC respectively, the average diurnal range was considerably high, with temperature fluctuating by between 9.4^oC and 12.9^oC.

Complementing Tables 23 - 26, are Figures 5-8, which show monthly variations in semen attributes and also an association between these variations and those of climatic elements.

In Figure 8 it can be observed that lowest densities for all breed groups were recorded just around the time of highest diurnal temperature range (February - March). A roughly linear increment in spermatozoa concentration was noted among Norwegian bucks as "Cool months" were approached. In constrast to this, semen volume in both Norwegian and Local bucks showed a considerable decline as temperatures fell from 32.6^oC to 28.8^oC. This was also associated with a generally rising level of relative humidity, (55 - 63%) and reduction in the amount of radiation (18.92 - 14.40 $MJ/m^2/day$).

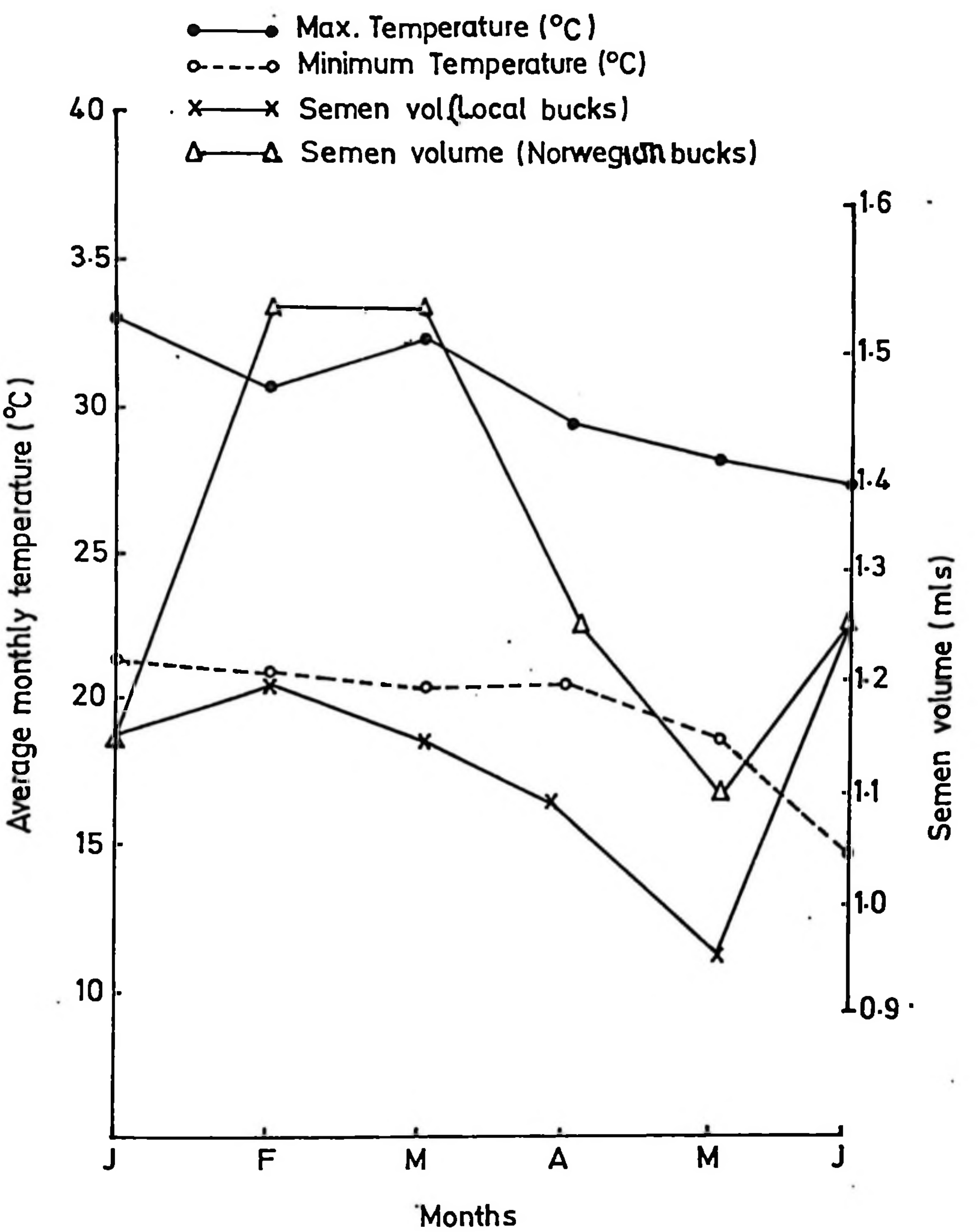


Fig. 5 : Monthly variation in semen volume and changes in enviromental temperature.

Table 27 : Monthly average values of climatic factors during the experimental period

Month	Max. Temp.(^{o}C)	Min. Temp. (^{o}C)	Diurnal Range (^{o}C)	% RH	RAD*	Sunshine hours
January	32.9	21.0	11.9	57.0	19.88	8.7
February	30.9	20.8	10.1	59.0	15.52	4.6
March	32.6	20.3	12.3	55.0	18.92	7.7
April	29.7	20.3	9.4	70.0	14.67	5.9
May	28.8	18.2	10.6	63.0	14.40	-
June	28.1	15.2	12.9	54.0	14.0	7.6

RAD* = Radiation in $MJ/m^2/day$

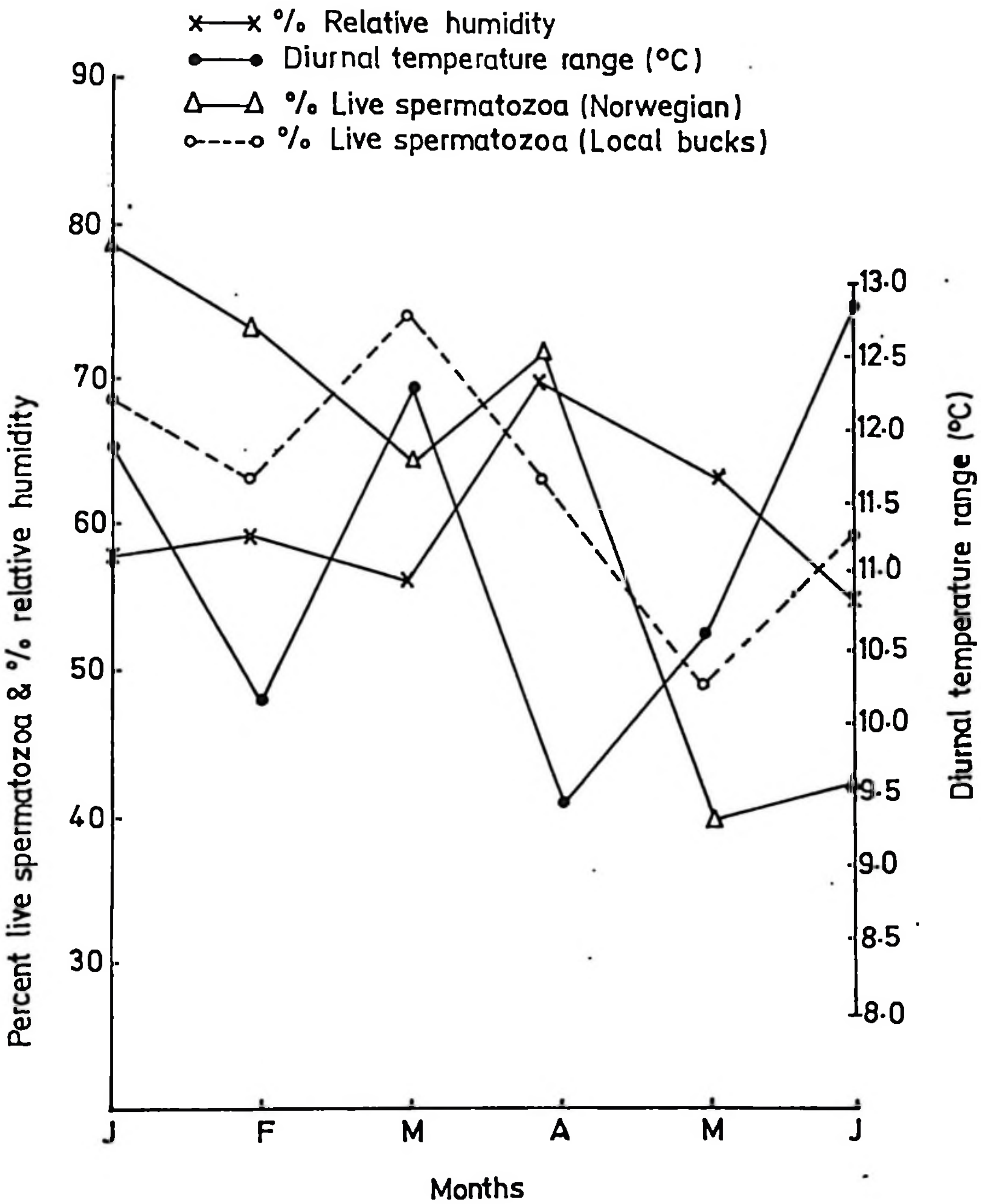


Fig. .6 : Relative humidity, diurnal temperature range and percent live spermatozoa in ejaculates.

The proportion of livespermatozoa showed a diminishing trend in both breed groups as the range between maximum and minimum temperatures widened (Fig. 6). Whereas the percent livespermatozoa was generally reducing between April and June in all breed groups, density was generally increasing, starting earlier among Norwegian bucks and month later in the Local bucks.

Although in June the absolute amount of semen volume was equally as high in the Local bucks as in Norwegian bucks, its magnitude of increase between May and June was more remarkable among the Local bucks than Norwegian bucks (Fig. 5).

Monthly fluctuations in wave - motion scores for both groups (Norwegian and Local breeds in(Group I) showed a generally increasing level as maximum and minimum temperatures fell from 32.9°C - 29.7°C and 21.0°C - 20.3°C, respectively. Highest magnitude of positive response in wave - motion scores was noted among Norwegian bucks during the period of minimum diurnal range of temperature (9.4°C). The converse is true for the Local bucks who showed an apparently better response during periods of higher diurnal temperature range. This however, was more apparent when maximum temperature were high than when they were low.

Table 28 shows an association between climatic factors with variations in percent livespermatozoa.

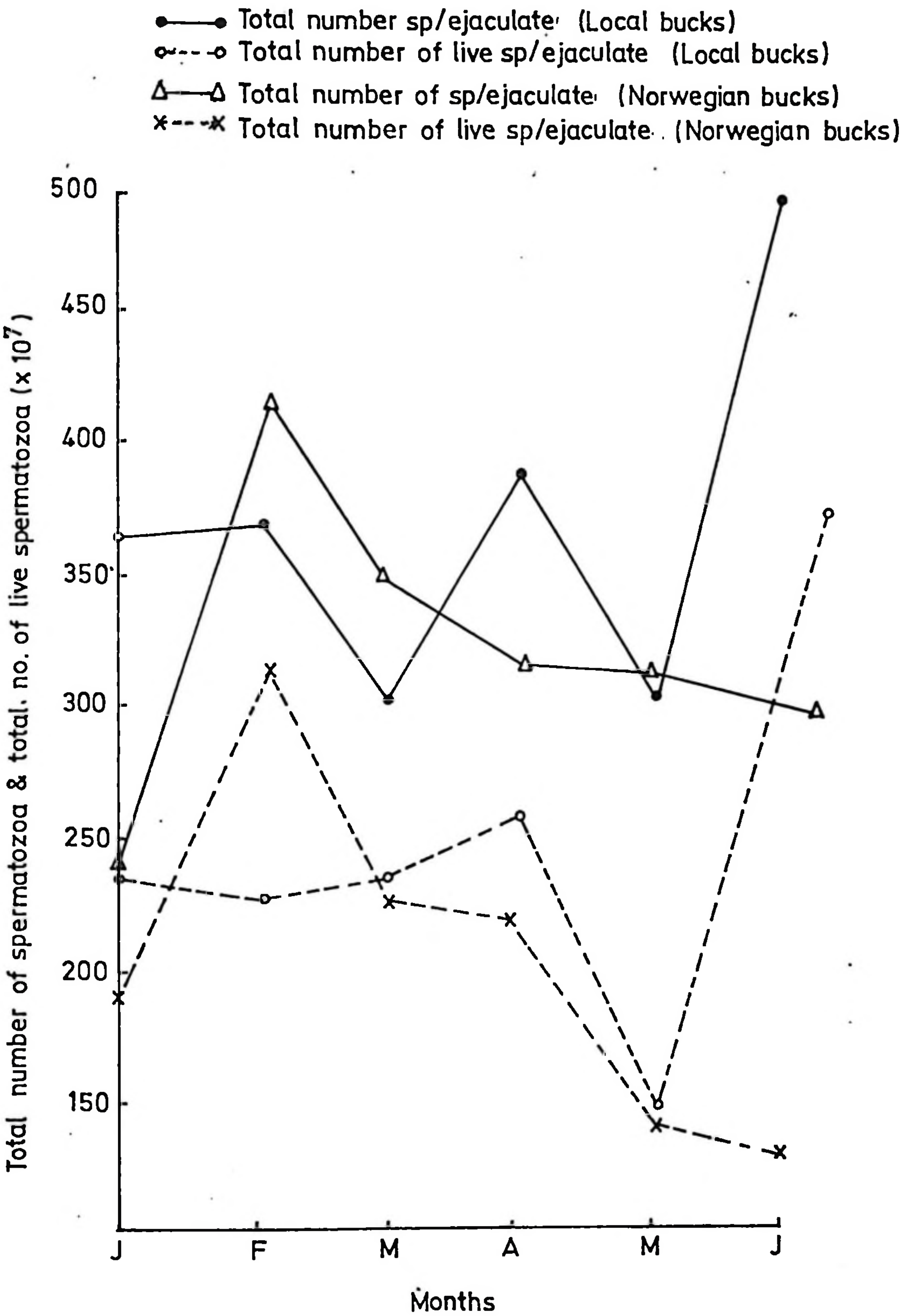


Fig.7: Monthly variations in total number of spermatozoa and in total number of live spermatozoa per ejaculate.

Table 28. ' : Effect of changes in temperatures, radiation and sunshine hours on the proportion of livespermatozoa in ejaculates of Norwegian and Local bucks

Month	% livespermatozoa[1]		% livespermatozoa[2] change in		Max Temperature	Rad	Sunshine hours
	Norwegian	Local	Norwegian (% points)	Local	(°C)	(MJ/m^2/ day)	
January	79.0	69.0			32.9	19.80	8.7
	a[3]	a					
February	73.0	62.0	6a	7a	30.9	15.5	4.6
	b	b					
March	64.0	75.0	-9b	13b	32.6	18.9	7.7
	c	c					
April	72.0	63.0	8c	-12b	29.7	14.7	5.9
	d	d					
May	40.0	49.0	-28d	-14d	28.8	14.4	-
	e	e					
June	42.0	59.0	2e	10e	28.1	14.9	7.6

1 % Livespermatozoa = rounded to whole numbers

2 % Livespermatozoa = change in percent points of livespermatozoa

3 a - e = comparison between successive months (all comparisons are based on mean values and are not statistical)

It can be seen (Table 28) that both Norwegian and Local bucks experienced about the same extent of reduction in the percent live-spermatozoa (6% and 7% in Norwegian and Local bucks, respectively) as the amount of radiation fell from 19 MJ/m^2/day to 15 MJ/m^2/day with an associated fall in maximum temperature (32°C - 30°C) and amount of sunshine hours (8.7 - 4.6 hours). But as the temperatures rose again to 32°C and amount of radiation increased from 15 MJ/m^2/day to 18 MJ/m^2/day, Local bucks experienced a rise by about 13 percent units in the proportion of livespermatozoa whereas Norwegian bucks showed a further decline from 72% to 64%). Further observation shows opposite response as temperatures fell from 32°C to 29°C and radiation amounted to 14 M/m^2/day with sunshine hours standing at nearly 6 hours per day.

A sharp drop in the number of live spermatozoa was noted in both breeds (Local and Norwegian) between March and April (Fig. 8). Conversely, a gradual increase in the total number of spermatozoa in the same period compansated for the drop in the number of live spermatozoa. A test for interactions between breed and months showed no significant effects for all the traits observed (Table 30).

