SEASONAL FERTILITY OF BILLY GOATS

By

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THESIS

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DECLARATION

I, hereby declare that this thesis entitled "Seasonal Fertility of Billy Goats" is a bonafide record of research work done by me during the course and that the thesis has not previously formed the basis for the award to me of any Degree, Diploma, Associateship, Fellowship or other similar title of any other University or Society.

27/9/95

Mannuthy,
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CERTIFICATE

Certified that this thesis entitled "Seasonal Fertility of Billy Goats" is a record of research work done independently by Sri. C. Ibraheem Kutty under my guidance and supervision and that it has not previously formed the basis of the award of any Degree, Fellowship or Associateship to him.

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INTRODUCTION

Domestic goats (*Capra hircus*) though ubiquitous in its distribution, more than two third of it is concentrated within 30° north and south latitude. India has a goat population of 110 lakhs of which 15.8 lakhs are in Kerala state. While the state forms only 1.18 per cent of the area of Indian Union 14.3 per cent of the goat population of the nation is in Kerala. It has a population density of about 40 goats per km^2 and goat to cattle ratio is 1:2.2 in contrast to national ratio of 1:17.9. Growth of the goat population for the last 30 years also was proportionate to the growth of human population and the number of homesteads. It shows that goat has become an integral part of the social life of the state. Realisation of it may probably be the reason for greater interest now being evinced on goat husbandry.

Kerala that is lying on the west of the peninsular India between 8°-18′ and 12°-48′ north latitude has the Western Ghats as its eastern boundary. Because of this geographical location, the climate and vegetations of Kerala are peculiar from the adjoining areas of the peninsula lying in the same latitude. The climate and vegetations appears to be the reason for relatively higher population of goats and almost to the practical exclusion of sheep in the region.

Goats in the tropical region do not have a distinct breeding season unlike their counterparts in the sub tropics, where they are seasonal breeders. In the tropical area though they breed round the year there are variations due to influence caused by photoperiod, climate, quality and quantity of feed, management and breed.

Efficiency of reproduction is the basis for economic production of any livestock. As such a detailed comprehension of the reproductive behaviour and pattern of goats in the state in the circumstance of geographic and climatic peculiarities and in the context of greater interest now being evinced on goat husbandry is imperative. It was in this background the present study was taken up with the following objectives:

1. To elucidate seasonal variation in semen characteristics in relation to fertility of billy goats

2. To find out whether the variations are in consonance with the change in pattern of oestrous cycle of nannies.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Seasonal variation in fertility of billy goats is reported to occur as in the case of the females. Since the male fertility is very much associated with sexual behaviour and correlated with semen characteristics and morphometry of the testes it is easier than in the females, to study its variations.

2.1. Seasonal effects on reproduction of goats

Domestic goats are seasonally polyoestrous and their breeding activity is influenced by photoperiod (Pineda, 1989). Bucks may also alter their capacity for reproduction according to the seasons of the year (Cupps, 1991) but, Jainudeen and Hafez (1993) while concurring with the view said this seasonality is governed by photoperiodicity with oestrous activity commencing during the period of decreasing day length. Further they said that in the tropical zone where there is less variation in length, indigenous goats tend to breed throughout the year with restricted sexual activity during some months and they attributed the restricted sexual activity to high environmental temperature and lack of feed during the period. They have also stated that sexual activity increases once the rainy season sets in thus increasing the feed availability.

Elwishy *et al.* (1970) observed that variation in sexual desire and semen characteristics of Damascus bucks were largely influenced by changes in relative humidity than either by sunshine or ambient temperature. They also observed that the relative humidity adversely affect sexual desire as well as semen characteristics than other climatic variables that were kept constant.

It has been reported by Leidl *et al.* (1970) that the seasonal rhythm of reproduction in male goats affects only the functional relationship of androgens and components of accessory sex gland secretions whereas germinal cells show no fluctuation. Hoffman *et al.* (1972) reported they could not observe seasonal variation in spermatogenesis of sexually mature animals, while they observed variation in spermatogenesis and function of vesicular gland of pubertal animals.

Seasonal variation in blood level of hypophyseal and gonadal hormones were observed in the male Pygmy goat which are seasonal breeders under temperate climatic conditions. Serum LH and testosterone increased with decreasing day length and attained maximum in October. Lowest level of LH was observed in November and of testosterone in June, whereas serum FSH increased slightly in September but, highest level of it was in April (Muduuli *et al.*, 1979). Miyamoto *et al.* (1987) observed peak serum FSH and LH at the peak of summer and that returned to low level in autumn. Serum testosterone also increased in mid-summer and it was maintained until the early winter.

Perezllano *et al.* (1992a and 1992b) observed no significant influence of season on sexual behaviour parameter of Verato bucks, though during ascendant photoperiod, libido and serving capacity values were slightly lower and reaction time values were higher than during descendant photoperiod and lowest libido values were in winter season. They concluded that reproductive cycle of animals in mid-low latitude are not markedly affected like in other zones of higher latitude by the length of photoperiod, though there is an appreciable slight seasonality of breeding.

Walkden-Brown and Restall (1992b) reported that Australian Cashmere bucks are clearly seasonal with a summer peak in live weight and testis size and an autumn peak in reproductive hormones and odour score. Debeneth and Coll (1992) observed 3 main periods of endocrine activity such as constant low testosterone in winter, a transition period characterised by episodic low basal testosterone levels in spring, constant high testosterone with maximum mean values in summer and decreasing levels in autumn. On comparison of this with hormone levels of females they observed that seasonal endocrine and gonadal activity in males consistently remained ahead to that of females, suggesting differences in regulatory mechanism.