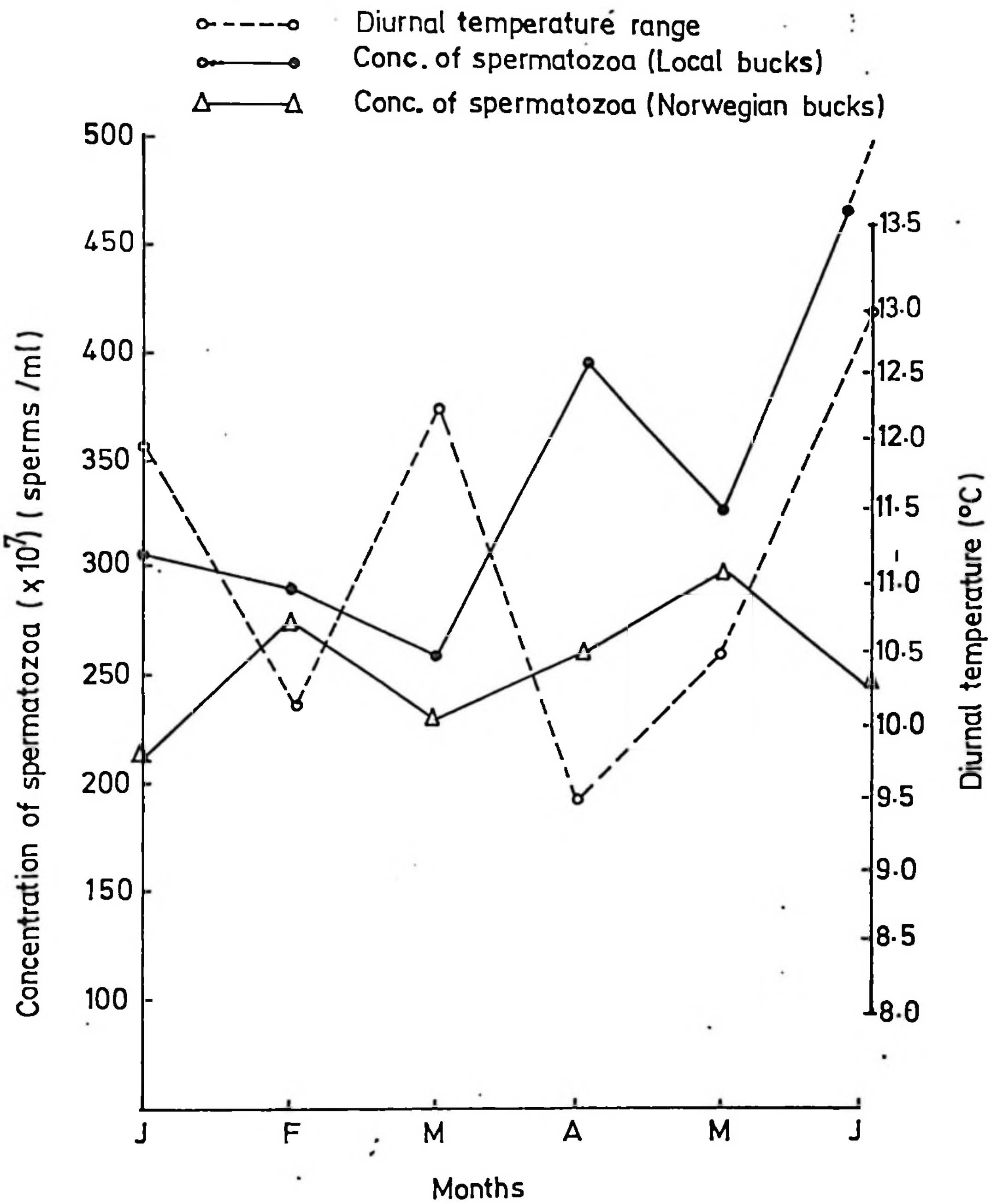


Fig. 8. Association between monthly diurnal temperature range and concentration of spermatozoa in ejaculates (sperms/ml)

4.4 Effect of the season

Table 29 shows results of multiple factors and their effects on the semen attributes. Significantly ($P < 0.05$) higher values of semen density were noted during period II (S II) in both the Local and Norwegian bucks. Comparison between breeds shows that Local bucks recorded significantly superior values in densities in both periods S I and S II. For percent livespermatozoa, significantly higher values were reported in period I (72.4% and 68.8% for Norwegian and Local bucks, respectively) than in period II.

Comparisons between "breeds within seasons" and between seasons within breed were also made. Except for semen volume and percent livespermatozoa, all other traits showed significant breed differences within a given season (Table 30). Local bucks exhibited superior values for wave - motion scores, density total number of spermatozoa per ejaculate in all seasons. No significant breed x season interactions were observed for all traits. This is inspite of the reverse order of superiority that was observed in percent livespermatozoa and total number of live spermatozoa per ejaculate for which the two breeds assumed opposite ranks in period S I and S II.

Table 29 : Mean ± S.E. for semen attributes in Norwegian and Local bucks during the two seasons

		Seasons	
		[1]S I	[2] S II
P_1 Semen volume (ml)			
Norwegian		1.42 ± 0.02	1.20 + 0.10
Local		1.19 ± 0.10	1.06 ± 0.21
	$\bar{x}$	1.34 ± 0.12	1.13 ± 0.10
P_2 Livespermatozoa			
Norwegian		72.4 ± 6.13	51.9 ± 3.22
Local		68.8 ± 4.72	57.6 ± 6.84
	$\bar{x}$	70.6 ± 9.35	55.8 ± 3.89
P_3 Wave - motion			
Norwegian		1.85 ± 0.22	1.75 ± 0.8
Local		2.28 ± 0.85	2.46 ± 0.3
	$\bar{x}$	2.10 ± 0.52	2.3 ± 0.40
P_4 Density (x 10^7/ml)			
Norwegian		237.7 ± 17.5	258.35 ± 13.94
Local		289.6 ± 12.72	410.30 ± 53.38
	$\bar{x}$	263.65 ± 25.93	334.32 ± 75.90
P_5 Total spermatozoa/ ejaculate (x 10^7)			
Norwegian		337.53 ± 20.75	310.00 ± 38.90
Local		338.83 ± 25.96	434.60 ± 62.35
	$\bar{x}$	338.18 ± 22.86	372.30 ± 50.66
P_6 Total livespermatozoa/ ejaculate (x 10^7)			
Norwegian		244.50 ± 13.53	160.79 ± 9.06
Local		233.10 ± 20.11	250.33 ± 18.43
	$\bar{x}$	238.80 ± 16.32	205.50 ± 13.24

[1]SI = Season I, [2]SII = Season II

Table 30 : Summary of the analysis of variance results for table 29

	Source					
	Breed (B)		Season (s)		B x S	
Parameters	df	F-ratio	df	F-ratio	df	F-ratio
P_1	1	3.26	1	3.04	1	0.38
P_2	1	0.64	1	21.0**	1	3.09
P_3	1	6.94*	1	0.47	1	1.23
P_4	1	14.29**	1	7.11**	1	0.54
P_5	1	4.48*	1	1.69	1	1.71
P_6	1	10.37**	1	0.84	1	2.87

Observations of seasonal variation in ejaculate attributes within a given breed group showed that Norwegian bucks performed better in period I than in period II for all traits except semen density. For the Local bucks, remarkably higher values of wave - motion scores, density, total sperms per ejaculate and total number of liverspermatozoa per ejaculate were observed in period II.

4.5 Mineral content in seminal plasma

Table 31 shows results from mineral analysis of pooled semen plasma drawn from ejaculates of individual bucks. No statistical test was made to test for significance of variations. However, it is apparent that there is a marked difference in mineral content between the different breed groups.

Table 31 : Mineral content in pooled seminal plasma of the ejaculates collected from the three breed groups

	Buck groups				
	[1]N_1	N_2	[2]L_1	L_2	½ N
Sodium (mg/100 ml)	129.00	168.53	187.70	89.50	131.62
Potassium (mg/100 ml)	40.46	87.00	57.60	-	93.00
Calcium (mg/100 ml)	5.80	4.31	3.28	9.62	5.0
Magnessium (mg/100 ml)	5.35	5.60	6.40	-	7.55
Copper (mg/100 ml)	0.14	0.10	0.18	0.12	0.11
Zinc (mg/100 ml)	0.88	0.53	0.65	-	0.46

[1]N_1, N_2 = Young and old Norwegian bucks respectively (Gr. I & II)

[2]L_1, L_2 = Young and old Local bucks

5. DISCUSSION

5.1 Effect of the buck s within breeds

The significant variation among bucks in ejaculate volume, sperm concentration, mass motility score and total number of livespermatozoa demonstrated in this study is in conformity with observations made by Iritani et al .(1964), Maskeev (1971) and Bouillon (1973). Mittal and Pandey (1972) have shown highly significant differences between bucks in their semen quality for all of the parameters above except sperm concentration. Likewise, Misra and Mukherjee (1984) have reported significant differences among males within the same breed with respect to spermatozoan measurements and percent livespermatozoa.

Results from computations of simple and multiple coefficients of regression between semen volume and liveweight are indicative of the fact that differences in liveweight among bucks accounts to a considerable extent in the variations noted in semen volume. The correlation value of 59.4% reported in this work exceeds that of 41% noted by Bouillon (1973). Similar observations have been reported by Colas et al (1975) among rams.

Akin to differences in liveweight was the difference in testicular dimensions noted among bucks of all breed groups. Testicular circumference had a significant association (r = 41%) with semen volume. This value falls far below that of 61% reported by Carew and Egbunike (1980) for Maradi goats rared under extensive systems in a tropical environment. The small number of animals observed and the fact that the possible seasonal changes in testicular dimensions were not considered in this study may, explain the disparity between these two results. It can be infered from these observations that liveweight and testicular measurements coupled with their association with semen quality can be used as a basis for selection of males for semen production. A similar suggestion has been given by Saacke (1982).

When each ejaculate (within bucks) was considered as a possible source of variation, it was noted that except for sperm density, variations among ejaculates for all other parameters were non-significant. This suggests that sperm density is an attribute of a particular ejaculate, whereas overall ejaculate attributes are a characteristic of an individual buck. It follows that some bucks showed persistently superior semen samples than other bucks within their contemporary breed groups.

A close association between sperm density and mass motility score and between mass motility and percent livespermatozoa in the same buck was observed. Though the trend was incosistent, there was nevertheless, a tendency for ejaculates with higher sperm density to also exhibit higher mass motility score and percent livespermatozoa. This observation partly agrees with that reported by Raadsma and Edey (1985) who showed that motility score was closely related to sperm density but not percentage live or abnormal spermatozoa. In an earlier study Goerke et al.(1970) reported a phenotypic correlation of 67% between sperm concentration and mass motility score.

Differences in age is one of the factors suggested to influence variations in semen attributes among individuals (Traldi, 1983; Vinha, 1980; Bongso et al.,1982, Tiwari et al.,1982). Prasad et al.(1970) reported that among Barbari bucks ranging in age between 4.5 months and 36 months, a significant age - influenced difference in semen volume and sperm - motility existed. Older bucks showed higher values for both parameters than the young ones. Similarly, Corteel (1975), reported a significant age - effect on semen volume in rams, while Sinha et al (1981) noted age - effect on sperm concentration among Jamnapari bucks. In a later work Sinha and Sahni (1985), reported significant age effects on ejaculate volume, mass motility score and sperm concentration in Muzaffarnagri rams aged between 1½ to 5 years.

The age factor can only be cautiously ascribed to the variations between individual bucks noted in this experiment. At best it can only apply among Local bucks whose age difference was rather more pronounced than any of the remaining groups. Indeed, the confounding effects of liveweight and scrotal dimensions contributed more significantly to the variations noted irrespective of the age of an individual.

It would have been expected that total number of spermatozoa per ejaculate would show significant variation among individuals . Contrary to observations reported by Rathore (1970), Katsyak (1970) and Maskeev (1971) no significant variations was observed. Since a negative correlation has been shown by some workers (Menger and Neubert, 1985), it follows that variation in volume is likely compensated by corresponding changes in sperm density to obviate marked differences in the total number of spermatozoa among individuals. Chaudhry and Mahmoud-ul-Hassan (1984) have reported that higher ejaculate viscosity was related to smaller volume and higher concentration, whereas greater volume was associated with higher pH in ejaculates collected from Barbari bucks.

5.2 Effect of the breed

The Norwegian and Local bucks in experimental group I differed significantly in most of the traits observed. The abscence of significant breed effect on differences observed in semen volume between the two breeds was rather contraversial. Inspite of the fact that Norwegian bucks had significantly superior liveweight, they gave no higher semen volume than the Tanzanian local bucks.

Contrary to observations in group I, significant breed effect was noted for semen volume and percent livespermatozoa in group II bucks. Norwegian bucks exhibited significantly higher semen volume than both the Local and the Norwegian half-crosses bucks. It is suggested that the superiority of Norwegian bucks in semen volume and the inferiority of Local and crossbred bucks in the same parameter is closely related to the relative differences in liveweight and testicular measurements between the breeds compared. Norwegian bucks significantly excelled both the Tanzanian local and Norwegian half crosses in these two parameters.

The superiority of local bucks in group I for mass motility scores and higher number of spermatozoa can partly be explained by the higher density of the samples drawn from them. Mass motility scores for all breed groups among group II bucks suggested that, the density, proportion of livespermatozoa in ejaculates and mass activity are inherently related to the degree and extent of individual spermatozoan activity.

The influence of breed on body weight, testicular measurements and on quantity and quality of semen has been reported in various studies. Singh et al (1985) reported significant breed effect in respect to ejaculate volume, mass motility score, sperm concentration and percent livespermatozoa when comparing Black Bengal, Jamnapari and Jamnapari crossbred bucks. Similar studies reported by Kumi-Diaka et al (1985) have shown significant influence of the breed on only percentage of abnormal spermatozoa among three breeds of sheep in Nigeria. In the same study by Kumi-Diaka (1985), and contrary to what was reported by Borgohain et al (1983), breed differences in scrotal circumference and other ejaculate attributes were noted to be non - significant.

Studies such as those of Napier (1961) and Beatly (1970) have shown that significant variations in sperm phenotype and semen attributes are genetically based rather than caused by the external environment. These findings are in agreement with those reported by Purser (1973), Zerfas and Steinbach (1982) and Bordoloi and Sharma (1983). In a more elaborate study, Rao et al. (1985) reported highly significant breed differences in enzyme activity of ejaculates drawn from Nali and corriedale rams. Cochran et al. (1985) observed significant breed differences in mass motility, percentage forward motility and an interaction between breed and stage of collection in their studies on Suffolk, Hampshire, Finnish Landrace, St. Croix and Barbados Black Belly rams. Recent studies by Boland et al (1985) reported little difference in semen quality between three breeds of rams. However, it was noted in the same study that Dorset Horn rams exhibited superior average motility scores than both Suffolk and Texel rams. These results partly agree with those reported by Mickelsen et al (1981), McGrath et al (1979), Misra and Mukherjee (1984) and Land and Sales (1977).

Barwick *et al*.(1985) reported significant breed differences in testis diameter between 1.5 years old Border Leicester and their crosses. Similar results for testis length were reported by Misra *et al*. (1984) among Sirohi and Sirohi x Beetal bucks and by Land (1970) for Finnish Landrace and Scottish rams. Observations reported in the present study agree with these results in respect to testicular length and circumference. Norwegian bucks as well as Norwegian x Tanzanian Local bucks had significantly larger testicular measurements than the local breed.

It would be of interest to survey the association between scrotal morphology and semen attributes of various breeds. Selection of male goats based on scrotal morphology has been suggested by Nunes *et al*.(1984) for Moxoto goats. In their study it was noted that males with divided scrotum were superior to those with a normal scrotum in ejaculate volume, sperm concentration, total sperm number, mass motility, forward sperm motility and as well as in having lower incidence of sperm abnormalities.

Though testis weight was not considered in this study, its close correlates (length and diameter) are suggestive of the fact that the superiority of Norwegian bucks in ejaculate volume is primarily due to their larger testicular size. The study by Cameron *et al*. (1984) conform with this suggestion. A recent study in Australia by Walker *et al*.(1985a) demonstrated that breed differences for semen attributes and testis volume do exist and that these differences are genetically based. Similar results were reported by Burfenning and Tulley (1982). In an attempt to explain the genetic base of the differences noted here, earlier work by Walker et al.(1985b) and Purvis et al (1983) excluded the involvement of F-gene in the differences noted among the different genotypes of rams. Lal and Pant (1984) have shown that crossbreeding does influence changes in quantitative biometry of ovine spermatozoa. The sperm head shape of F_1 crossbreds was shown to be significantly different from that of the mid parents. In the same study, it was also shown that variations between the genotypes observed were significant for all traits (Sperm head length, width area,shape and mid piece length).

There have been occassional reports which rejected the hypothesis of breed differences in respect to semen quality. Working with Corriedale and Romney Mash rams, Almeida et al.(1984) reported no significant differences between the two groups in semen quality. Similarly Silva and Nunes (1984) reported no significant breed differences between Santa Ines and Brazilian Somali rams in respect to sperm motility and percentage live-spermatozoa. It seems that, whether or not breed differences are statistically significant will very much depend on the genetic closeness of the breeds being compared. Since the compared groups in this study were of diverse origin, it follows that the observations in this experiment were not unexpected. The suggestion that there could be a genetic base in the superiority noted among Norwegian bucks for semen volume is further fortified by the fact that Norwegian half-crosses in experimental group II had higher ejaculate volumes than the local bucks in the same group. The abscence of statistically significant breed dfferences for semen volume between Norwegian and Tanzanian Local bucks in group I could not be fully explained. It is suggested that the differences existing between the two breeds could have been confounded by the significant influence of individual bucks variations. This suggestion is in agreement with observations reported by McGrath et al. (1979) who showed no breed differences in semen volume between Dorset Horn, Suffolk and Lincoln rams. It was also noted in the present study that bucks of both breeds were often nervous and unreceptive to the electro-ejaculator during semen collection time. This may account for the lack of unformity in samples collected particularly during the initial stages of the experiment.

5.3 Monthly and seasonal variations

Among bucks of all breed groups (both group I & II), significant monthly variations were observed in respect to mass - motility score, sperm concentration and percent livespermatozoa. Results conforming with this observation have been reported by several workers (Ortavant et al. 1985, Paredes 1984, Muhunyi et al. 1985). For bucks in group I, monthly variation in semen volume was inconsinstent and non significant. However, for both the Local and Norwegian bucks. Lowest semen volumes were recorded in May, whereas highest volumes were recorded between February and March.

Seasonal variations were noted particularly in sperm concentration. Significantly higher sperm concentration was recorded during the "cool months" (April - June). For percent livespermatozoa, significantly higher values were recorded during January - March (hot months) for both breed groups in group I. Although all traits except semen volume showed significant "within season" breed differences, no breed x season interactions were noted. This is inspite of the fact that Norwegian and Local bucks assumed opposite ranking in percentage livespermatozoa during periods I and II (hot and cool months,respectively).

This anomaly could possibly have been due to the small number of animals compared and to the short time of comparison.

Considering all semen attributes together, Norwegian bucks produced better ejaculates in January (hot months) whereas for the local bucks. superior ejaculates were collected in June (cool months). This was rather unexpected as it was assumed that the Norwegian bucks would experience a heat stress during the hot months and therefore produce poor ejaculates. As for the Local bucks, the improvement in ejaculate characteristics during cool months can be attributed to the fact that this is the traditional period of highest natural mating activities in Morogoro. Although mating and kidding is continous throughout the year, it has been reported in earlier studies at Morogoro (Kyomo,1977) that most kiddings occur shortly after the short rains in December. This suggests that most matings are effected between May and July. It is likely that there is an association between feed availability, females receptivity and conditioned high sexual activity in Local males. Studies by Almeida & Lincoln(1984)in Brazil have shown that average percent livespermatozoa, mass motility score and sperm concentration were shown to attain maximum values during the rainy season. Costa (1981) reported that ejaculate volume, mass motility and progressive motility of semen of Somali sheep in Brazil, were significantly higher in the rainy season than in the dry season. It was also noted that sperm survival, semen pH and number of spermatozoa per ejaculate were not significantly affected by season and that percent dead spermatozoa and incidence of sperm abnormalities were higher in the dry than in the rainy season. In Pakistan, high ambient temperature and humidity have been shown to relate to lower sperm motility and increased incidence of abnormal sperm heads in ejaculates collected from bucks (Chaudhry and Mahmuodoul-Hassan 1984). Saxena and Vripathi (1983) observed that season had a singificant effect on incidence of sperm head primary and secondary abnormalities, mid piece secondary abnormalities and that sperm morphology was optimum in autum and winter for ejaculates collected from Murrah bulls. Batabyal et al.(1985) reported significant seasonal effect on biochemical and biometrical attributes of semen in Nali rams. In the same work, it was also reported that season significantly affected semen consistency, ejaculate volume, seme concentration and spermatozoan dimension(particularly sperm head width and midpiece length). In the tropical regions of Brazil Silva and Nunes (1984)reported significantly higher ejaculate volumes and sperm concentration during the rainy than the dry seasons.However, sperm number per ejaculate, sperm motility and percent livespermatozoa were unaffected by season. Amir et al (1986) reported significant season x ejaculate interaction in Finn cross rams. Results from the present study closely correspond to most observations quoted here. The significantly higher sperm concentration noted among Anglo-Nubian bucks during the summer in India (Vinha 1980a) does not agree with the present observations. The findings by Sinha et al (1981) on Jamnapari bucks and El-Fouly et al.(1980) on Ossimi and Rahmani rams are in conformity with those Vinha (1980). Those findings suggests that summer season corresponds to the time of highest spermatogenic activity in at least some of the tropical goats and sheep breed. The high conception rate (CR) associated with mating on days with high ambient temperature as reported for Damascus goats (Cyprus Agric. Res. Inst. 1984) support this arguement and also suggests that there exist a complementary effect of high sexual activity, semen quality and females receptivity. But this would contradict observations by several other workers(Hernendez 1981; Chaudhry and Mahmoud-ul Hassan 1984) who has consistently observed negative effects of high ambient temperatures and with that reported by Mattos et al.(1984) who reported that German Merino ewes inseminated with semen collected during winter had a significantly higher lambing rate than those with ejaculates collected during summer. This conclusive suggestion could not be substaintiated by the present study. Ironically, it is further complicated by the unexpected apparently better ejaculates collected from Norwegian bucks during the hot months.

Observation on the climatic factors and their association with monthly variations in semen volume would suggest that the Local bucks, being indigenous to the environment, should have experienced lower extent of changes than the Norwegian bucks. But further observations on other semen attributes is suggestive of the fact that there is a partly common and partly differential response between Norwegian and Local bucks with respect to sensitivity to changes in climatic elements. The low spermatozoa concentration and the falling proportion of livespermatozoa that was noted during the time of highest diurnal temperature range(February - March) suggest that both breeds were equally sensitive to temperature change in respect to these parameters.

For the Norwegian bucks a trend of increasing sperm concentration associated with the approach of cool months was expected. In rams, Johnson and Desjardins (1973) reported a coincidence of maximum spermatogenic and steroidogenic activity with the decrease in ambient temperature and photoperiod but the fall in semen volume during the same period (cool months) in both breed groups was rather unexpected - particularly for the Norwegian bucks. However, this fall seem to have been associated with increasing sperm concentration as well as with the generally rising level of relative humidity (RH). The fact that local bucks experienced a more remarkable increase in semen volume towards June, suggests that they experienced less stress due to temperature fluctuations during the transitional period.

Differential sensitivity is further noted in the changes in percentage livespermatozoa as associated with changes in the amount of solar radiation and sunshine hours. Furthermore, although both breeds groups produced ejaculates with increasing level of mass motility scores as temperatures fell, the Norwegian bucks showed highest magnitude of positive response when temperature fluctuation (diurnal range) was minimal.

It is of interest to note that contrary to expectations, Norwegian bucks showed no seasonality in reproductive capability. This is inspite of the fact that there were significant seasonal variations in ejaculates. Results from this study suggest that Norwegian bucks can well adapt to the mating pattern of the Local bucks. This capability is possibly associated with a somewhat constant length of photoperiod under the tropical environment. Thwaites (1965) postulated that the constancy in day - length under tropical conditions could eliminate seasonal character of breeding or modify it to a rythm with some degree of seasonality. Perhaps if this study was extended for a long period this modified rythm could have been discernable.

The effect of season on semen characteristics has been reported by many workers (Sinha and Sahni, 1985; Ringwall et al. 1985; Boland et al., 1985; Valerani , 1964; Vinha, 1975; Dwivedi , 1977). The findings by most workers have been mainly complementary with only a few occasional contraditions. However, there seem to be a general concesus in the arguement that reproduction in many species is confined to a time of the year when the probability of survival for both the adults and the offspring is maximum.

Reports by Muhunyi et al. (1982), Greyling and Grobelaar (1983) Dymundssen et al. (1982), Paredes (1984), Cameron et al. (1984), Tekin and Muyan (1985) and Ortavant et al. (1985) have all indicated a significant influence of the season on semen attributes of the goats or rams. Seasonal changes in ejaculate volume, percentage livespermatozoa and percent abnormal spermatozoa have been associated with changes in light (photoperiod) and maximum daily temperatures (Cupps et al. 1960; Maule et al. 1966; Williams, 1972, Jackson and Williams, 1973). Working on Barbari bucks, Mittal (1982) reported a significant effect of the season on the proportion of livespermatozoa at room temperature. This proportion ranged from 62.15% in winter to 82.03% in the summer. This observation suggests that some tropical breeds of goats produce better ejaculates during the summer than during winter months. Reported from the Sudan by Galil and Galil (1982a) based on observations of seminal plasma of Sudan desert sheep support this suggestion.

Several studies have demonstrated that acute exposure of the mammalian testis to elevated temperatures results in decreased spermatogenesis (Gomes et al 1971). Other workers have shown that acclimatization of animals to elevated ambient temperatures is associated with continued spermatogenesis (Sod-Moriah et al. 1974). This may suggest that decreases in testicular function following acute elevation of ambient temperatures are more a result of the rapid change in temperature rather than a response to higher temperature per se (Gomes and Joyce, 1975). This observation may also explain the noted decrease in sperm concentration and proportion of live-spermatozoa in both the Local and Norwegian bucks during the period of maximum diurnal range of temperature. Dwivedi (1977) also reported a drastic fall in motility and sperm concentration consequent to exposing rams previously kept indoors to temperatures higher than shed temperatures. A significant correlation (- 0.30) between season and mass motility as well as deterioration in semen quality with increasing temperature and humidity has been reported for Tabasco and Pelibuey rams in Latin American tropics (Hernandez et al. 1981). Similar trends were reported by Summermatter and Flükiger (1985) in Saanen and Chamois goats and by Savkin and Reshtov (1984) in bulls raised in higher latitudes. Howarth (1969) reported a decline in semen quality during hot summer periods in rams. Contrary to these observations, in Kenya, Anderson (1944) noted that better semen in bulls was obtained during periods of high ambient temperature. Poor ejaculates were collected during periods of lowest maximum temperature (cool months) and highest humidity. Anderson (1944) suggests that scrotal stimulation by climatic elements, particularly temperature and sunshine hours, provokes the production of either poor or good quality semen.

It is well established that seasonal fluctuations of the photoperiod has a dominating influence on the phasing of reproductive activity of breeds of sheep and goats originating from higher latitudes (Jackson and Williams ,1973, Pelletier and Ortvant ,1975, Schanbacher and Lunstra ,1976; Lincoln and Davidson, 1977; Lincoln and Kay , 1979). In an elaborative study by Schanbacher and Lunstra (1976), it was shown that serum testosterone concentration follows seasonal sexual activity of the rams which was noted to be highest during short photoperiods. Contradictory opinions have been reported with respect to the mechanism by which photoperiod influences sexual activity (D'Occhio et al. 1985, Findley 1985, Hoffman, 1973, Chandrasekher et al. 1985). Generally two mechanism, one steroid dependent (Campbell & Schwartz 1978, Gay & Midgley, 1969) and another steroid, independent (Gibson et al. 1975, Yarney & Sanford 1983, Ringwall et al. 1985b, Reviers et al. 1985, and Kirkpatric, 1985) ,are said to be involved.

The "short - day" photoperiodic theory may not be applicable to all breeds of sheep and goats or to all environments. Studies in Algeria by Halima et al. (1980) and in Israel by Goot (1969) conform to this arguement. It is suggested that in sheep with a long sexual season, genetic heterozygosity may be responsible for regulating the breeding season by allowing other environmental stimuli besides light to trigger - off sexual activity (Goot, 1969). A clear annual rythm in sexual and spermatogenic activity has been reported in the Sudan Desert rams under conditions of constant photoperiod (Galil and Galil 1982a). The controversy in this respect is further extended by observation reported by Almeida and Lincoln (1984).

The responses demonstrated in the investigations by Rouget (1962) and Thwaites (1965) emphasis the role of adaptation to differing photoperiods and hence its importance both from the ecological and economic point of view. The literature reviewed by Quirke and Hanrahan (1984) for evidence of genetic variation in sexual function of rams gives similar emphasis on the role of adaptation of different genotypes under different environments. Results reported by Colas et al. (1985) seen to indicate similar trend for Ile-de-France rams. Lincoln and Davidson (1977) reported that abrupt change from long to short - days induced specific succession of responses in the reproductive system that include a rise in plasm LH and Follicle stimulating hormone(fsh9, followed immediately by a rise in plasma testosterone level and an accompanied growth of the testes in Soay rams. Ravault. (1976) suggests that the concentration of prolactin in peripheral blood could be a possible criterion of sexual seasonality. However, other workers have shown that there is no clear relationship between seasonal variation in the concentration of plasma prolactin and the expected period of reproductive function (Carr and Land, 1982, Howles _et al_. 1980). Occhio and Brooks (1983a) reported a significant correlation (0.65) between seasonal changes in plasma testosterone levels and mating activity in Border Leicester rams and that peak testosterone levels preceded peak mating activity by 1 - 2 months. In a further work D'Occhio and Brooks (1983b)noted that mean plasma testosterone levels for Merino rams were significantly higher in summer than in winter or spring. Mika _et al_. (1984) reported a similar conformity between testosterone concentration and mating season in rams of different breeds.

There have been occassional reports rejecting the effect of season on semen attributes. Reports by Mittal (1984, 1985) have shown that inspite of the monthly variations noted in semen attributes (volume, sperm motility, concentration, percent livespermatozoa, percent abnormal spermatozoa, fructose, citric acid, lactic acid, DNA concentration) of Magra, Marwari and Corriedale rams; season had no significant effect on any of the parameters studied. It was concluded that in a hot dry environment, the reproductive activity of indigenous and exotic rams is generally non - seasonal. The report by Carmenate _et al_.(1982) showed no significant effect of air temperature, day length and amount of rainfall on ejaculate volume, sperm motility, sperm concentration, percent livespermatozoa, semen pH and semen density of Pelibeuy and Corriedale rams. Similar observations were reported by Greyling and Grobbellar (1983) who noted no significant seasonal effect on semen quality in Boer and Angora goats and by Zheltobryukh _et al_.(1985) in Caucasian and Merino rams. An earlier review by Symington and Oliver (1966) and a recent one by Fowler (1984) point to a similar conclusion. Recent reports by Boland et al.(1984) and Menger and Neubert (1985) point to the fact that although season does influence semen characteristics, photoperiod has no significant effect on semen volume, mass motility and percent dead or abnormal cells in at least some tropical breeds of rams.

The fact that the photoperiod factor may not have an overiding influence in seasonal variations of semen attributes under tropical environment must be interpreted with caution. The findings in this study indicate that, although day length is relatively constant the amount of sunshine hours and solar radition varies considerably between the different months. Observations by Stigter (1980) in Tanzania have also shown similar results. Changes in percent livespermatozoa in both Norwegian and Local bucks were shown to correspond with changes in amount of sunshine hours and solar radiation together with changes in maximum daily temperatures. It seems that a multiple of factors are involved in effecting seasonal changes in semen quality. Conclusions in this respect should take into consideration the differences in all the factors mentioned here before any meaningfull rejection of the photoperiodic effect or seasonal influence on semen attributes is put forward.

Seasonal variations in testicular linear measurements has been shown to have an association with changes in semen quality. The study by Downey et al. (1984) indicated that there is a significant correlation between scrotal circumference and both daily temperature (- 0.38) and day length. Day length and daily temperature also significantly correlated with testis firmness. Mickelsen et al. (1982) reported that percent normal spermatozoa in

Suffolk, Lincoln, Columbia and Polypay rams was highest when mean scrotal circumference was highest and lowest when scrotal dimensions were lowest. Libido and serving capacity followed a similar trend. Islam and Land (1977) observing Merino and Finnish Landrace rams, reported that time and characteristics of seasonal variation in testis diameter showed similarity with characteristics of seasonal variations in the reproductive performance of females of corresponding breed type. Seasonal testicular cyclicity corresponding to temperature fluctuations has also been reported by Drymundsen et al. (1982) among Icelandic rams which exhibited greatest testis diameter during autumn than spring. Simplicio et al. (1982) reported significant seasonal changes in the linear measurements and consistency of the testis among Brazilian Somali rams. The associated changes in ejaculate volume, mass motility score, percent motility and sperm concentration were however, not sufficient to prevent the rams being used for breeding throughout the year. This remark supports the generally accepted phenomenon of non-seasonality in breeding capacity in tropical breeds of sheep and goats.