Sexual activity of Malabari bucks indicated by reaction time did not show any variation between winter, summer, monsoon and post-monsoon

seasons (Patil and Raja, 1978). Whereas sexual activity parameters of Baladi goats such as ejaculation frequency and exhaustion time differed significantly between seasons with highest ejaculation frequency and longest exhaustion time in autumn and the values were lowest in spring. Though reaction time and number of courtship acts per ejaculate differed significantly between months, seasonal changes were not significant (Ashmawy, 1979).

Sexual vigour of Jamnapari and Beetal bucks of Indian arid zone was generally high in all the seasons of the year (Mittal, 1985, 1986 and 1987b) whereas crossbred bucks showed significant seasonal fluctuation with low sexual activity during summer and with satisfactory level of libido in winter (Mittal, 1986 and 1987a). Singh and Purbey (1992) recorded highest level of testosterone in hot dry summer (May to June) and the lowest in winter season (December to February). Significant variation occurs in reaction time between bucks and it was positively correlated with sperm concentration. Singh and Purbey (1994) reported that reaction time was significantly longer in winter and was lowest during dry summer season in indigenous bucks.

2.1.1. Environmental variables

Variation in duration, intensity and quality of light influences temperature and availability of food and shelter to animals and these indirect influences were thought to be primary controlling factors of seasonal reproduction in animals.

Later, it was recognised that there are direct effects of light and temperature on the reproductive performance of animals (Johnson *et al.*, 1970). Temperature appears to be a minor factor in the control of reproduction, length of daylight and amount of feed are of greater importance and difference in these two variables result in altered sexual activity during summer months in sheep and goats (Engle, 1946). Malikov (1963) reported that the atmospheric pressure and temperature exercise its influence on quality of semen. According to Elwishy *et al.*(1970) variation in sexual desire and semen characteristics of Damascus goats were largely influenced by changes in relative humidity than by either of sunshine or ambient temperature.

In goats subjected to hyperthermia no marked changes in semen volume or sperm numbers were observed. However, sperm motility was reduced and abnormal spermatozoa increased (Yokoki and Ogasa, 1977).

Gangwar (1988) reported that high air temperature and rain fall distribution of tropics cause heat stress to livestock and it reduces efficiency of growth, production and reproduction through altered endocrine status. Intermittent slight but repeated, increase in the scrotal subcutaneous temperature induces in sheep a significant increase in embryonic death. The changes being apparent from the 4th day of heat treatment indicating that the effect must have occurred on sperms stored in the epididymis (Mieusset *et al.*, 1992).

Deficiency in diet adversely affect the testicular function of rams and it is due to the fall in energy and protein intake and deficiency of trace minerals indirectly affects by impairing the appetite (Martin and White, 1992). Prezllano (1992b) reported that influence of photoperiod was not significant on sexual behaviour in Verato bucks but it has significant influence in overall seminal parameters. Australian Cashmere bucks exhibit marked reproductive seasonality and nutrition is a powerful modulator of seasonal cycle. Seasonal regulation of testicular mass and sperm production appears to be primarily dependent on feed intake and growth (Walkden-Brown *et al.*, 1994).

Out of the atmospheric variables affecting spermatogenic activity of goats during different seasons, air temperature caused variation in the histology of testis of goats thus affecting semen quality (Mukherjee *et al.*, 1980). All seminal characteristics of crossbred bucks which were directly correlated with fertility status were adversely affected by high ambient temperature and low nutritional status (Mittal, 1986). A significant difference in live weight was recorded between breeding seasons with maximum weight in winter and minimum in summer months which coincided with forage availability of the area. Variation in day length, ambient temperature and humidity did not affect any of the semen characteristics of Beetal bucks (Mittal, 1987b).

According to Baruah *et al.* (1992) high ambient temperature-high humidity complex of spring season adversely affects the sex vigour as well as volume and other semen characteristics of Black Bengal bucks. Quality of Kambing-Kantjang buck semen was adversely affected by high ambient temperature (Murugaiyah, 1992). According to Singh and Purbey (1994) longer day and high ambient temperature during summer provided more suitable environment for better progressive motility of spermatozoa.

2.2. Morphometry

Goats with small testes were significantly lower in body length and height at withers and rump (Lohle and Barfuse, 1961). Machado *et al.* (1991) reported significant increase in scrotal circumference with increasing body weight in Alpine, Moxoto breeds and their crossbred bucks. Scrotal circumference, age and body weight had high positive correlation with testicular parameters. Ejaculate volume, body weight, Scrotal circumference, testicular size and semen characteristics were positively correlated while negative correlation was found between percentage live and percentage abnormal sperms and body weight (Chauhan and Israel, 1992).

Significant seasonal variation occurred in live weight, Scrotal circumference, paired testes weight, total testicular sperm, mean seminiferous tubular diameter, paired epididymal weight and total epididymal sperm, while in Australian Cashmere bucks number of sperm per gram of testicular parenchyma did not vary significantly between season. Total testicular sperm was highly correlated with testes weight and Scrotal circumference (Walkden-Brown and Restall, 1992a). Australean Cashmere bucks are clearly seasonal with a summer peak in body weight and testis size and an autumn peak in reproductive hormones (Walkden-Brown and Restall, 1992a).

In British bucks although body weight increased during the period of study the testis size decreased from October to January, thereafter, it increased to reach original size in August (Ahmed and Noakes, 1993). According to Walkden- Brown *et al.* (1994) seasonal regulation of testis mass and thereby sperm production of Australian Cashmere goats appears to be primarily dependent on feed intake and growth as high quality diet induced large increase in body mass and testicular mass without influencing the seasonally low concentration of FSH and LH present at the time.

Mukherjee *et al.* (1960) observed significantly lower seminiferous tubular diameter in goats during autumn season than in other seasons. During summer and autumn the spermatogenesis was lesser than in winter and spring.

Bilaspuri and Guraya (1980) reported marked variation in testicular lipid content between the five seasons.

Daily sperm production and external Scrotal length was correlated besides width and circumference in Maradi goats (Carew and Egbunike, 1980). The effect of season was highly significant on body weight in Sirohi goats, the live weight was higher in winter than in other seasons. The difference between summer, monsoon and spring and initial mass was statistically not significant (Misra, 1983). Scrotal circumference was significantly correlated with semen volume, sperm concentration, sperm tail abnormality and distal protoplasmic droplet (Borgohain *et al.* 1983b).

According to Misra *et al.* (1984), body weight at six months has significant positive correlation with testicular measurements at 3 months. Testis length at 3 months could be considered as a basis for selection of kids for a higher body weight at six months. In non-descript Indian bucks testicular weight was lesser in summer than in winter seasons and testis weight has highly significant correlation with total sperm number per unit weight (Jindal, 1984).

Statistically significant difference was not seen between right and left testis in length, width and thickness (Baishya *et al.*, 1985). Mahmood *et al.* (1988 and 1989) also observed no significant difference between right and left

testes measurements, while body weight was significantly correlated with scrotal circumference and all testicular measurements. In Black Bengal and Ganjam bucks, testicular volume was found to have significant correlation with initial motility and sperm concentration, so also, length of Cauda epididymis correlates significantly with initial motility. Scrotal and testicular volume have been positively correlated with fertility (Giri *et al.,* 1994).

2.3. Physical attributes of semen

Season did not affect semen quality or glycerol kinase activity of native Japanese goats, while their crossbreds with Saanen and pure bred Saanen showed a decrease in glycerol kinase activity during June to August and thereafter regained earlier level (Mohri *et al.,* 1970).

In Anglo-Nubian bucks semen characteristics as progressive motility and percentage of abnormality varied significantly with seasons, while volume and sperm concentration did not vary significantly (Vinha, 1975 and 1979). Corteel (1975) reported significant differences in semen characteristics between breeds, seasons, age and individual bucks of French Alpine and Poitou breeds.

Considerable variation in semen trait were observed among bucks, between ejaculates and between seasons of the year in African dwarf goats kept in Germany (Mann, 1980).

According to Perezllano *et al.* (1992a) influence of season was insignificant on semen characteristics in Verato bucks except for total number of spermatozoa per ejaculate. Machado *et al.* (1991) reported that semen production and its overall quality were better during dry season than in rainy seasons in Alpine, Moxoto and their crossbreds. Under tropical climatic conditions semen of excellent quality suitable for artificial insemination could be obtained from Barbari and Jamnapari bucks at any time of the year (Sahni and Roy, 1968).

There was highly significant differences between individual bucks in semen quality but differences between weeks on daily collection for 5 weeks, were not significant except for sperm concentration in Barbari and Jamnapari bucks (Mittal and Pandey, 1972). Summer and autumn were the most favourable season for semen production in Barbari bucks and winter was the least favourable season both quantitatively and qualitatively (Mittal, 1982). In Jamnapari bucks none of the semen characteristic varied significantly between seasons (Mittal, 1985 and 1986). In exotic crossbreds of Beetal and Jamnapari semen characteristics were adversely affected by the high ambient temperature

and low nutritional status as a result some of the seminal characteristics yielded a lower rating during summer season but in winter it was satisfactory (Mittal, 1986 and 1987a).

Physical, morphological and biochemical characteristics of Beetal buck semen showed no significant variation between seasons (Mittal, 1987b). Semen quality of Black Bengal bucks adjudged by volume, sperm concentration initial motility, livability and abnormality percentage, were best in summer followed by winter and autumn in descending order (Baruah *et al.*, 1992).

2.3.1. Volume

Semen collected at twice weekly intervals for 6 weeks, average ejaculate volume was reported to be 0.67±0.03 ml for Zambian native bucks and 1.34±0.05 for Boer bucks and between collections there was no significant difference (Igboeli, 1974). Semen volume was largest (1.68 ml) in autumn and smallest (1.3 ml) in summer but the difference was not significant (Vinha, 1975 and 1979). Yokoki and Ogasa (1977) observed no marked variation in semen volume of goats exposed to hyperthermia.

Ritar *et al.* (1992) reported a daily decline in semen volume of Angora bucks when they were subjected to hourly collection five times a day, on each

of 5 consecutive days during the breeding season. In Boer bucks semen collected during November to January yielded a higher volume while volume was almost same during summer and winter (Tuli and Holtz, 1992). In Zairabi and Zairabi x Anglo-Nubian bucks, Ibrahim and Yousri (1992) reported to have obtained highest volume of semen during spring-summer. In British bucks semen volume decreased from October to minimum values during April to July, then it increased to reach highest value by September to October (Ahmed and Noakes, 1993). Misra and Sengupta (1965) reported a lower volume of Jamnapari buck semen during autumn. Semen volume of Malabari bucks showed significant variation between seasons. Maximum volume was observed during post monsoon season (October and November) and least volume was during winter (December to February) (Patil and Raja, 1978).