Observations in the present study with respect to extent of fluctuations in ejaculate attributes indicate that the capacity to adjust to changes in climatic factors is a characteristic of an individual buck rather than of a breed group. Thus the significant ram x season interactions for percent livespermatozoa, semen volume and fructose concentration as reported by Batabyal et al, (1985) may partly explain the abscence of significant breed x season interactions for all parameters observed in the present study. Similar suggestion has been proposed by Yusof et al. (1982) for the significant bull x month interactions for percentage abnormal spermatozoa among Jersey bulls in Malaysia.

5.4 Mineral content in seminal plasma

No statistical analysis was made to test for differences noted in the mineral contents of seminal plasma of the different breed groups. The values presented were based on means of pooled samples of individual bucks. Seasonal changes in mineral contents were also not accounted for in this study.

It is apparent that there were marked differences in mineral content between the different breed groups for some minerals - particularly sodium and potassium. This agrees with reports by Karagiannidis et al. (1985) on Chimois and Friesian rams where significant breed differences in zinc concentration were noted.

With the exception of potassium, the content of other mineral closely correspond to those reported by Quinn et al.(1962) in rams seminal plasma collected by electro - ejaculator. The apparently low potassium levels reported in this study may have resulted from technical errors associated with the extraction method used. Values for calcium, magnesium, zinc and copper conforms with those reported by Dundar et al. (1983) in Angora goats and by Gonzalez (1984) in Polworth rams.

No attempt was made to show association between mineral content and semen attributes. This was deliberately avoided to obviate misleading interpretation of results which could have been caused by the marked variation in semen quality among bucks and between ejaculates. Correlations among the cations were also not considered. Studies by Dundar et al. (1984) have shown that there exists a negative correlation between sodium and potassium in seminal plasma. Earlier work by Quinn et al.(1966) showed evidence of reciprocal relationship between potassium and calcium concentration in ram spermatozoa and with respect to percent unstained cells. The apparently high calcium levels reported in this study compared to that frequently reported in literature may be due to the semen collection method used. Electro-ejaculator has been shown to produce ejaculates with high calcium levels compared to samples collected by artificial vagina (A.V.) (Varshney, 1977).

The role of cations in semen quality and spermatozoan physiology has been extensively documented. Breitbart et al.(1985) demonstrated that calcium is involved in the control of sperm motility of ram spermatozoa. Quinn et al.(1970) reported that an excess of extracellular calcium was inhibitary to the motile activity of ram spermatozoa Bredderman and Foote (1971) using cell volume as an index, found that excess calcium caused both structural and permeability changes in bovine spermatozoa. Carbonic anahydrase, an enxyme essential for sperm motility has been reported to be inactivated by excess presence of copper ions (Oster, 1972). The study by Maynard et al.(1975) confirmed copper toxicity for human spermatozoa.

The roles played by sodium, potassium, magnesium and zinc in the sperm metabolism and general ejaculate attributes are reviewed in the relevant section of the present work.

A simultaneous assessment of mineral levels in seminal and blood plasma and in feeds provided to the bucks could have provided a better assessment of the mineral status in the bucks used in this experiment. But due to lack of adequate facilities this task could not be performed.

CONCLUSION

The findings in this study emphasize that variations among individuals is the primary reason for the differences observed in ejaculate characteristics. Body weight and testicular measurements are the principles indicators of sperm producing capacity. The individual variations noted here should provide basis for setting appropriate male:female ratios in planned matings. The number of females exposed to a particular male should take into consideration the ability and capacity of that particular male to serve them. It is suggested that males weighing less than average standard mature weight for the breed should be exposed to a restricted number of females. There seems to be a need for developing formula applicable to goats similar to that proposed by Strautmanis (1984) for evaluating fertilizing ability of bulls's semen.

Monthly and seasonal variations noted among bucks of all breed groups indicate an underlying cause which is yet to be established. It is suggested that annual rythms in spermatogenic activity do exist in the breed observed in this study. However, for all breed types this rythm does not exclude the possibility of using the males to serve throughout the year. Norwegian bucks seem to be well adapted and less sensitive to heat stress than expected. The seasonal variations in ejaculte characteristics should be taken into account when planning matings.

Further studies are recommended in establishing the cause of the observed variation in semen attributes. An extension of this study for at least two years may provide better insight with respect to appropriate timing of matings. The seasonal cyclicity of testicular functions as well as hormone profiles should be studied. This may offer clues to the underlying physiological basis of the variations in ejaculate characteristics and differences between the breed types. In addition, studies should be made to establish the exact relationship between semen attributes and light intensity. This may help to explain the apparent seasonal cyclicity among breeds raised under constant photoperiod.

REFERENCES

Aliev, C.I. (1965). The effect of various types of rations on the fertilizing ability of ram semen. Ortsevocdstvo 11 (9) 13 - 15 (Anim. Breed. Abstr.34: 486).

Aliev, M.G. (1964). Fertility in stud bulls in relation to the inclusion of skim milk in the ration. Zivotnovodstvo 26 (7): 71 - 72 (Anim. Breed. Abstr.33: 268).

Almeida, G.P., R.H.Albeinio, H.M.Butler, and G.A. Plama (1984). Collection of ram semen. A comparison between two frequencies of collection. Revista Argentina de Produccion Animale. 4 (8): 823 - 833 (Anim. Breed. Abstr.53 (12): 7595).

Almeida, O.F.X., & G.A. Lincoln (1984). Reproductive photorefractoriness in rams and accompanying changes in the patterns of melatonin and prolactin secretion. Biol. Reprod. 30 (1) : 143 - 158.

Allison, A.J. (1975). Optimum ram ewe ratios. Proceedings of the Ruakura Farmers Conference 27 : 8 - 13 (Anim. Breed. Abstr. 44 : 4266).

Almquist, J.O. & R.P. Amman (1961). Reproductive capacity of dairy bulls. J. Reprod. Fert. 3 : 260 - 268.

Amann, R.P., J.O. Almquist & J.T. Lambiase (1966). Seasonal cycles in bull semen characteristics. J. Anim. Sci. 25: 916 - 923.

Amann, R.P. (1966). Effect of ejaculation frequency and breed on semen characteristics and sperm output of rabbits. J. Reprod. Fert. 11: 291 - 293.

Amir, D., H. Gacitua, M. Ron & A.R. Lehrer (1986). Seasonal variation in semen characteristics and fertility of Finn Cross rams subjected to frequent ejaculation. Anim. Reprod. Sci. 10 (1) 75 - 84.

Amir, D., R. Volcani, and A. Genizi (1965). Seasonal fluctuations in the sexual activity of Awassi, German Mutton Merino, Corriedale, Border-Leicester and Dorset - Horn rams. J. Agric. Sci. 64: 115- 134.

Amir, D. (1966). The effect of successive ejaculation at different seasons on some semen characteristics of Awassi rams. . J. Agric. Res. 16 : 41 - 44.

Anderson, J. (1944). Seasonal variation in the reproductive capacity of the bull. J. Agric. Sci. 35 : 184 - 196.

Arbeiter, K. (1963). Investigations on the effect of different qualities of hay on the biological semen quality of male goats. Anim. Breed. Abstr. 33 : 467.

Arscott, G.H. & J.E. Parker (1967). Effectiveness of vit. E in reversing sterility of male chickens fed a diet high in linoleic acid. J. Nutrit. 91 : 219 - 226.

Ashmawy, G.M. (1979). Seasonality in the masculine sexual behaviour of the Baladi goat. Anim. Breed. Abstr. 48 : 3193.

Aslanyan, M.M. & M.S. Dariush (1972). Micro-elements stimulate reproductive capacity of rams. Orstsevodstvo 18 (9) : 38 - 39 (Anim. Breed. Abstr. 41 : 482).

Aslanyan, M.M. & M.S. Dariush (1973). The effect of trace elements on some semen indeces of rams. Anim. Breed. Abstr. 42 : 1468.

Austin, J.W., R.B. Leidy., G.M. Krise, & E.W. Hupp (1968). Normal values for semen collected from Spanish goats by two methods. J. Appl. physiol. 24 : 369 - 372.

Baicoinne, G., N. Zenfirescu & I. Dumetrescu (1964). The use of Iodinated Oats for the stimulation of the quantitative and qualitative production of semen. Proceed. 5th Congr. Anim. Reprod. and A.I. Vol. III 140 - 143.

Barwick, S.A., R.J. Kilgour & A.C. Gleeson (1985). Ram mating performance in Border - Leicesters and related breed types, I : Pan - test performance and measures of testis diameter. Aust. J. . Exp. Agric. 25 (1) 9 - 16.

Batabyal, A.K., S.R. Chaudhry, R.S. Yadav, & D.S. Balaine (1985). Effects of season on biometrical and biochemical attributes of semen in Nah rams. Ind. J. Hered. 17 (1 - 2) : 43 - 48.

Bavister, B.D. (1969). Environmental factors important for <u>in vitro</u> fertilization of the hamster. J. Reprod. Fert. 18 : 544 - 549.

Beaty, T. & H.L. Williams (1971). The reproductive performance of British breeds of sheep in an equatorial environment. Brit Vet. J. . 127 : 1 - 19.

Beaty, R.A. (1970). Genetics of the mammalian gamete. Biol. Rev. 45 : 73-119.

Becker, W.A. (1964). Comparing entries in Randmom sample tests. Poult Sci. 40 : 1507 - 1514.

Bereznev, A.P. (1966). Inorganic phosphorous : a factor regulating spermatogenesis. Anim. Breed. Abstr. 34 : 2672.

Black, D.L., L.V. Crowley, R.T. Duby & C.H. Spilman (1968). Oviduct secretions in the ewe and effect of oviduct fluid on oxygen uptake by raw spermatozoa in vitro. J. Reprod. Fert. 15 : 127 - 136.

Blackshaw, A.W. (1954). A bipolar rectal electrode for the electrical production of ejaculation in sheep. Aust. Vet. J. 30 : 249 - 253.

Bieri, J.G. & E.L. Prival (1966). Effect of deficiencies of tocopherol, retinol and zinc on lipid composition of rat testis. J. Nutr. 89 : 55 - 60.

Bilaspuri, G.S. & S.S. Guraya (1980). Quantitative studies on seasonal variations in testicular lipids of the goat (Capra hircus) testes. Ind. . J. . Exp. Biol. 18 (2) 205 - 206.

Bilaspuri, G.S. & S.S. Guraya (1984). The seminefereous epithelial cycle and spermatogenesis in goats. J. . Agric. Sci. 103 (2) : 359 - 368.

Bishop, D.W. (1962). Spermatozoan Motility. Amer. Assoc. Advan. Sci. Washington D.C. pp. 125.

Biswas, N.M. and C. Debb (1965). Testicular degeneration in rats during hypervitaminosis A. Endocrin. 49 : 64 - 65.

Biswas, N.M. & C. Debb (1965). Role of ascorbic acid in testicular degeneration and adrenal hypertrophy in tyrosine-fed rats. Endocrin. 79 : 1157 - 1159.

Boland, M.P., A.A. Al-Kamal , T.F. Crosby., N.B. Haynes., C.T. Howles, D.K. Kelleher, D.K. & I. Gordon (1984). Semen characteristics and hormone concentration in the ram as affected by breed, season, and photoperiod. In Res. Rept. 1982 - 83, Faculty of General Agric. Univ. Coll., Dublin. (Anim. Breed. Abstr. 53 (6). 3660).

Bongso, T.A., M.R. Jainudeen, & A.S. Zahrah (1982). Relationship of scrotal circumference to age body weight and onset of spermatogenesis in goats. Theriogenology 18 (5) 513 - 524.

Bouillon, J. (1973). Pre-testing young bucks for production of spermatozoa Anim. Breed. Abstr.42 : 617.

Bordoloi, R.K. & P.K. Sharma (1983). Variation in the percentage of abnormal and percentage of live spermatozoa in different breeds of goats. Ind. Vet. J. . 60 (6): 455 - 456.

Borgohain, A.C., C.K. Rajkonwar & B.C. Deka (1983). Sperm abnormalities in bucks. Ind. J. . Anim. Sci. 53 (8) 909 - 911.

Borgohain, B.N., B.R. Benjamin, B. Baruah & B.C. Joshi (1983). The testicular constitency and scrotal circumference in relation to the seminal characteristics among goats. Ind. . J. Anim. Sci. 53 (11) 1233 - 1235.

Braden, A.W.H., K.E. Turnbull, P.E. Mattner & G.R. Moule (1974). Effect of protein and energy content of the diet on the rate of sperm production in rams. Aust. J. Biol. Sci. 27 (1) : 67 - 73.

Bredderman, P.J. & R.H. Foote (1971). The effects of calcium ions on cell volume and motility of bovine spermatozoa. Proceed. Soc. Exp. Biol. Med. 137: 1440.

Breitbart, H., S: Rubeinstein, & L. Nass-Arden (1985). The role of calcium and Ca^{2+} - ATPase in maintaining motility in ram spermatozoa. J. Biol. Chemist. 260 C2D : 11548 - 11553.

Brown, P.D., J.G. White, & J.K.Voglmayr (1972). Amino acids in the secretions of the male reproductive trait. J. Reprod. Fert. 28 : 143.

Bujard, E.J. Mauron & E. Bujard (1964). Examen histologie des prinnipaux organes de rats soumis a des regimes a base de lait en pondre deficient on non en lysine. Arch. Ant. 47 : 239 (Anim. Breed. Abstr. 32 - 657.

Bunyan, J.E.A. Murrell, J.Green, & A.T. Diplock (1967). On existence and significance of lipid preroxides in Vit. E-deficient animals. Brit. J. Nutr. 21 : 475 - 479.

Butler, W:R., A.D. Johnson, & W.R. Gomes (1968). Effect of short term Vit. A deficiency on testicular lipids in the rate. J. Reprod. Fert. 15 : 157 - 163.

Burfening P.J. & D. Tulley (1982). Effect of selection for high and low prolificacy on libido and scrotal circumference. Proceed. 2nd World Congr. Genet. Appl. Livestock Prod. Madrid; Spain. Vol. VII pp. 536 - 542.

Cameron, A.W.N., I.J. Fairnie., D.H. Curnow, E.J. Keogh & D.R. Lindsay (1984). The effect of frequency of semen collection and testicular size on the output of spermatozoa by rams. In 10th Int. Congr. Anim. Reprod. & A.I. - Univ. Illinois, Vol. II : 16 23.

Cameron, A.W.N., I.J. Fairnie & E.J. Keogh (1984). Semen quality, quantity and flock fertility. In Reproduction in Sheep. Camb. Univ. Press. pp. 78 - 85.

Camenate, C., P. Gamicik & J.J. Hernandez (1982). Effect of some climatic factors on physical and morphological characters of ram semen. Revista Cubana de Reproduccion. Animale 8 (2) : 17 - 24.

Campbell, C.S. & N.B. Schwartz (1978). The impact of constant light on Oestrous cycle of the rat. The Physiol. 21 : 1677

Carew, B. & G.N. Egbunike (1980). Sperm production rates in Maradi goats extensively managed in a tropical environment. In 9th Interm. Congr. Anim. Reprod. & A.I. Vol. III pp. 49.

Carr, W.R. & R.B. Land (1982). Seasonal variation in plasma concentration of prolaction in castrated rams of breeds of sheep with different seasonality of reproduction. J. Reprod. Fert. 66 : 231 - 235.

Casady, R.B., R.M. Meyers &. J.E. Legates (1953). The effect of exposure to high temperature on spermatogenesis in the dairy bull. J. Dairy Sci. 36 : 14 - 16.

Cernova, Z.I. (1969). The effect of zinc sulphate on semen and blood characters of stud rams in relation to season of the year. Askaniya Nova 14 (1) : 165 - 171 (Anim. Breed Abstr.37 : 1053).

Chaudhry, S.A. & Mahmoud - Ul-Hassan (1984). Some observations on semen collection technique and morphological abnormalities of goats buck spermatozoa. Pakistan Vet. . J. 4(4) : 227- 228.

Chandrasekhar, Y. , M.K. Holland, M. D'Occhio & B.P. Setchell (1985). Spermatogenesis, seminal characteristics and reproductive hormone levels in mature rams with induced hypothyroidism and hyperthyroidism. J. Endocr. 105 (1): 39 - 46.

Chernova, Z.I. & M.N. Aslanyan (1971). The effect of zinc sulphate on indices of semen and blood in different seasons. Khimiya-Sel'Khoz 9 (5) : 56 - 57. (Anim. Breed. Abstr. 39: 2351).

Cochran, R.C.J.K. Judy, C.F. Parker and D.M. Hallford (1985). Prefreezing and post-thaw semen characteristics of five ram breeds collected by electroejaculation. Theriogenology. 23 (3) 431 - 440.

Colas, G., Y. Guerin, V. Clanet & A. Solari (1985). Effect of daylength on production and fertilizing ability of spermatozoa in Ile-de-France rams Reprod. Nutr. Devel. 25 (1) : 101 - 111.

Colas, G.D. Persconic, M. Courot & R. Ortarant (1975). Effect of collection frequency on production of spermatozoa in Young Romanov ram. Annales de Zootechnie 24 (2) 189 - 198 (Anim. Breed.Abstr. 44 : 6501.

Collins, R.M., J.B.G., Bell & G.P. Vinson (1968). The effects of elevated temperature on testis furnction. Proc. 6th Intern. Congre. Anim. Reprod. Artif. Insem. Vol. I pp. 261.

Corteel, J.M. (1976). Seasonal variations in motility and fertilizing ability of goat spermatozoa. Annales de Zootechnie·25 (4) : 567 - 571. (Anim. Breed. Abstr. 45: 3723).

Corteel, J.M. (1975). Production of semen by goats: Seasonal variation in quantity and quality of collected semen in relation to age. Anim. Breed. Abstr. 44 : 3249.

Costa, E.P. DA (981). Seasonal variations in physical and morphological semen characters in woolless Somali Sheep bred extrensively in

North-Eastern Brazil. Thesis : Escola Vet. Univ.Federale de Minas-Gerais, Brazil. (Anim. Breed. Abstr. 53 (9): 5820).

Courot, M. (1976). Semen quality and quantity in the ram. In sheep Breeding; Proceed. Intern. Congr. Muresk. Perth. Edit. Tomes, G.J. d.E. Robertson & R.J. Lightfoot pg. 276 - 285.

Crocker, K.P., T.J. Robinson & J.N. Shelton (1974). The transport of spermatozoa in ewes treated with steroid hormones. J. Reprod. Fert. 36: 461 - 462.

Cupps, P.T. B. McGowan, D.F. Rahlmann, A.R. Reddon & W.C. Weir (1960). Seasonal changes in the semen of rams. J. Anim. Sci. 19 : 208 - 213.

Cyprus, Agricultural Research Institute (1984). Some environmental factors affecting reproduction in the Damascus goat. Ann. Report. 1983. Nicosia Cyprus.

Dass, D. & N.S. Sidhu (1975). The size of spermatozoa from Black Bengali and Barbari goats (Capra-hircus) . J. Reprod. Fert. 44 : 333 - 334.

Daudu , C.S. (1984). Spermatozoa output, testicular sperm reserves and epodidymal storage capacity of the Red Sokoto goats indigenous to nothern Nigeria. Theriogenology 21(2): 317 - 324.

Davies, D.V., T. Mann, & L.E.A. Rowson (1957). Effect of nutrition on the cnset of male sex hormones activity and sperm formation in monozygous bull calves. Proc. Roy. Soc. B 147: 332 (Anim. Breed. Abstr. 24: 631).

Davis, G.I. & R.K. Meyer (1973). Seasonal variation in LH and FSH of bilaterally castrated snowshoe hares. Gener. Comp. Endocr. 20 : 60 - 68.

Davidenko, V.M., I.S. Shikarenko & M.A. Kleopina (1983). The quality of ram semen in relation to breed, age and fleece weight. Zhivotnovodstvo 7: 56 - 58. (Anim. Breed. Abstr. 51: 6521)

De Vryst, A., L. Henriet, W. Vervack, R. Arnould & M. Van Belle & A. Moreels (1964): A study of amino acid composition of bull semen. Proceed. 5th Intern. Congr. Anim. Reprod. & A.I. VOl. III : 106 - 113.

Djanuar, R. (1965). Effect of high temperature on spermiogenesis of rams. Commun. Vet. 9 : 13 (Anim. Breed. Abstr. 35 : 2136).

Dixon, J., T.E. Patrick., L.L. Rusoff, H.C. Kellgreen, & J.O.Shelurick (1965). Effect of Vit. A on semen characteristics, blood composition and physiological responses of breeding bulls. J. Dairy Sci. 48 : 840 - 846.

D`Occhio, M.J., D.E. Brooks (1983a). Seasonal changes in plasma testosterone concentration and mating activity in Border-Leicester, Poll-Dorset, Romney and Suffolk rams. Aust. J. Exp. Agric. Anim. Husb. 23 (122): 248 - 253.

D`Occhio , M.J., D.E. Brooks (1983b). Seasonal changes in the plasma testosterone profile in Merino rams. Aust. J. Exp. Agric. Anim. Husb. 23 (122): 254 - 258.

D`Occhio, M.J., K.A.A. Galil, D.E. Brokks & B.P. Setchell (1985). Differential effects of gonadectomy on sensitivity to testosterone of brain centres associated with gonadotrophin negative feedback and with mating behaviour in rams. J. Endocr. 104 (1) : 69 - 75.

Dott, H.M. & I.G. White (1964). Effect of potassium on ram spermatozoa studied by a flow dialysis techniques. J. Reprod. Fert. 7 : 127 - 138.

Dougherty, K.A., A.T.K. Cockett & R.L. Urry (1976). Semen analysis : Apparent biological breaks in semen quality when related to sperm concentration. Androl. 8 (1) : 123 - 124.

Downey, B.R., A.R.J. Pierce & L.M. Sanford (1984). Seasonal differences in pituitary and testicular functions in bulls. In 10th Int. Congr. Anim. Reprod. & A.I., Univ. Illinois Vol. II : paper No. 146, 3 pp.

Ducker, M.J., J.C. Bowman & A. Temple (1973). The effect of constant photoperiod on expression of Oestrus in the ewe. J. Reprod. Fert. 19 : 143 - 150.

Dukelow, W.R. (1967). Wheat germ oil and reproduction. A review, Acta Endoc. 56 : Suppl. 121 : 5 pp.

Dundar, Y.N., Tekin & A. Altintas (1983). Semen fructose and fructolysis and some chemical constituents in seminal plasma from Angora goats. Anim. Breed. Abstr. 53 (1) : 264.

Dutt, R.H. & E.C. Simpson (1954). Environmental temperature and fertility of Southdown rams early in the breeding season. J. Anim. Sci. 13 : 1019.

Dutt, R.H. & P.T. Hamm (1975). Effects of exposure to high environmental temperature and shearing on semen production of rams in winter. J.. Anim. Sci. 16 : 328 - 334.

Drymundssen, O.R., P. Sigtryggson, S.S. Torsteinsson (1982). Seasonal variation in testis size of Icelandic rams. J. Agric. Res. Icel. 13 (1-2): 55 - 60.

Dvorak, M. & Z. Veznik (1964). The effect of vitamin - A deficiency on the reproduction of animals. Veterinarstoi 14 (1):25 - 29. (Anim. Breed. Abstr. 35 : 259).

Dwivedi, I.S.D. (1977). Effect of shed temperature and grazing time on semen quality of exotic rams. Ind. Vet. J. 54 (9) : 732 - 734.

El-Fouly, M.A., M.M. Shafie, & S.A. Kandael (1980). Seasonal variation in semen quality of Ossimi and Rahmani rams. Egypt. J. Anim. Prod. 17 (2) 101 - 116.

El-Sayed, M.A.I., A.A. Seida & A.M. Ghallal (1983). Some semen characteristics of Baladi male goats. Assiut. Vet. Med. J. 10 (20): 167 - 171. (Anim. Breed. Abstr. 53 (1) : 261).

El-Wishy, A.B., S.A. El-Sawaf, F.Elmikkawi, & A.A. Omar (1971). Monthly and seasonal variation in sexual activity of male Damascus goats. Ind. J. Anim. Sci. 41 : 562 - 569.

El-Wishy, A.A., M.S. Abdou, F. El-Mikkawi and S.A. El-Sawaf (1978). The effect of feeding potassium iodide on blood hormones and semen picture of rams. Vet. Med. J. - Cairo 14 (10) 197 - 204.

Erb, R.E., F.N. Andrew & J.H. Hilton (1942). Seasonal variation in semen quality of dairy bull. J. Dairy Sci. 25 : 815 - 825.

Erwing, L.L. & N.L. VanDamark (1960). Effect of temperature elevation *in vivo* on subsequent metabolic activity of rabbit testicular tissue *in vitro*. J. Reprod. Fert. 6 : 9 - 16.

Erwing, L.L. & N.L. Van Demark (1963). Effect of *in vitro* temperature elevation on tissue slices and perfused testes *in vitro*. J. Reprod. Fert. 6 : 17 - 20.

Erwing, L.L., A.R. Means, C.G. Beames, & R.D. Montgomery (1966). Biochemical changes in rat testis during postnatal maturation. J. Reprod. Fert. 12 : 295 - 302.

Findlay, J.K., T.W. Gill, B.W. Doughton (1985). Influence of season and sex on the inhibitory effect of ovine follicular fluid on plasma gonadotrophin in gonadectomized sheep. J. Reprod. & Fert. 73 (2) 329 - 335.

Fischer, H. & J. Mann (1979). Investigations on semen quality in African Dwarf Goats. Zwergzieguböcker Zuchtlhygiene 14 (2) : 78 - 79 (Anim. Breed. Abstr. 47 : 6648).

Flipse, R.J. & J.O. Almquist (1963). Effect of quantity of protein in the concentrate mixture on the growth, reproductive development and semen production of dairy bulls. J. Dairy Sci. 44 : 905 - 909.

Flipse, R.J. & J.O.Almquist (1961). Effect of total digestible nutrient (TDN) intake from birth to four years of age on growth and reproductive development and performance of dairy bulls. J. Dairy Sci. 44 : 910 - 914.

Foley, C. W. & Williams (1967). Effect of bicarbonate and oviduct fluid on respiration of spermatozoa. Proc. Soc. Exp. Biol. Med. 126 : 634 (Anim. Breed Abstr. 34 : 2613).

Foote, R.H. & G. W. Trimberger (1968). Artificial Insemination. In Reproduction in Farm Animals. Edit. E.S.E. Hafez; Lea & Febiger; Philad. Pennsyl. U.S.A. p. 135.

Fowler, D.G. (1984). Reproductive behaviour of rams. In : Reproduction in sheep. Cambridge Univ. Press, U.K. pg. 39 - 46.

Fowler, D.G. (1965). Semen quality of Merino rams. 2: The effect of seasonal changes in daylength on semen quality. Aust. J. Exp. Agric. Anim. Husb. 5 : 247 - 251.

French, M.H. (1970). Observations on the goat. F.A.O. Agric. studies. No. 80 Italy, pp 204.

Fulkerson, W.J., A.L. Synnott & D.R. Lindsay (1982). Number of spermatozoa required to effect a normal rate of conception in naturally mated Merino ewes. J. Reprod. Fert. 66 (1) : 129 - 132.

Galal E.S.E., A.A. El-Gamal, A. ABOUL-Nagar, & M.A. El-Fouly (1978). Comparative studies on sexual activity and semen characteristics of different breeds of rams. Anim. Prod. 27 (3) : 261 - 267.

Galil, K.A.A., & A.K.A. Gahil (1982a). Seasonal variation in some characteristics of ejaculated spermatozoa of Sudan Desert Sheep in tropics.J. Agric. Sci. 99 (1) : 35 - 43.

Galil, K.A.A. & A.K.A. Galil (1982b). Seasonal variation in some characteristics of seminal plasma of Sudan Desert sheep in the tropics J. Agric. Sci. 99 (1) 45 - 49.

Gall, C. (1970). Goat Production. McGraw-Hill, New York, 549 pp.

Gambal, D. (1966). Effect of hormones on the testicular lipids of Vit. A - deficient rats. J. Nutr. 89 : 203 - 205.

Garbers, D.L. & N.L. First (1971). The importance of centrifugal force in determining semen characteristics. J. Reprod. Fert. 25 : 439 - 441.

Gay, V.L. & A.R. Midgley Jr. (1969). Response of the adult rat to Orchidectomy and Ovariectomy as determined by LH radio immuno assay Endocr. 84 : 1359 - 1364.

Ghanam, S., H. Al-Aliy & S: Deeb (1966). The effect of different levels of Vit. A on the reproductive organs of young bulls. Intern. J. Fert. II : 306 - 309.

Gherardi, P.B., D.R. Lindsay, C.M. Oldham (1980). Testicle size in rams and flock fertility. Proceed. Aust. Soc. Anim. Prod. 13 : 48 - 50.

Gibson,W.R., B.K. Follet., & B. Gledhill (1975). Plasma levels of LH in gonadectomized japanese quael exposed to short or long days. Journ. Endocr. 64 : 87 - 101.

Gibson, R.M., & P.A. Jewell (1982). Semen quality, female choice and multiple mating. Behaviour 80 (2) : 9 - 31.

Goettsch, M. (1960). Comparative protein requirements of the rat and mouse for growth, reproduction and lactation using casein diets. J. Nutr. 70 : 307 - 311.

Goerke, T.P., F.A. Thrift, & R.H. Dutt (1970). Heritability of semen traits and their relation to fertility in Southdown sheep. J. Anim. Sci. 31 : 445 - 450.

Goldberg, G.M., S.T. Golderby & J.J. Gold (1961). An endocrine mechanism involved in testicular changes produced by a DL-ethionine supplemented diet. Endocr. 60 : 430 - 433.

Gomes, W.R. & M. C. Joyce (1975). Seasonal changes in serum testosterone in adult rams. J. Anim. Sci. 41 (5) : 1373 - 1375.

Gomes, W.R., W.R. Butler, & A.D. Johnson (1971). Effect of elevated ambient temperature on testis and blood levels and <u>in vitro</u> biosynthesis of testosterone in the rams. J. Anim. Sci. 33 :- 804

Gonzalez, C.I.M., J.P. Neves, C.A.M., Silva (1984). Determiantion of the concentration of the sodium, potassium, calcium and magnesium in ram semen after different times of incubation at 37°C. Revista Brasileira de Repr. Animale 8 (3) : 174 - 178.

Gregoire, T.M. (1958). Effect of ejaculation frequency on semen characteristics in rabbits. J. Reprod. Fert. 37 : 156 - 164.

Greyling, J.P.C. & J.A.N. Grobbelaar, (1983). Seasonal variation in semen quality of Boer and Angora goat rams using different collection techniques. South Afric. J. Anim. Sci. 13 (4) 250 - 252.

Griesbach, W.E., M.E. Bell, & M. Livingston (1984). Changes in pituitary gonadotrophs of the Vit. E-deficient male rate. Endocr. 60 : 729 - 732.

Grocock, C.A. & J.R. Clark (1974). Photoperiodic control of testis activity in the vole (microtus agretus) J. . Reprod. Fert. 39 : 337 - 347.

Grozevskaya, S.B. (1964). The effect of some trace elements on semen production of stud bulls. Anim. Breed. Abstr. 33 : 2347.

Hamner, C.E. & W.L. Williams (1963). Effect of the female reproductive tract on sperm metabolism in the rabbit and fowl. J. Reprod. Fert. 5 : 143-145.

Hamner, G.E. & W.L. Williams (1964). Identification of sperm stimulating factor of rabbit oviduct fluid. Proc. Soc. Exp. Biol. Med. 117 : 240 (Anim. Breed. Abstr. 32 : 1960).

Hafez, E.S.E., A.L. Badreldin & Y.H. Dariush (1955). Seasonal variations in semen characteristics of sheep in the sub-tropics. J. Agric. Sci. 45: 283 - 292.

Halima - Darbeida & R. Brudiex (1980). Seasonal variation in plasma testosterone and dihydrotestosterone levels and in metabolic clearance rate of testosterone in rams in Algeria. J. Reprod. Fert. 59 : 229 - 235.

Hartel, M. (1967). On the influence of feeding nitrate on the semen of bucks. Vet. Med. Diss. 49 pp. Hanover F.R.G.

Harpner, A.E. (1964). Amino acid toxicities and imbalances. In : Mammalian Protein Metabolism. Eds. H.N. Munro, & J.B. Allison, Vol. 2. Academic Press. N. York. p. 87.

Hernändez, L.J.J., F.P. Martinez, D.F. Lozano, P.H. Roamn, R.H. Castillo (1981). seasonal variation in semen characters of Tabasco or Pelibuey rams in the tropics. In Proceed. 8th Meet. Latin Amer. Assoc. Anim. Prod. Vol. 16 : 139.

Hernderson, L.C. (1960). Variance components estimates of some boar semen characteristics and their use in designing experiments. J. Reprod. Fert. 15 : 423 - 426.

Hilderbrandt, J. (1967). Investigations on the effect of nitrates on protein - bound iodine, Vit. A and mineral content of the blood and on semen quality in bucks. Vet. Med. Diss. 55 pp. Hanover F.R.G.