No significant variation in semen volume was reported between summer and autumn seasons in Jamnapari bucks maintained under arid climatic conditions (Mittal, 1985). Reddy *et al.* (1989) reported significant influence of season on semen volume of local bucks of Tirupati recording higher volume during winter (January to February) in bucks above 2 years and during north east monsoon (October to December) in bucks below 2 years.

Significant decrease in volume of semen is reported in Kambing-Kantjang bucks exposed to high environmental temperature for 7 days every

month (Murugaiyah, 1992). Singh and Purbey (1994) reported significant influence of season on ejaculate volume, highest volume being in wet summer and lowest in winter.

2.3.2. Colour

Igboeli (1974) reported that ejaculate colour of Zambian native bucks and Boer bucks ranged from creamy white to yellow and varied considerably among goats within and between breeds and also between ejaculates of the same goat. Semen of British bucks is reported to vary from yellow or whitish yellow during September to December to white during rest of the year (Ahmed and Noakes, 1993).

2.3.3. H-ion concentration

Memon *et al.* (1986) found that pH of semen was lower in samples collected by artificial vagina compared to samples by electroejaculation. Ibrahim and Yousri (1992) observed a lower pH of semen of Zairabi and Zairabi x Anglo Nubian bucks which received 50 mg zinc per day compared to those without it.

In Malabari bucks, Patil and Raja (1978) observed no significant variation in semen pH between summer, monsoon, post-monsoon and winter seasons. Significant variation is reported in semen pH between different age groups in local bucks of Tirupati (Reddy *et al.*, 1989). Significant positive correlation is reported between volume and pH of semen of non-descript Indian bucks. Between seasons the highest pH was recorded during spring and lowest in dry summer (Sing and Purbey, 1992 and 1994).

2.3.4. Sperm concentration

Consistency of buck semen varied with seasons, being more dense in February, April and May (Tuli and Holtz, 1992).

Elwishy *et al.* (1970) reported that although highly significant monthly and seasonal differences in sperm concentration were observed, the total number of sperm per ejaculate of Damascus bucks failed to show neither monthly nor seasonal significant differences. Great differences were observed in sperm number per ejaculate between the periods of March to August and September to February in African dwarf goats kept in Germany (Mann, 1980). Sperm concentration of Anglo-Nubian bucks were greater in summer and lowest in winter but the differences were not significant (Vinha, 1975 and 1979).

When semen was collected 5 times daily from six mature sexually rested Angora bucks at one hour interval, there was a decline in sperm concentration and number of spermatozoa on consecutive days, while successive ejaculates within a day differed only in number of spermatozoa (Ritar *et al.*, 1992). Machado *et al.* (1991) reported significantly higher sperm concentration in the rainy season than in dry season in Alpine, Moxoto and Alpine x Moxoto bucks. They also observed that during dry season semen production of cross-bred was significantly better than that of purebreds.

Varato bucks yielded a greater number of sperm per ejaculate during descendant photoperiod though a good semen quality was maintained throughout the year (Perezllano *et al.* 1992a). In Boer bucks Tuli and Holtz (1992) reported maximum sperm concentration in February, April and May. In British bucks sperm concentration was lowest during November and highest during May (Ahmed and Noakes, 1993).

Patil and Raja (1978) reported significant difference between seasons with maximum sperm concentration in monsoon and least during summer in Malabari bucks. Similarly sperm concentration and number of sperms per ejaculate differed significantly between seasons in local bucks of Tirupati with lowest number during hot weather period (Reddy *et al.*, 1989). Exposure of

bucks to high environmental temperature resulted in a significant decrease in concentration of spermatozoa in Kambing-Kantjang bucks (Murugaiyah, 1992).

Season and age had a significant effect on sperm concentration and ejaculate volume of Jamnapari bucks, sperm concentration was highest during winter in young bucks and lowest during rainy season, while in older bucks, highest sperm concentration was in summer and the lowest was in rainy season (Sinha *et al.,* 1981). Significant variation occurs in sperm concentration between individual bucks. Influence of season on sperm concentration was highest and significant in autumn (Singh and Purbey 1992 and 1994).

2.3.5. Mass activity and initial motility

In Zambian native and Boer bucks motility of second ejaculate was slightly better (Igboeli, 1974). Sperm motility of French Alpine and Poitou bucks varied significantly between season (Corteel, 1975). Motility of Anglo-Nubian buck semen was highest in spring and lowest in summer (Vinha, 1975 and 1979). There was not much difference in sperm motility of African dwarf goats kept in Germany between the periods March to August and September to February (Mann, 1980).

Mass activity was reported to be better for semen collected by artificial vagina than semen collected by electroejaculation (Memon *et al.* 1984). The highest percent of motile spermatozoa was reported to be during winter compared to other seasons in Zairabi and Zairabi x Anglo-Nubian bucks (Ibrahim and Yousri, 1992). In Boer bucks semen collected during November to January showed higher mass activity and initial motility and they were same during summer and winter (Tuli and Holtz, 1992). Ahmed and Noakes (1993) reported better mass activity and motility during September to December in British bucks.

Misra and Sengupta (1965) reported that semen quality of bucks in autumn season was poor. Highly significant correlation occurs between sperm motility and sperm concentration of Barbari bucks (Prasad *et al.*, 1970). Patil and Raja (1978) reported significant variation in initial motility of Malabari buck semen between summer, winter, monsoon and post-monsoon seasons. Highest motility is seen recorded during post-monsoon and lowest was during winter. Mittal (1986 and 1987a) reported significantly lower motility during summer in exotic crossbreds while indigenous bucks did not show any significant seasonal variation.

In local bucks of Tirupati motility varied with season, highest being during winter and north east monsoon (Reddy *et al.*, 1989). Significant

reduction in motility in the semen of bucks exposed to high ambient temperature was reported eventhough there was no appreciable change in mass activity (Murugaiyah, 1992). Significant influence of season on initial mass activity was noticed with the highest being in wet summer and lowest in winter. Season did not affect progressive motility of spermatozoa significantly but it varied with highest and lowest progressive motility in hot summer and winter seasons respectively (Singh and Purbey, 1994).

2.4. Sperm morphology and viability

2.4.1. Sperm abnormalities

Arbeiter (1964) reported an average of 15.5 per cent abnormal spermatozoa of different types after a study on 144 ejaculates of nine healthy bucks. In Anglo-Nubian bucks incidence of sperm abnormalities was reported to be highest in spring and lowest in autumn and winter, the difference was significant also (Vinha, 1975 and 1979). In goats subjected to hyperthermia percentage of abnormal spermatozoa increased 15-20 days after application of hyperthermia (Yokoki and Ogasa, 1977).

Abnormal spermatozoa percentage differed between bucks but not between seasons in African dwarf goats (Fischer and Mann, 1979). Photoperiod

had no significant effect on percentage of normal acrosome in Verato bucks (Perezllano *et al.*, 1992a). Roca *et al.* (1992) reported that presence of distal protoplasmic droplet and acrosome damage were the most frequently seen sperm abnormalities in buck semen. They have also observed that season rather than the age of bucks, significantly influence the occurrence of sperm abnormalities.

Abnormal spermatozoa percentage in different breeds of goats did not show any seasonal variation and recorded extremely low throughout the year (0.5 to 4 per cent) (Sahni and Roy, 1972). Patil and Raja (1978) observed significant seasonal variation in abnormal sperm count in Malabari bucks highest count was in summer, followed by winter and the lowest was during post-monsoon season. Bordoloi and Sharma (1983) reported that variation in the percentage of total abnormal spermatozoa between different breeds was non-significant but mid-piece abnormalities between them varied significantly.

Borgohain *et al.* (1983a) reported non-significant variation in abnormal sperm count between breeds, between bucks and between months except mean mid-piece abnormality which varied significantly between breeds. In crossbred bucks, mean abnormal sperm percentage was higher compared to indigenous bucks and between seasons crossbred bucks showed a significantly lower abnormal sperm percentage during summer (Mittal, 1986 and 1987a). Percentage of abnormal sperms did not significantly vary between seasons in

Tirupati local bucks of two years and above, while those below two years showed highly significant variation (Reddy *et al.*, 1989).

2.4.2. Sperm vitality

In Zambian native bucks and Boer bucks not much variation is reported between two collections in the same week with regard to percentage of live spermatozoa (Igboeli, 1974). Chauhan and Israel (1992) reported that the body weight has a negative correlation with percentage of live and abnormal sperms in 11 Tanzanian and Norwegian bucks studied. Live sperm proportion was higher during November to January and it was same during summer and winter in Boer bucks (Tuli and Holtz, 1992). Dead and abnormal sperms were highest during May in British Bucks (Ahmed and Noakes, 1993).

Percentage of live spermatozoa was lower in goat semen during autumn (Misra and Sengupta, 1965). Proportion of live spermatozoa was not significantly altered between seasons in Malabari bucks (Patil and Raja, 1978) while, significant alteration was reported in Barbari bucks (Mittal, 1982). Highly significant variation was also reported in live sperm percentage between Beetal, Saanen and Non-descript Assam goats (Bordoloi and Sharma, 1983). High proportion of live spermatozoa was seen in crossbred bucks during winter than in summer while such a variation was not seen in indigenous bucks (Mittal, 1986 and 1987a).

In local bucks of Tirupati, percentage of live sperm did not vary much between seasons (Reddy *et al.*, 1989). A significant decrease in percentage of live sperm was reported in bucks subjected to high environmental temperature (Murugaiyah, 1992).

2.4.3. Sperm metabolism by MBR test

More oxygen utilization and less lactic acid accumulation indicating better metabolic activity is reported for bovine semen collected during summer and suspension of the sperms in seminal plasma of winter reversed this trend only to a lesser extent indicating that seasonal effect on metabolism resides in the cells (Nakabayashi and Salisburry, 1959). Ozan (1961) reported a significant negative correlation between number of live spermatozoa and MBR time of ram semen.

The relative length of time required for reduction of Methylene blue to leucomethylene blue serves as an indicator of number and activity of spermatozoa, however, it is influenced by factors which alter the hydrogen reduction (Kumaran, 1960). Comparison of metabolic activity of buck spermatozoa based on oxygen uptake showed that metabolic rate was poor during autumn (Misra and Sengupta, 1965).