Hiroe, K., J. Masaki., T. Tomizuka & A. Hanada (1964). The effect of nutrition on characteristics of Holstein bull semen. Anim. Breed. Abstr. 33 : 1200.

Hiroe, K. & T. Tomizuka (1965a). Effect of nutrition on characteristics of goat semen. Bull. Nation. Inst. Anim. Indust. 8 : 17 - 24.

Hiroe, K. & T. Tomizuka (1965b). Effect of high environmental temperature on semen production in domestic animals. Bull. Nation. Inst. Anim. Indust. 9 : 27 - 35.

Hoffman, B., B. Leidl, & H. Karg (1972). Seasonal rythm of reproduction in the male goat. In VIIth Intern. Congr. Anim. Reprod. & A.I. pg. 423 - 424.

Hoffman, J. (1973). The influence of potoperiods on reproductive function in the female mammals. In Handbook of Physiology : Edit: Greep. R.O. & E.B. Astwood, Vol. 2 : part I pg 57 - 77. American Physiol. Soc., Washington, D.C.

Holmberg, O. (1968). Seasonal variation in libido and semen characteristics in the ram. Nord. Vet. Med. 20 : 630 - 633.

Howarth, B. Jr. (1969). Fertility in the rams following exposure to elevated ambient temperature and humidity. J. Reprod. Fert. 19: 179 - 183.

Howles, C.M., G.M. Webster & N.B. Haynes (1980). The effect of rearing under long or short photoperiod on testis growth plasma testosterone and prolactin concentration and development of sexual behaviour in rams. J. Reprod. Fert. 60 : 437 - 447.

Igboel, G. & A.M. Rakha (1971). Ejaculation and ejaculate characteristics of the Angoni Short horn Zebu bulls. J. Reprod. Fert. 26 : 183 - 184.

Igboel, G. (1974). A comparative study of the semen and seminal characteristics of two breeds of goats. E. A. Agric. For. J. 40 : 132 - 137.

Iritani, A., Y. Nishikawa & S. Nagasawa (1964). Studies on the egg-yolk Coagulation enzyme in goat semen. Jap. J. Anim. Reprod. 10 : 44 - 62.

Islam, A.B.M.M. & R.B. Land (1977). Seasonal variation in testis diameter and sperm output of rams of breeds of different prolificacy Anim. Prod. 25 (3) : 311 - 317.

Israel, S.H. (1984). Puberty in goats in relation to testicular development and semen characteristics. A. special project report. Dept. Vet. Surg. Obstr. & Reprod., Sokoine University of Agriculture.

Jackson, G. & H.L. Williams (1973). The effect of imposed light rythm on semen production of Suffolk rams. J. Agric. Sci. 81 : 179 - 188.

Jain, Y.C. & S.R. Anand (1975). Phospholipids of goat spermatozoa and the seminal plasma. Biol. Reprod. 12 (3) : 393 - 395.

Jennings, J.J. & J. McWceney (1976). Effect of frequent ejaculation on semen characteristics in rams. Vet. Rec. 98 (12) : 230 - 233.

Jennings, J.J. (1976). Effects of season and mating on semen characteristics in rams. In VIIIth Intern. Congr. Anim. Reprod. and A.I. Vol. I 121.

Johari, D.C. (1973). Studies on the semen quality of Polworth, Ramboillet, Bikaneri and Rampur-Bushair rams. Ind. J. Anim. Health 12 (1): 85 - 88.

Johnson, B.H. & C. Desjardins (1973). Seasonal effects on testis function in rams. J. . Anim. Sci. 37 : 247.

Johnson, A.D., N.L. VanDemark, W.R. Gomes, & G.D. Hodgen (1970). Ram testis lipids and lipase after high temperature. J. Anim. Sci. 26 : 945 - 949.

Jones, E.E. & G.W. Salsbury (1962). The action of carbon dioxide as a reversible inhibitor of mammalian spermatozoan respiration. Fedn. Proc. Fedn. Am. Socs. Biol. 21 : 86 (Anim. Breed. Abstr. 30 : 963).

Juma, K.N. & F. Dessouky (1969). Semen characteristics of Awassi rams. J. . Agric. Sci. 73 : 311 - 314.

Kang, S.W. & K.S. Chung (1977). Effect of hyperthermia on semen production in goats. Jap. J. Anim. Reprod. 23 (3) 93 - 98.

Karagiannidis, A. , K. Stamatiadis, & P. Tsakalof (1985). Variation of zinc ram semen and its relationship to other semen characters . Bull. Helenic Vet. Med. Society 36 (3): 117 - 127.

Kategile, J.A.,F.S.Mghóngo &J.Fredriksen(1978).Effect of iodine supplementation on reproductive performance in goats. Anim. Breed. Abstr. 50: 6340.

Katsyak, L. (1970). Effect of age on quality and quantity of semen in the ram. Anim. Breed. Abstr. 39 : 2035.

Kidunda, R. (1981). Mineral status of beef cattle at Mkata and Dakawa Ranches. Special Project. University of Dar es Salaam.

Kirkpatric, C.H. (1985). The role of androgens on sexual functions in rams. J. Reprod. and Fert. 61 : 53 - 59.

Knight, T.W. (1973). A study of factors which affect the potential fertility of the ram. Ph.D. Thesis, Univ. West. Aust.(Anim. Breed. Abstr. 42 : 2133.

Knight, T.W. (1974). Distribution of Oestrus and fertility during joining In : Sheep fertility; Recent Research and its application. West. Aust. Proceed. Symp. Univ. West Aust. 17 - 21.

Knight, T.W. (1977). Methods for the indirect estimation of testis weight and sperm numbers in Merino and R .mney mash rams. N.Z. J. Agric. Res. 20 : 291 - 296.

Kurian, N.I. & C.K.S.V. Raja (1965). Studies on the semen characteristics of Malabari bucks. Karala Vet. 4 : 31 - 33.

Kyomo, M.L. (1977). Meat from goats in Tanzania. Ph.D. Thesis. University of Dar es Salaam .

Lamont, J.L. (1964). Seasonal fluctuations in the semen quality of Merino rams in South Africa. Proceed. S. Afric. Soc. Anim. Prod. 3 : 43 - 55.

Land, R.B. & D.I. Sales (1977). Mating behaviour and testis growth of Finnish Landrace, Tasmanian Merino and Crossbred rams.Anim. Prod. 24: 89 - 90.

Land, R.B. (1970). The mating behaviour and semen characteristics of Finnish Landrace and Scottish Blackface rams. Anim. Prod. 12: 551- 560.

Laurans, R. & M. Negriere (1964). Observations on some semen characters in the bull. Proceed. 5th Congr. Anim. Prod. & A.I. Vol. IV : 611 - 616.

Leathem, J.H. (1961). Nutritional effects on the endocrine secretions. In Sex on Internal Secretions. Edit. W.C. Young 3rd ed. Williams & Wilkins, Baltimore, Maryland, U.S.A., p. 666.

Leonard, J.M., P.T. Capell & C.A. Paulsen (1976). Semen analysis: importance in evaluation of male infertility. Androl 8, Supp. : 61 - 68.

Lincoln, G.A. & W.D. Davidson (1977). The relationship between sexual and aggressive behaviour and pituitary and testicular activity during the seasonal sexual cycle of rams and the influence of photoperiod. J. Reprod. Fert. 49 : 267 - 276.

Lincoln, G.A. (1976). Seasonal variation in the episodic secretion of LH and testosterone in rams. J. Endocr. 69 : 213 - 226.

Lincoln, G.A. & R.N. B. Kay (1979). Effects of season on the secretion of LH and testosterone in intact and castrated red deer stags (Cervus elaphus). J. Reprod. Fert. 55 : 75 - 80.

Lindahl, P.E. & J.E. Kihlström (1952). J. Dairy Sci. 35 : 373 - 405.

Linsay, D.R. (1969). Sexual activity and semen production of rams at high temperature. J. Reprod. Fert. 18 : 1 - 3.

Lino. B.F. (1972). The output of spermatozoa in rams. II: Relationship to scrotal circumference, testis weight and the number of spermatozoa in different parts of the urogenital tract. Aust. J. Biol. Sci. 25 : 359 - 366.

Lodge, J. & G. Salsbury (1970). Seasonal variation and male reproductive efficiency. In: The Testis, Vol. 3, Edit. Johnson, A.D., W.R. Gomes, and N.L. Van-Demark, Acad. Press. New York pp 139 - 167.

Lodge, J.R. & G.W. Salisbury (1963). Factors influencing metabolic activity of bull spermatozoa. VI : Metabolic Co_2 and fructose. J. Dairy Sci. 46 : 140 - 146.

Lodge, J.R. & G.W. Salisbury (1965). Control of sulfite release of carbone dioxide inhibition of anaerobic glycolysis of bovine spermatozoa. J. Dairy Sci. 48 : 1688 - 1690.

Lopatko, M.I. (1966). The hydrogen ion concentration:-an important index of semen quality. Ortsevodstvo 12 (8): 27 - 28.

Lutwak-Mann, C.(1962). The dependence of gonadal function upon vitamins and other nutritional factors. Vit.Horm. 18: 63 - 74 (Anim. Breed Abstr. 31 : 658).

Malikov, D.I. (1963). The effect of atmospheric pressure on reproduction in rams. Nauk-Moskiv 8(6): 82 - 86 (Anim. Breed Abstr. 32 : 489).

Mann, J. (1981). Spermatological studies on African dwarf goats (Capra-hircus) In German. Thesis, Justus - Leibig, Univers. (Anim. Breed Abstr. 30 : 7301).

Mann, T.H. (1964). The Biochemistry of Semen and of the Male Reproductive Tract. John Wiley & Sons Inc. New York: 493 pg.

Marinov, P. & Dacheva (1984). Individual variation of ram semen freezability and correlation to K^+, Na^+ and Citric acid levels in seminal plasma. In 10^{th} Intern. Congr. Reprod. & A.I.-Univ. Illinois Vol. III : 385 B, pp.

Marshall, F.H.A. (1937). On the change-over in the oestrus cycle in animals after transference across the equator, with further observations on the incidence of the breeding seasons and the factor controlling sexual periodicity. Proceed. Roy.Soc. Biol. 122 : 413 - 428.

Maskeev, V.M. (1971). The effect of age of stud rams on the quality and quantity of their semen. Alma-Ata 7 : 168 - 171(Anim.Breed Abstr.39:2366)

Mattner, P.E. & A.W.H. Braden (1967). Studies in flock mating of sheep. II Fertilization and pre-natal mortality. Aust. J. Exp. Agric. Anim. Husb. 7 : 110 - 116.

Mattos, R.C., A.R. Günzel, J.P., Neves (1984). Seasonal effects on the semen of Merino rams, with special emphasis on acrosome morphology. Revista Brasiliera de Reprod. Animale 8 (1) : 47 - 56.

Maynard, P.V., M. Elstew, & J.A. Chandler (1975). The effect of copper on the distribution of elements in human spermatozoa. J. Reprod. & Fert. 43 : 41 - 48.

McGrady, A.V. & L. Nelson (1972). The relationship between sperm cell biopotential and the control of calcium movements. Proceed. 5th Congr. Pharmac., San Fransisco., Abstr. NO. 919 (Anim. Breed. Abstr. 40 : 3532).

McGrath, P.E., M.P. Boland & I. Gordon (1979). Effect of sexual preparation procedures on semen characteristics in the ram. J. Agric. Sci. 93 : 761 - 763.

Meachem, T.N., T.J. Cunha, A.C. Warmick, J.F. HentegesJr. & A.D. Horgrove (1963). Influences of low protein rations on growth and semen characteristics of young beef. J. Anim. Sci. 22 : 115 - 117.

Meachem, T.N., A.C. Warmick, T.J.Cunha, J.F. Henteges, Jr. & R.L. Shirley (1964). Hematological and histological changes in young beef bulls fed low protein rations. J. Anim. Sci. 23 : 380 - 384.

Meilles, J. & M.M. Nelson (1966). Effects of hormonal imbalances on dietary requirements. Vitamins Hormones 18 : 205 - 209. Anim. Breed. Abstr. 33 : 1129.

Menger, H. & L. Neubert (1985). Variation in semen quality over the course of a year and its significance for the evaluation of rams for use in artificial insemination. Anim. Breed. Abstr. 53 (11). 7070.

Mickelsen, W.D., L.D., Paisley & J.J. Dahmoen (1982). Seasonal variation in scrotal circumference, sperm quality and sexual ability in rams. J. Amer. Vet. Med. Assoc. 181 (4): 376 - 380.

Mika, J., J. Picha, D. Pichova, J. Petelikova (1984). Seasonal variation in the concentrations of LH and testosterone in the blood of rams of different breeds. Ziv. Vyroba 29 (1): 79 - 89 (Anim. Breed. Abstr. 52 (6): 3354).

Mistra, B.S. & D.P. Mukherjee (1984). Breed differences in the characteristics of goat spermatozoa. Ind. Vet. J. 61 (4): 315 - 322.

Misra, R.K., R.P. Jain, & A.K. Basuthakur (1984). Testis biometry as a basis of selection for body weight in kids. Ind. J. Anim. Sci. 54 (3) 263 - 266.

Mishra, H.R., R.C. Singh, & P.N. Roychoudhry (1969). Seasonal variations in spermatozoa characteristics of Tharparkar and Hariana bulls. Zootechnie Vet. 24 : 274.

Mittal, J.P. (1982). Seasonal variation in semen quality of Barbari bucks. Ind. Vet. J. 59 (12): 957 - 959.

Mittal, J.P. (1985). Libido and semen quality of Jamnapari bucks under arid conditions, Ind. Vet. J. 62 (2): 179.

Mittal, J.P. (1985). A study on sexual season of Marwari sheep of Rajasthan desert. Ind. Vet. J. 62 (3) : 247 - 248.

Mittal, J.P. (1984). Sperm production in the ram. Relationship to tropical environment. Anim. Breed Abstr. 53 : 5024.

Mittal, J.P. & M.D. Pandey (1972). Evaluation of semen quality of Barbari and jamnapari bucks. Ind. J. Anim. Prod. 2 (4): 14 - 19.

Mori, A. (1959). Studies on reproductive failure of ram caused by underfeeding. II On effects of feeding milk, pork and eggs to impotent ram. J. Agric. Res. 17 : 923 - 926.

Moule, G.R., A.W.H. Braden & P.E. Mattne (1966). Effects of seasons, nutrition and hormone treatment on the fructose content of ram semen. Aust. J. Agric. Res. 17 : 967 - 976.

Mukherjee, D.P. & S.P. Singh (1966). Seasonal variations in the characteristics of bull spermatozoa. Ind. J. Vet. Sci. 36 : 104.

Mukherjee, D.P. (1971). Morphology of spermatozoa in relation to fertility of animals. J. Reprod. Fert. 27 : 293.

Mukherjee, D.P. (1964). Melanizing activity of semen and its relation to percentage live spermatozoa of bulls, goats and rams. J. Reprod. Fert. 7 : 29 - 36.

Murdoch, R.V. & J.G. White (1966). Factors affecting the metabolism of acetate and glucose by ram and bull spermatozoa. Aust. J. Biol. 19 : 857 - 870.

Murdoch, R.N. & I. G. White (1968). Studies of the metabolism of human spermatozoa. J. Reprod. Fert. 16 : 351 - 356.

Murdoch, R.N. & I.G. White (1970). Studies of the stimulating effect of bicarbonate on the metabolism of ram spermatozoa. J. Rrprod. Fert. 25 : 231 - 242.

Muhunyi, W., E.Z. Drobnis, E.A. Nelson & T.Y. Lin (1982). Season, breed and age influence on production and freezability of dairy goat semen. Proc. 3rd Intern. Conf. Goat Prod. and Disease. Tucson Arizona, U.S.A. pp. 283.

Nair, K.P., E. Mathai & N. Nanda Kumaran (1982). A note on sodium and potassium in the semen of bucks. Ind. J. Anim. Sci. 52 (7): 608 - 609.

Napier, R.A.N. (1961). Fertility in male rabbit. I. Sensitivity of spermatozoa to handling techniques. J. Reprod. Fert. 2 : 246 - 269.

Nunes, J.F., A.E.F.D. Silva, S.Riera, F.De-A, Melo-Lima, F.A. Ponce De Leon (1984). Preliminary report on observed differences in goat sperm characteristics based on scrotal morphology. Anim. Breed. Abstr. 53 (8): 5068.

Okolski, A., M. Krelowska-Kulas, Z. Zapletal, E. Dudek., & W. Bielauski (1972). Effect of feeding a low protein diet on some semen characters in rams. Anim. Breed. Abstr. 41 : 4031.

Olds, D. & N.L. Van-Demark (1957). The behaviour of spermatozoa in luminal fluids of bovine female genitalia. Amer. J. Vet. Res. 18 : 603 - 609.