Lactic acid content was reported to have a negative correlation with percentage of motile and live spermatozoa in Jamnapari and Barbari bucks (Singh *et al,* 1985). Season had no significant effect on MBR time in Jamnapari and Beetal bucks, while their exotic crossbreds showed higher and lower MBR time during summer and winter seasons respectively (Mittal 1986 and 1987a).

2.4.4. Sperm resistance to hyperosmotic medium

By subjecting the sperms to unfavourable conditions, the percentage of resistant sperms may be obtained which gives a rapid means of assessing the probable storage and fertilizing capacity of the sperms (Kumaran, 1960). According to Maule (1967) measurement of the deleterious effect of 1 per cent sodium chloride solution on sperm survival will be worthy for further investigation in view of variation in osmotic pressure of different diluents.

Sperm resistance and survival were greater in winter and spring than in summer in Askanian rams even though sexual activity was maintained throughout the year (Aslanjan and Lisovaja, 1963). Highly significant variation is reported between breeds of bull with regard to resistance of sperms to 1 per cent sodium chloride solution. The spermatozoa of Red Dane bulls showed larger R value than that of crossbred bulls (Bhatt and Chauhan, 1984).

An osmotic resistance test was described for bovine semen by Rvell and Mrode (1994) and was found to be very useful in routine semen assessment for predicting the post-thaw activity of sperms. Hypo-osmotic swelling test is a simple and economic test used for evaluating fertilizability of spermatozoa and functional integrity of acrosome membrane (Hafez, 1993).

Cold shock resistance of buck semen was observed to be poor during autumn season by Misra and Sengupta (1965). Sharma *et al.* (1991) observed significant positive correlation of Milavanov's 'R' value with other common tests for semen quality and concluded that Milavanov's test using 1 per cent saline is of minimum importance for routine semen evaluation and confounding effect of dilution will interfere with the correct assessment of semen quality.

2.5. Sperm preservation and storage

Initial motility, motility of extended semen stored at 4-5° C and viability showed a highly significant monthly and seasonal variation in Damascus bucks (Elwishy *et al.*, 1970). Semen collected in the summer months did not maintain motility during storage as did the semen collected during cooler months of the year (Johnson *et al.*, 1970).

Corteel (1976) reported that motility of chilled buck semen decreased markedly from beginning of June to Mid-July and then it gradually increased. The average conception to artificial insemination with chilled semen also decreased corresponding to the decrease in motility. In African dwarf goats maximum survival time of sperms in neat semen showed great variation between the periods March to August and September to February (Mann, 1980). Singh *et al.* (1982) reported that the effect of extenders on motility, live sperm per cent and lactic acid accumulation was non-significant and the effect of period of preservation was highly significant in buck semen stored at +5°C.

2.6. Season and Fertility

Variation in conception rate between seasons may be related to variation in the semen characteristics but, in all cases the amount of variation in fertility that can be accounted by variation in a related semen characteristic is small (Bishop, 1955). According to Linford *et al.* (1976) laboratory tests are inadequate as methods of predicting fertility of semen samples but can be used for setting limits, outside which poor samples can be discarded. The average conception rate to artificial insemination with chilled semen collected twice weekly between June and August from 2 French Alpine goats was 57.3 per cent

at the start and end of the period but it fell to 15 per cent during the period from 26th June to 14th August and this fall was found to be due to decrease in motility (Corteel, 1976).

Sudarsanan and Raja (1973) reported an overall conception of 75.8±8 per cent in Malabari goats with 3 matings. Mathai and Nair (1981) reported that variation in conception with year, breed of buck and season were not significant, while a significant reduction occurred in conception rate due to storage of semen beyond 24 h. Barbari goats artificially bred with semen extended in goat milk during different seasons showed a superior conception rate during autumn (September-October) than in rainy (July-August), summer (April-May) and winter (November-December) (Prasad, 1981).

In Pashmina goats artificial insemination from October to March resulted in conception rate that was almost double of the result obtained from April to September (Mohan *et al.*, 1983).

Krishnakumar (1992) reported two seasonal peaks in the occurrence of oestrus and conception in Nanny goats in Kerala. He reported 26.61 per cent, 25.95 per cent and 24.13 per cent conception during the periods September to November, March to May and June to August respectively. Average numbers of kids born from animals conceived during September to November was

lower (1.27) compared to those conceived during March to May (1.35) and June to August (1.55). In Deccani ewes difference in the conception between two seasons were significant showing higher conception in July to August than in January to February, while in Dorset x Deccani crossbreds, difference in the conception rate between above seasons were non-significant (Bhoite *et al.,* 1992).

MATERIALS AND METHODS

MATERIALS AND METHODS

The study was carried out at Kerala Agricultural University Goat Farm, Mannuthy for a period of one year from 1st of May 1994 to 30th of April 1995. Seven adult bucks of Malabari and their exotic crosses and of 1-4 years age were used for the study. They were fed and managed under intensive system (Fig. 3.1) and the conditions were uniformly maintained during the period of study.

3.1. Environmental variables

During the period of the study maintained daily recordings of maximum and minimum temperature and humidity from maximum and minimum and dry and wet bulb thermometers installed inside the animal shed (Fig. 3.1).

3.2. Morphometry

3.2.1. Body weight

Animals were weighed on a platform balance at biweekly intervals and a body weight record was maintained during the period of study.