Olster, D.H. (1985). A comparison of puberty and seasonality in the ram. Diss. Abstr. Intern. Series B : 45 (12) 3733 - 3734.

Ortavant, R., J. Pelletier, J.P. Ravault, J. Thimonier & P. Volland-Nail (1985). Photoperiod : main proximal and distal factor of the circannual cycle of reproduction in farm animals. Oxford Reviews of Reproductive Biology 7 : 305 - 345.

Oster, G.K. (1972). Chemical reactions of the copper interauterine device. Fert. Steril. 23 : 18 - 23.

Pandey, R.P., S.N. Sinha, S.K. Mukherjee & B. Singh (1982). The level of certain ions in the semen of Saanen and Barbari bucks. Ind. J. Anim. Sci. 35 (1) 79 - 80.

Pant, K.P. & D.P. Mukherjee (1972). The effect of seasons on the sperm dimensions of buffalo bulls. J. Reprod. Fert. 29 : 425 - 429.

Paredes, G.E. (1984). Ethology of the goat (C. hircus)Anim. Breed. Abstr. 53 (9) : 5862.

Pecora, P. & L. Arata (1964). B-glucoronidase and esterase activities of rat testis after x-ray treatment. J. Reprod. Fert. 8 : 281-287.

Pelletier, J. & R. Ortavant (1975). Photoperiodic control of LH release in the ram. I. Influence of increasing and decreasing light photoperiods. Acta. Endocr. 78 : 435 - 441.

Pelletier, J. (1973). Evidence for photoperiodic control of prolactin release in rams. J. Reprod. Fert. 35 : 143 - 147.

Phillips, E.W., B. Knapp, L.C.. Heemstra & O.N. Eaton (1945): seasonal variation in the semen of bulls. Amer. J. Vet. Res. 4: 115.

Prasad, S.P., A. Roy, & M.D. Pandey (1970). Effect of daily semen collection for eight weeks. Agra Univ. J. Res. Sci. 19 (3): 61 - 66.

Prasad, S.P., A. Roy & M.D. Pandey (1970). Effect of age on semen quality and development of sex libido in Barbari males. Agra Univ. J. Res. Sci. 19 (2). 23 - 30.

Pretorius, P.S. (1969). Seasonal changes in semen characteristics of Merino rams on different feeding levels. Agro-Animalia 1 : 53 - 59.

Purser, A.F. (1973). Variation in date of onset of the breeding season in sheep. Anim Breed. Res. Org. Report. pg. 24 - 30.

Purvis I.W., L.R. Piper, B.M. Bindon, T.N. Edey, Y.M. Curtis and R.D. Nethery (1983). Further studies on testis size in crossbred Booroola rams. Proceed. 15th Ann. Conf. Aust. Soc. Reprod. Biol. Canberra - Aust. 34 pp.

Quinn, P.J. & I.G. White (1968). Distribution of Adenosine-triphosphatase (ATPase) activity in ram and bull spermatozoa. J. Reprod. Fert. 15 : 449 - 452.

Quinn, P.J., I.G. White & J.K. Voglmayr (1970). Use of a continuous flow dialysis apparatus of determine effects of cations, buffers and osmotic pressure on ram spermatozoa. J. Reprod. Fert. 22 : 253 - 255.

Quinn, P.J., I.G. White & B.R. Wirrick (1965). Studies of the distribution of the major cations in semen and male accessory secretions. J. Reprod. Fert. 10 : 379 - 383.

Quinn, P.J. & I.G. White (1966). Variation in semen cations in relation to semen quality and methods of collection. Fert. Steril. 17 : 815 - 825.

Quirke, J.F. & J.P. Hernandez (1984). Breed differnces in the breeding season in sheep. In : Endocrine causes of seasonal and lactational anaestrus in farm animals. A seminar in the C.E.C. Programme of Cordination of Research on Livestock Productivity and Management. 2 - 3 rd October, 1984, Netherlands, M. Nijhoff Publ. (1985). ISBN 0 - 8938 - 738 - 8.

Raadsma, H.W., & T.N. Edey (1985). Mating performance of paddock - mated rams. I: Changes in mating performance, ejaculate characteristics and testicular size during the joining period. Anim. Reprod. Sci. 8 : 79 99.

Radford, H.M. (1961). Photoperiodism and sexual activity in Merino ewes. I. Effect of continuos light on development of sexual activity Aust. J. Agric. Res. 12 : 147 - 153.

Rao, B.R., B.T. Jairan, J.N. Pandey (1985). Distribution of certain enzymes in semen of Nali and Corriedale rams. Ind. Vet. J. 62 (4) : 349 - 351.

Rathore, A.K. (1970). A comparative study of semen collection in Merino rams by electro-ejaculator and artificial vagina. Ind. Vet. J. 47 : 668 - 671.

Ravault, J.P. (1976). Prolactin in the ram. Seasonal variation in the blood plasma from birth until three years old. Acta. Endocr. 83: 720 - 725.

Reviers, M.T.H., De C. Perreau & G.A. Lincoln (1985). Photoperiodic variations of somatic and germ cell populations in Soay ram testis. J. Reprod. Fert. 74 (2): 329 - 334.

Ringwall, K.A., R.P. Wetteman, J.V. Whiteman & P.E. Junieuicz (1985a). Seasonal changes in testosterone and Luteinizing hormone in the serume of mature F_2 Finnish landrace x Dorset rams classified as seasonal or non-seasonal. Ann. Sci. Res. Report. Agric. Expt. Station. Oklahoma State Univ. (Anim. Breed. Abstr. 53 (12) : 7613).

Ringwall,,K.A., R.P. Wettemann & J.V. Whiteman, (1985b). Seasonal changes in scrotal circumference and sexual flush in mature Finnish Landrace x Dorset rams. Ann. SCI: Res. Report. Agric. Exp. Station Oklahoma State Univ. (Anim. Breed. Abstr. 53 (12) : 7632).

Rouget, J. (1962). Regulation des saisons sexuelles chez de brebis de races differents au moyon de diverse rythmes luminex. Biophysics 2: 209 - 222 (Anim. Breed. Abstr. 32 : 406).

Roussel, J.D. & O.T. Stallcup (1966). Cytochemical comparison between the activity of lactic dehydrogenese - diphosphopyridine mucleotide-diaphorase system in the testis and epididymis compared to some semen characteristics. Intern. J. Fert. 13 : 142 - 149.

Saacke, R.G. (1982). Components of semen quality. J. Anim. Sci. 55 : 1 - 13.

Sadykov, R.E. & S. Arifov (1969). Variations in the physiological characters of stud rams following treatment with calcium iodide Anim. Breed. Abstr. 39 : 630.

Sahni, K.L. & A. Roy (1967). A note on summer sterility in Romney Marsh rams under tropical conditions. Ind. J. Vet. Sci. 37 : 335 - 338.

Sahni, K.L. & A. Roy (1972). A note on seasonal variations in the occurance of abnormal spermatozoa in different breeds of sheep and goats under tropical conditions. Ind. J. Anim. Sci. 42 (7): 501 - 503.

Sahni, K.L. & S.B. Tiwari (1975). The effect of ejaculation frequency on semen characteristics of Ramboillet rams at different seasons. Ind. Vet. J. 52 (6) : 421 - 425.

Saha, D.N. & N.S. Sindhi (1982). A note on certain biochemical attributes of seminal plasma in different breeds of shepp (ovis aries). Ind. Vet. J. . 59 (12) : 990 - 991.

Saito, S., I.M. Bush & W.F. Whitmore (1967). Effects of certain metals and chelating agents on rat and dog epididymal spermatozoan motility. Fert. Steril. 18 : 517 - 529.

Salamon, S. (1962). Studies on A.I. of Merino sheep. III : The effect of frequent ejaculation on semen characteristics and fetilizing capacity. Aust. J. Agric. Res. 13 : 1137.

Salisbury, G.W., N.L. Van-Demark, J.R. Lodge & R.G. Cragle (1960). Inhibition of spermatozoan metabolism by pCo_2, pH, K-ion and anti-bacterial compounds. Amer. J. Physiol. 198 : 659 - 667.

Salisbury, G.W. (1959). Reversal by metabolic regulators of Co_2-induced inhibition of mammalian spermatozoa. Proc. Soc. Exp. Biol. Med. 101 : 187 (Anim. Breed. Abstr. 27 : 539).

Savkin, V.A. & A.I. Reshetov (1984). Seasonal variation in semen quality and physiological traits in bulls. Anim. Breed. Abstr. 53 (4) 2075.

Saxena, V.B. & S.S. Vripathi (1983). Sperm abnormalities in Murrah bulls as affected by different seasons. Ind. J. Anim. Res. 17 (1): 25 - 30.

Schröder, G. (1963). Morphological investigations on bull semen. Arch. Tierz 6 : 284 - 299. (Anim. Breed. Abstr. 35 : 459).

Schoirren, J.M. (1975). Meaning of normal values of the ejaculate for fertility. Z. Nautkr. 50 : 97 - 103 (Anim. Breed. Abstr. 47: 503)

Scott, T.W., I.G. White & E.F. Annison (1962). The biochemical role of bicarbonate in metabolism of ram spermatozoa. Biochem. J. 82 : 392 - 398.

Schanbacher, B.D. & D.D. Lunstra (1976). Seasonal changes in sexual activity and serum levels of LH and testosterone in Finnish Landrace and Suffolk rams. J. Anim. Sci. 43 (3) : 644 - 650.

Semenov, S.I. & P.S. Koretskii (1971). The effect of type of feeding on the reproductive ability of rams and the quality of their progeny. Ortsev. Kozov. 31 (1) : 100 - 106 (Anim. Breed. Abstr. 43: 639)

Setchell, B.P. (1974). Secretions of the testis and epididymis. J. Reprod. Fert. 37 : 165 - 177.

Shelby, D.R. & C.W. Foley (1966). Influence of Co_2 absorbent on the consumption of oxygen by boar spermatozoa. J. Anim. Sci. 25 : 352 - 356.

Shettles, L.B. (1960). The relation of dietary deficiencies to male fertility. Fert. Steril. 11 : 88 - 92.

Simkiss,K. (1967). Calcium in reproductive physiology. A comparative study of vertebrates. Reinhold, New York pp. 123.

Simpson, E.C. (1966). Semen production and fertility of rams following exposure to controlled ambient temperatures. Diss. Abstr. 26 : 4143.

Silva, A.E.D.F. & J.F. Nunes (1984). Seasonal effect on sexual activity and semen quality in wooless sheep of the Santa Ines and Somali breeds. Rev. Braz. Reprod. Anim. 8 (4) : 207 - 214.

Sinha, N.K. & K.L. Sahni (1985). Effect of age and season on certain characteristics of Muzaffarnagri rams. Ind. J. Anim. Health 24 (1): 45 - 48.

Sinha, N.K., G.M. Wani & K.L. Sahni (1981). Effect of season and age on seminal attributes of Jamnapari bucks. Ind. Vet. J. 58 (12): 963 - 965.

Simplicio, A.A., G.S. Rierca, E.A. Nelson & K.D. Pant (1982). Seasonal variations in seminal and testicular characteristics of Brazilian Somali rams in the hot semi - arid climate of tropical north-east Brazil. J. Reprod. Fert. 66 (2) 735 - 738.

Smirnov, I.V. (1964). The effect of osmotic factors on bull and boar spermatozoa. Anim. Breed. Abstr. 33 : 44.

Symth, P. & I. Gordon (1967). Seasonal and breed variations in the semen characteristics of rams in Ireland. Irish Vet. J. 21 : 222 - 233.

Snedecor, G.W. & W.G. Cochran (1980). Statistical Methods. Seventh Ed. The Iowa State Univ. Press. Ames. Iowa U.S.A.

Sod-Moriah, V.A., G.M. Goldberg & E. Bedrack (1974). Intra-scrotal temperature, testicular histology and fertility of heat - acclimatized rats J. Reprod. Fert. 37 : 263.

Stigter, C.J. (1980). Solar radiation as statistically related to sunshine duration. A comment using low - latitude data. Agric. Meteorol. 21 : 173 - 178.

Strautmanis, D.A. (1984). Evaluating bulls for the fertilizing ability of their semen. Zhivt. 9 : 48 - 50 (Anim. Breed. Abstr. 53 (12) 173).

Summermatter, P. & A. Flükiger (1985). Semen production in male goats during the early part of the year. Anim. Breed. Abstr. 53 (12): 7658).

Symington, R.B. & J. Oliver (1966). Observation on the reproductive activity of tropical sheep in relation to the photoperiod. J. Agric. Sci. 67 : 7 - 12.

Tekin N. & M. Muyan (1985). Reproduction in the goat. - A review; Doga Bilim Dergisi 9 (2) 208 - 219 (Anim. Breed. Abstr. 57 (8): 6152).

Tewari, S.B., R.P. Sharm & A. Roy (1968). Effect of frequency of semen collection on seminal attributes and fertility in goats Ind. J. Vet. Sci. 38 : 607 - 615.

Thimomier, J., J.P. Rawault, & R. Ortavant (1978).. Plasma prolactin variations and cyclic ovarian activity in ewes submitted to different light regimes. J. Reprod. Fert. 58 : 401 - 416.

Thompson, J.N., J. McChowell & G.A.J. Pitt (1964). Vitamin A and reproduction in rats. Proc. Roy, Soc. B 159 : 510 (Anim. Breed. Abstr. 33 : 729).

Tilton, W.A., A.C. Warnick, T.J. Cunha, P.E. Loggins & R.L. Shirley (1964). Effect of low energy and protein intake on growth and reproductive performance of young ram. J. Anim. Sci. 23 : 645 - 648.

Tiwari, S.B. & K.L. Sahni (1982). Semen production in relation in to age, body weight and testis dimension in crossbred rams (Rambouillet x Malpura) under semi-arid conditions. Ind. Vet. J. 59 (12) 995 - 997.

Tomkins, T. & M.J. Bryant (1976). Influence of mating pressure and season on the semen characteristics of rams. Anim. Prod. 22 (3): 371 - 378.

Traldi, A. De (1981). Physical and morphological characters of semen from Moxoto goats from puberty to sexual maturity. Anim. Breed. Abstr. 53 (9): 5865.

Trejo, G.A. (1984). Seasonality in rams. In Memorias, Bases de la cria ovina - Mexico (Anim. Breed. Abstr. 53 (11): 7094).

Turek, F.W. & C.S.Campbell (1979). Photoperiodic regulation of neuro-endocrine - gonadal activity. Biol. Reprod. 20 : 32 - 50.

Ulyanov, A.N. & A.P. Kovalenko (1972). Influence of season on semen quality in rams of different breeds. In VIIth Intern. Congr. Anim. Reprod. & A.I. pg. 491.

Valerani, L. (1964). Summer climatic conditions and fertility in bulls. Investigations and considerations on a quinquennium of activity at the Milan Bull centre. Proceed 5th Intern. Congr. Anim. Reprod. and A.I. Vol. III : 185 - 194.

Van Demark, N.L., G.R. Fritz, & R.E. Mauger (1964). Effect of energy intake on reproductive performance of dairy bulls. II. Semen production and replenishment. J. Dairy Sci. 47 : 898 - 904.

Varshney, V.P., B.P. Sengupta, & M.D. Pandey (1977). Enzymatic constituents of goats' semen. Ind. Vet. J. 55 (4) : 348 - 349.

Varshney, V.P. (1977). Biometrical studies on the morphology of ram spermatozoa. Ind. J. . Anim. Sci. 47 (7) 427 - 429.

Vinha, N.A. (1980). Physical and morphological aspects of goat semen. Memorias. Assoc. Latino - Americana de Prod. Animali, 14 : 103 - 104. (Anim. Breed. Abstr. 50 _ 7311).

Vinha, N.A. & F. Megale (1974). Physical and morphological aspects of goat semen Arquivo da Escole de Veterinaria da Universidade Federal de Minas Gerais 26 (3) : 299 - 305. (Anim. Breed. Abstr. 43 : 5300).

Vishwa-Karma, P. (1962). The pH and bicarbonate ion concentration of the oviduct and uterine fluids. Fert. Steril. 13 : 481 - 487.

Vinha, N.A. (1980). Seasonal variation in semen production and quality in goats. Memorias Assoc. Latino-Americana de prod. Animalia 14 : 105 - 107 (Anim. Breed. Abstr. 50 : 7312).

Waites, G.M.H. & B.P. Setchell (1964). Effect of local heating on blood flow and metabolism in the testis of the conscious rams J. Reprod. Fert. 8 : 339 - 342.

Wales, R.G. & B.J. Restall (1966). The metabolism of ram spermatozoa in the presence of genital fluids of the ewe. Aust. J. Biol. Sci. 19 : 199 - 213.