3.2.2. Scrotal circumference

Maximum scrotal circumference was measured after containing both testicles within the scrotum by the hand held at the neck of scrotum and biweekly record of it was maintained.

Fig.3.1. Thermometers fixed on the side of entrance to billy barn

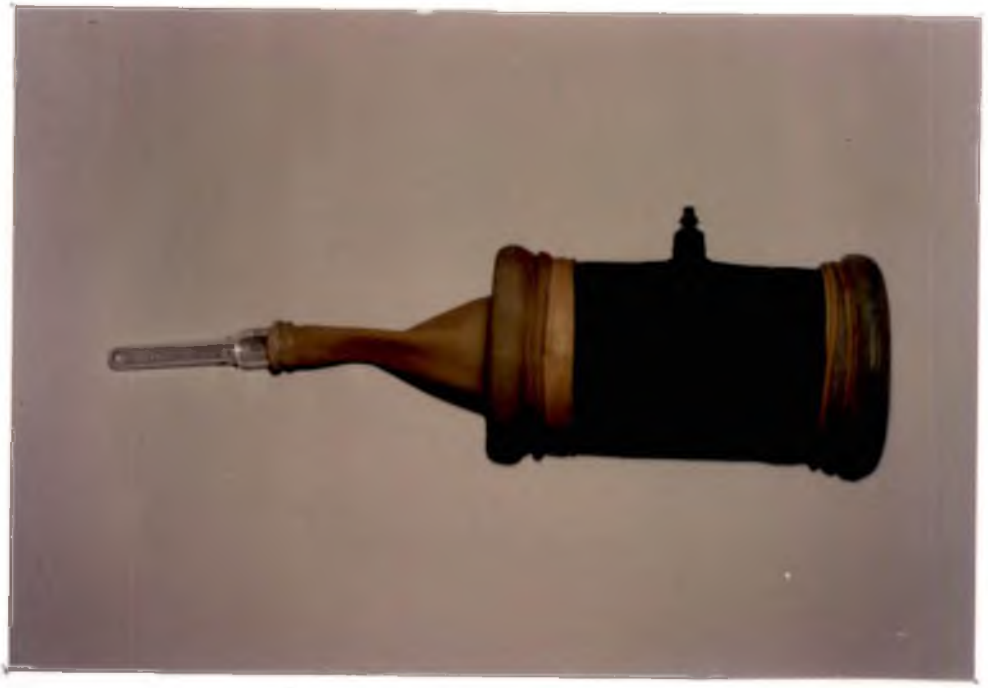


Fig.3.2. Danish type (modified) artificial vagina used in the study

3.2.3. Testicular length and diameter

Length and diameter of right and left testicles were measured at biweekly intervals using vernier calipers and a record of it was kept.

3.3. Physical attributes of semen

3.3.1. Semen collection

Semen was collected by rotation, from each of the bucks weekly once in the morning and it was subjected to preliminary and detailed evaluation.

Semen was collected using a Danish type artificial vagina remodelled with a rubber hose length of 15 cms to suit to bucks (Fig.3.2). A slender 2 ml glass vial receptacle with decimal graduation was attached to the free end of the rubber cone for easy reading of volume soon after collection.

Artificial vagina was prepared to have inside temperature of 45-50° C and required pressure was provided by blowing in air. The mouth of artificial vagina was lubricated and collection vial was insulated with a polystyrene cube.

One of the bucks was used as mount. Sexual stimulation for a thrust and good collection from buck was achieved by two or three false mounts. Collection vial with semen was detached from the artificial vagina and was kept in a water bath at 37° C.

3.3.2. Volume - was recorded readily from the graduations on the collection vial.

3.3.3. Colour - was recorded by visual observation and graded on the intensity of yellow colour from 'Y' to 'YYYY' for light yellow to intense yellow colour.

3.3.4. H-ion concentration - A drop of semen was mixed with a small drop of universal pH indicator solution (BDH), aspirated to a capillary tube and matched with standard. The value thus obtained was recorded as pH of the sample.

3.3.5. Consistency - was assessed by visual examination of resistance to flow and graded as watery, thin milky, thick milky and creamy.

3.3.6. Density - was graded and expressed as 'D' to 'DDDD' based on the visual examination of opacity of a drop of semen taken on a glass slide.

3.3.7. Sperm concentration - Sperm concentration was determined using Haemocytometer. Number of sperms enumerated in eighty small squares was multiplied by 10^4 to obtain the number of sperms per cubic millimetre.

3.3.8. Number of sperms per ejaculate - This was calculated by multiplying the volume of semen with sperm concentration.

3.3.9. Mass activity - A small drop of semen was taken on a glass slide and examined under low magnification of microscope for eddies, currents and swirls and on its intensity was expressed from '+' to '++++'.

3.3.10. Initial motility - A small drop of extended semen was taken on a glass slide and a cover glass was put over it. Motility was assessed under high magnification of the microscope and it was expressed in percentage.

3.4. Sperm morphology and viability

3.4.1. Sperm abnormalities

Percentage of abnormal sperm was estimated in a nigrosine-eosin stained semen smear under oil immersion objective of a microscope. From different microscopic fields on the slide a total of 333 sperms were counted keeping a note of specific abnormalities and the proportion of each were worked out from it and expressed in percentage.

3.4.2. Sperm vitality

Two drops of eosin (1%) and 4 drops of nigrosine (10%) were mixed on a glass slide, small drop of semen was mixed with it and smears were

prepared with the mixture. Under high magnification of the microscope a total of 100 sperms were counted keeping a note of dead and live sperms from the staining character and percentage of each were worked out.