Walker, S.K., R.W. Ponzoni, J.R. W. Walkley & A.S.C. Morbey (1985). The development of male reproductive traits in progeny of Merino strains of different reproductive performance. Anim. Reprod. Sci 8 (½): 61 - 78.

Wallace, J.C. & R.G. Wales (1964). Effect of ions on the metabolism of ejaculated and epididymal ram spermatozoa. J. Reprod. Fert. 8 : 187 - 203.

Williams, H.L. (1972). The interaction of genotype and environment on the reproductive performance of sheep. In VIIth Intern. Congr. Anim. Reprod. & A.I. Vol. III: 49 - 56.

Yarney, T.A. & L.M. Sanford (1983). The reproductive endocrine response of adult rams to sexual encounters with estrual ewes is seasons dependent. Hormones & Behaviour 17 (12): 169 - 182.

Yeates, N. T.M. (1947). Influence of variation in length of day upon the breeding season of sheep. Nature: 160 : 429 - 430.

Yeates, N.T.M. (1949). The breeding season of the sheep with particular reference to its modification by artificial means using light. J. Agric. Sci. 39 : 1 - 43.

Yokoki, Y. & A. Ogassa (1977). Effect of hyperthermia on semen production in goats. Jap. J. Anim. Reprod. 23 (3): 93 - 98.

Yusof, N., V. Venkataswany, S. Othman (1982). The semen production and quality of imported Jersey bulls in Malaysia. MARDI Res. 10 (2) : 273 - 276.

Young, L.G. & L. Nelson (1974). Calcium ions and control of the motility of sea urchin spermatozoa. J. Reprod. Fert. 41 : 371 - 378.

Zemjannis, R. (1970). Diagnostic and Therapeutic Techniques in Animal Reproduction. Second Edit. William & Wilkins Comp. Baltimore U.S.A. 242 pp.

Zerfas, H.P. & J. Steinbach (1982). Comparative studies on the quality and freezability of Alpine and Boer goat semen. Proceed. III Intern. Conf. Goat Prod. & Diseases Tucson, U.S.A. 283 pp.

Zheltobryukh, N.A., V.K. Ivakhnenko, & M.M. Atbazov (1985). The effect of semen and regime of use on semen production of rams Zhivotnovodstvo 3 : 44 - 46 (Anim. Breed. Abstr. 53 (7) : 4371.

Zyvkov, V.Y. (1962). Adenine nucleotides in the spermatozoa of ram, boar and stallion. Biol. Abstr. 43 . 680.

APPENDICIES

Analysis of variance

Semen volume by : Ejaculates (W)

Months (M)

Bucks (B)

Source of variation	Sum of squares	DF	Mean square	F	Significant of F
Main effects	8.428	14	0.602	2.442	0.005*
W	0.006	2	0.003	0.012	0.976
M	1.794	5	0.359	1.456	0.210
B	6.334	7	0.905	3.671	0.001
Explained	8.428	14	0.602	2.442	0.005*
Residual	25.142	102	0.246		
Total	33.562	116	0.289		

Analysis of variance

Semen density by : Ejaculates (W)

Months (M)

Bucks (B)

Source of variation	Sum of squares	DF	Mean squares	F	Significance of F
Main effects	16452.748	14	1175.196	3.682	0.000
W	947.724	2	473.862	1.485	0.230
M	13651.351	5	2730.270	8.553	0.000
B	1321.585	7	188.798	0.591	0.763
Explained	16452.750	14	1175.196	3.682	0.000
Residual	33196.828	104	319.200		
Total	49649.578	118	420.759		

Analysis of variance

Percent livespermatozoa by : Ejaculates (W)

Months (M)

Bucks (B)

Source of variation	Sum of squares	DF	Mean squares	F	Significance of F
Main effects	45.116	14	3.223	4.828	0.000
W	2.845	2	1.423	2.131	0.122
M	12.251	5	2.450	3.671	0.005
B	33.234	7	4.748	7.113	0.000
Explained	45.116	14	3.223	4.828	0.000
Residual	64.075	96	0.667		
Total	109.190	110	0.993		

Analysis of variance

Mass motility by : Ejaculates (W)

Months (M)

Bucks (B)

Source of variance	Sum of squares	DF	Mean squares	F	Significance of F
Main effects	1144796.750	14	81771.195	5.021	0.000
W	5935.447	2	2967.723	0.182	0.833
M	326093.250	5	65218.648	4.005	0.003
B	803077.812	7	114725.398	7.045	0.000
Explained	1144796.750	14	81771.195	5.021	0.000
Residual	1563411.750	96	16285.539		
Total	2708208.500	110	24620.078		

Analysis of variance

Total number of spermatozoa by : Ejaculates (W)

Months (M)

Bucks (B)

Source of variation	Sum of squares	DF	Mean square	F	Significance of F
Main effects	1459801344.000	14	104271528.000	1.455	0.144
W	192194832.000	2	96097416.000	1.341	0.266
M	429962080.000	5	85992416.000	1.200	0.315
B	863334592.000	7	123333512.000	1.721	0.113
Explained	1459801600.000	14	104271544.000	1.455	0.144
Residual	6521256960.000	91	71662168.000		
Total	7981058560.000	105	76010080.000		

Analysis of variance

Total number of livespermatozoa by : Ejaculates (W)

Months (W)

Bucks (B)

Source of variation	Sum of squares	DF	Mean square	F	Significance of F
Main effects	316039.031	14	22574.217	5.300	0.000
W	7114.449	2	3557.225	0.835	0.441
M	18537.893	5	3707.579	0.870	0.506
B	278835.219	7	39833.602	9.352	0.000
Explained	316039.031	14	22574.217	5.300	0.000
Residual	366301.531	86	4259.320		
Total	682340.562	100	6823.406		

Analysis of variance

Semen volume by : Breed

Source of variation	Sum of squares	DF	Mean square	F	Significance of F
Main effects	0.872	1	0.872	3.080	0.078
Q	0.872	1	0.872	3.080	0.078
Explained	0.872	1	0.872	3.080	0.078
Residual	28.887	102	0.283		
Total	29.760	103	0.289		

Analysis of variance

Semen density by : Breed

Source of variation	Sum of squares	DF	Mean square	F	Significance of F
Main effects	43.165	1	43.165	0.107	0.741
Q	43.165	1	43.165	0.107	0.741
Explained	43.164	1	43.164	0.107	0.741
Resdiaul	41316.570	102	405.064		
Total	41359.734	103	401.551		

Analysis of variance

Percent livespermatozoa by : Breed

Source of variation	Sum of squares	DF	Mean square	F	Significance of F
Main effects	6.702	1	6.702	6.853	0.010
Q	6.702	1	6.702	6.853	0.010
Explained	6.702	1	6.702	6.853	0.010
Residual	99.757	102	0.978		
Total	106.459	103	1.034		

Analysis of variance

Mass motility by : Breed (Q)

Source of variation	Sum of squares	DF	Mean square	F	Significance of F
Main effects	330658.312	1	330658.312	14.293	0.000
Q	330658.281	1	330658.281	14.293	0.000
Explained	330658.250	1	330658.250	14.293	0.000
Residual	2290329.500	99	23134.641		
Total	2620987.750	100	26209.877		

Analysis of variance

Total number of spermatozoa by Breed (Q)

Source of variation	Sum of square	DF	Mean square	F	Significance of F
Main effects	330279424.000	1	330279424.000	4.482	0.035
Q	330279392.000	1	330279392.000	4.482	0.035
Explained	330279424.000	1	330279424.000	4.482	0.035
Residual	7295384064.000	99	73690752.000		
Total	7625663488.000	100	76256632.000		

Analysis of variance

Semen volume by : Month and Breed (M, Q)

Source of variation	Sum of squares	DF	Mean square	F	Significance of F
Main effects	2.675	6	0.446	1.551	0.168
M	1.819	5	0.364	1.266	0.284
Q	0.783	1	0.783	2.726	0.098
2-way interactions	0.506	5	0.101	0.352	0.880
M Q	0.506	5	0.101	0.352	0.880
Explained	3.181	11	0.289	1.006	0.447
Residual	28.734	100	0.287		
Total	31.914	111	0.288		

Analysis of variance

Semen density by : Month and Breed (M, Q)

Source of variation	Sum of squares	DF	Mean square	F	Significance of F
Main effects	14294.220	6	2382.370	7.561	0.000
M	14289.629	5	2857.926	9.070	0.000
Q	21.492	1	21.492	0.068	0.784
2-way interactions	3045.524	5	609.105	1.933	0.095
M Q	3045.524	5	609.105	1.933	0.095
Explained	17339.744	11	1576.340	5.003	0.000
Residual	31509.506	100	315.095		
Total	48849.250	111	440.083		

Analysis of variance

Percent livespermatozoa by : Month and Breed (M, Q)

Source of variation	Sum of squares	DF	Mean square	F	Significance of F
Main effects	14.998	6	2.500	2.888	0.013
M	9.027	5	1.805	2.086	0.074
Q	9.369	1	9.369	10.824	0.002
2-way interactions	3.107	5	0.621	0.718	0.614
M Q	3.107	5	0.621	0.718	0.614
Explained	18.104	11	1.646	1.902	0.050
Residual	75.303	87	0.866		
Total	93.407	98	0.953		

Analysis of variance

Mass motility by : Month and Breed (M, Q)

Source of variation	Sum of squares	DF	Mean square	F	Significance of F
Main effects	638055.062	6	106342.500	6.421	0.000
M	339179.719	5	67835.945	4.096	0.002
Q	246754.812	1	246754.812	14.898	0.000
2-way interactions	225106.937	5	45021.387	2.718	0.025
M Q	225106.875	5	45021.375	2.718	0.025
Explained	863162.000	11	78469.273	4.738	0.000
Residual	1440935.250	87	16562.475		
Total	2304097.250	98	23511.197		

Analysis of variance

Total number of spermatozoa by : Month and Breed (M, Q)

Source of variation	Sum of squares	DF	Mean square	F	Significance of F
Main effects	778603904.000	6	129767320.000	1.833	0.101
M	448324480.000	5	89664896.000	1.266	0.285
Q	406377568.000	1	406377568.000	5.740	0.018
2-way interactions	545651712.000	5	109130344.000	1.541	0.184
M Q	545651648.000	5	109130328.000	1.541	0.184
Explained	1324255744.000	11	120386888.000	1.700	0.086
Residual	6301407744.000	89	70802336.000		
Total	765663488.000	1000	76256632.000		

Analysis of variance

Total number of livespermatozoa by : Month and Breed

Source of variation	Sum of squares	DF	Mean square	F	Significance of F
Main effects	81319.047	6	13553.175	2.178	0.052
M	16573.629	5	3314.726	0.533	0.753
Q	58215.773	1	58215.773	9.355	0.003
2-way interactions	47193.172	5	9438.635	1.517	0.192
M Q	47193.172	5	9438.635	1.517	0.192
Explained	128512.250	11	11682.932	1.877	0.053
Residual	553828.312	89	6222.790		
Total	682340.562	100	6823.406		

Analysis of variance

Semen volume by : Season (S)

Source of variation	Sum of squares	DF	Mean square	F	Significance of F
Main effects	1.045	1	1.045	3.710	0.054
S	1.045	1	1.045	3.710	0.054
Explained	1.045	1	1.045	3.710	0.054
Residual	28.715	102	0.282		
Total	29.760	103	0.289		

Analysis of variance

Semen density by : Season (S)

Source of variations	Sum of squares	DF	Mean square	F	Significance of F
Main effects	1.045	1	1.045	3.710	0.054
S	1.045	1	1.045	3.710	0.054
Explained	1.045	1	1.045	3.710	0.054
Residual	28.715	102	0.282		
Total	29.760	103	0.289		

Analysis of variance

Percent livespermatozoa by : Season (S)

Source of variation	Sum of squares	DF	Mean square	F	Signifi-cance of F
Main effects	0.445	1	0.445	0.428	0.522
S	0.445	1	0.445	0.428	0.522
Explained	0.445	1	0.445	0.428	0.522
Residual	106.014	102	1.039		
Total	106.459	103	1.034		

Analysis of variance

Mass motility by : Season (S)

Source of variation	Sum of squares	DF	Mean square	F	Significance of F
Main effects	175643.750	1	175643.750	7.111	0.009
S	175643.734	1	175643.734	7.111	0.009
Explained	175643.750	1	175643.750	7.111	0.009
Residual	2445344.000	99	24700.445		
Total	2620987.750	100	26209.877		

Analysis of variance

Total number of spermatozoa by : Season (S)

Source of variation	Sum of squares	DF	Mean square	F	Significance of F
Main effects	88958168.000	1	88958168.000	1.169	0.282
S	88958168.000	1	88958168.000	1.169	0.282
Explained	88957952.000	1	88957952.000	1.169	0.282
Residual	7536705536.000	99	76128336.000		
Total	7625663488.000	100	76256632.000		

Analysis of variance

Total number of livespermatozoa by : Season (S)

Source of variation	Sum of squares	DF	Mean square	F	Signifi- cance of F
Main effects	5759.713	1	5759.713	0.843	0.364
S	5759.713	1	5759.713	0.843	0.364
Explained	5759.688	1	5759.688	0.843	0.364
Residual	676580.875	99	6834.150		
Total	682340.562	100	6823.406		

Analysis of variance

Semen volume by :Breed and Season (Q, S)

Source of variation	Sum of squares	DF	Mean square	F	Significance of F
Main effects	1.704	2	0.852	3.057	0.050
Q	0.909	1	0.909	3.260	0.070
S	0.848	1	0.848	3.044	0.080
2-way interactions	0.107	1	0.107	0.382	0.545
Q S	0.107	1	0.107	0.382	0.545
Explained	1.811	3	0.604	2.166	0.095
Residual	30.103	108	0.279		
Total	31.914	111	0.288		

Analysis of variance

Semen density by : Breed and Season (Q, S)

Source of variation	Sum of squares	DF	Mean square	F	Significance of F
Main effects	7772.922	2	3886.461	10.511	0.000
Q	23.802	1	23.802	0.064	0.788
S	7768.331	1	7768.331	21.010	0.000
2-way interactions	1143.808	1	1143.808	3.094	0.078
Q S	1143.809	1	1143.809	3.094	0.078
Explained	8916.730	3	2972.243	8.039	0.000
Residual	39932.520	108	369.746		
Total	48849.250	111	440.083		

Analysis of variance

Percent livespermatozoa by : Breed and season (Q, S)

Source of variation	Sum of squares	DF	Mean square	F	Significance of F
Main effects	6.913	2	3.456	3.846	0.024
Q	6.228	1	6.228	6.929	0.010
S	0.941	1	0.941	1.047	0.310
2-way interactions	1.110	1	1.110	1.235	0.269
Q S	1.110	1	1.110	1.235	0.269
Explained	8.023	3	2.674	2.976	0.035
Residual	85.384	95	0.899		
Total	93.407	98	0.953		

Analysis of variance

Mass motility by Breed and season (Q, S)

Source of variation	Sum of squares	DF	Mean square	F	Signifi- cance of F
Main effects	464637.500	2	232318.750	12.067	0.000
Q	324079.344	1	324079.344	16.834	0.000
S	165762.187	1	165762.187	8.610	0.004
2-way interactions	10533.656	1	10533.656	0.547	0.468
Q S	10533.632	1	10533.632	0.547	0.468
Explained	475171.125	3	158390.375	0.227	0.000
Residual	1828926.125	95	19251.854		
Total	2304097.250	98	23511.197		

Analysis of variance

Total number of spermatozoa by : Breed and season (Q, S)

Source of variation	Sum of squares	DF	Mean square	F	Significance of F
Main effects	439829600.000	2	219914800.000	3.021	0.052
Q	350871424.000	1	350871424.000	4.820	0.029
S	109550192.000	1	109550192.000	1.505	0.221
2-way interactions	124294432.000	1	124294432.000	1.707	0.191
Q S	124294400.000	1	124294400.000	1.707	0.191
Explained	564124160.000	3	188041392.000	2.583	0.057
Residual	7061539328.000	97	72799376.000		
Total	7625663488.000	100	76256632.000		

Analysis of variance

Total number of livespermatozoa by : Breed and season (Q, S)

Source of variation	Sum of squares	DF	Mean square	F	Significance of F
Main effects	68556.117	2	34278.059	5.578	0.005
Q	62796.402	1	62796.402	10.218	0.002
S	3810.698	1	3810.698	0.620	0.439
2-way interactions	17669.539	1	17669.539	2.875	0.089
Q S	17669.545	1	17669.545	2.875	0.089
Explained	86225.687	3	28741.896	4.677	0.004
Residual	596114.875	97	6145.514		
Total	682340.562	100	6823.406		