3.4.3. Sperm metabolism by MBR test

This test was carried out at biweekly intervals. Methylene blue solution was prepared by dissolving 50 mg of methylene blue (BDH) in 100 ml of 1.96% aquous solution of sodium citrate.

In a 2 ml test tube 0.4 ml of Tris buffer and 0.1 ml of semen was taken, 0.05 ml of methylene blue solution was mixed with it, layered over with 0.5 ml of liquid paraffin and kept in a water bath maintained at 46.5°C. Time taken for the blue colour to disappear was noted as MBR time.

3.4.4. Sperm resistance to hyperosmotic medium

Resistance test was carried out at biweekly intervals. In a test tube 0.1 ml semen was taken and it was titrated with 2 per cent aquous sodium chloride starting with 0.1 ml gradually increasing the volume of addition, motility was checked after each addition of saline till the complete loss of motility. Volume of saline used per 1 ml semen (volume used for 0.1 ml semen x 10) was recorded as 'R' value expressed in ml.

3.5. Sperm preservation and storage

The semen after removal of an aliquot for evaluation by the above described tests, was extended using goat milk antibiotic extender in the ratio of 1:5.

Goat milk was heated for 10 minute at 92 to 95°C then cooled and filtered. To 5 ml of the milk 5000 IU of Benzyl penicillin and 5000 μg of dihydrostreptomycin sulphate was added to form the extender.

A portion of the extended semen was packaged in 2 ml vials and kept in a water bath and it was stored in a refrigerator. Motility was assessed at 24 and 48 h of storage.

3.6. Season and Fertility

With another portion of extended semen, the nannies of the farm which were in heat on the day of collection were inseminated. Success rate of artificial insemination was assessed on the basis of 40th day non-return rate, clinical examination by a method of combined abdominal manipulation with per rectal digital examination of reproductive tract at 90 days. Number and sex of kid, born were also recorded.

3.7. Analysis of the Data

The period of study was divided into four seasons based on the naximum and minimum temperature, humidity and also on length of day. Data on the morphometry semen characteristics and fertility were grouped in ıccordance with the above periods. It was statistically analysed to know the variations between the periods were significant, so that, it is attributable to nfluence of environmental variables.

RESULTS

RESULTS

4.1. Seasonal effects on reproduction of goats

4.1.1. Environmental variables

Monthly averages of daily recordings of maximum, minimum temperatures, humidity and length of day are given in Table 1 and quarterly averages of the same in Table 2.

Table 1 Monthly averages of maximum-minimum temperatures, humidity and day length

Month	Temperature in °C		Humidity (per cent)	Day length (h)
	Maximum	Minimum		
Sep	31.53	23.85	86.05	12.05
Oct	31.43	23.51	90.37	11.47
Nov	30.66	23.54	77.51	11.30
Dec	31.87	22.52	73.46	11.22
Jan	33.04	23.11	69.09	11.25
Feb	35.24	24.33	70.10	11.37
Mar	37.10	24.68	70.61	11.56
Apr	36.18	25.61	78.10	12.14
May	33.93	25.42	74.72	12.31
Jun	29.64	23.78	89.53	12.38
Jul	28.56	23.18	93.67	12.35
Aug	29.59	23.74	92.41	12.22

Table 2 Quarterly averages of Maximum-Minimum temperatures, humidity and day length

Quarter	Temperature in °C		Humidity (per cent)	Day length (h)
	Maximum	Minimum		
SON	31.20	23.36	84.64	11.47
DJF	33.38	23.48	70.88	11.28
MAM	35.73	25.23	74.47	12.14
JJA	29.26	23.56	91.87	12.32

Between quarters highest of maximum temperature of 35.73°C was recorded during March to May (MAM) and the lowest of 29.26°C was during June to August (JJA). Minimum temperature was highest during MAM and it was 25.23°C.

Highest humidity of 91.87 per cent was recorded during JJA while the lowest of 70.88 per cent was during December to February (DJF). Length of day decreased gradually from June to reach the shortest average day length of 11.22 h in December and thereafter increased gradually to reach the longest average duration of 12.32 in June.

The above informations are also presented in Figure 4.1. and 4.2., which formed the basis for classification of the period of study into four seasons for the purpose of analysis of the data. Day length and the maximum temperature during the day were given more emphasis than the minimum temperature and humidity. Humidity of the respective periods were taken into consideration to correlate its effect on the seminal and morphometric changes.

4.2. Morphometry

Quarterly and half yearly averages of body weight and scrotal circumference are given in Table 3. Though there was a steady increase in the average body weight of bucks during the period of study there was no significant variation between quarters. Variation in scrotal circumference between quarters was not significant and it maintained direct correlation to body weight. Scrotal circumference varied from 23 to 28 cm between animals and between periods and the average for all the bucks during the entire period was 25.06±0.18 cm. Correlation of humidity and day length with quarterly averages of body weight and scrotal circumference are given in Table 4. They were found to maintain an inverse relationship. Quarterly averages of biweekly measurements of length and diameter of testes are given in Table 5. Yearly average length of testes was 8.57±0.11 cm. There was no difference in average length between right and left testis.

Fig.4.1 MONTHLY AVERAGES OF MAXIMUM, MINIMUM TEMPERATURES, HUMIDITY AND DAY LENGTH

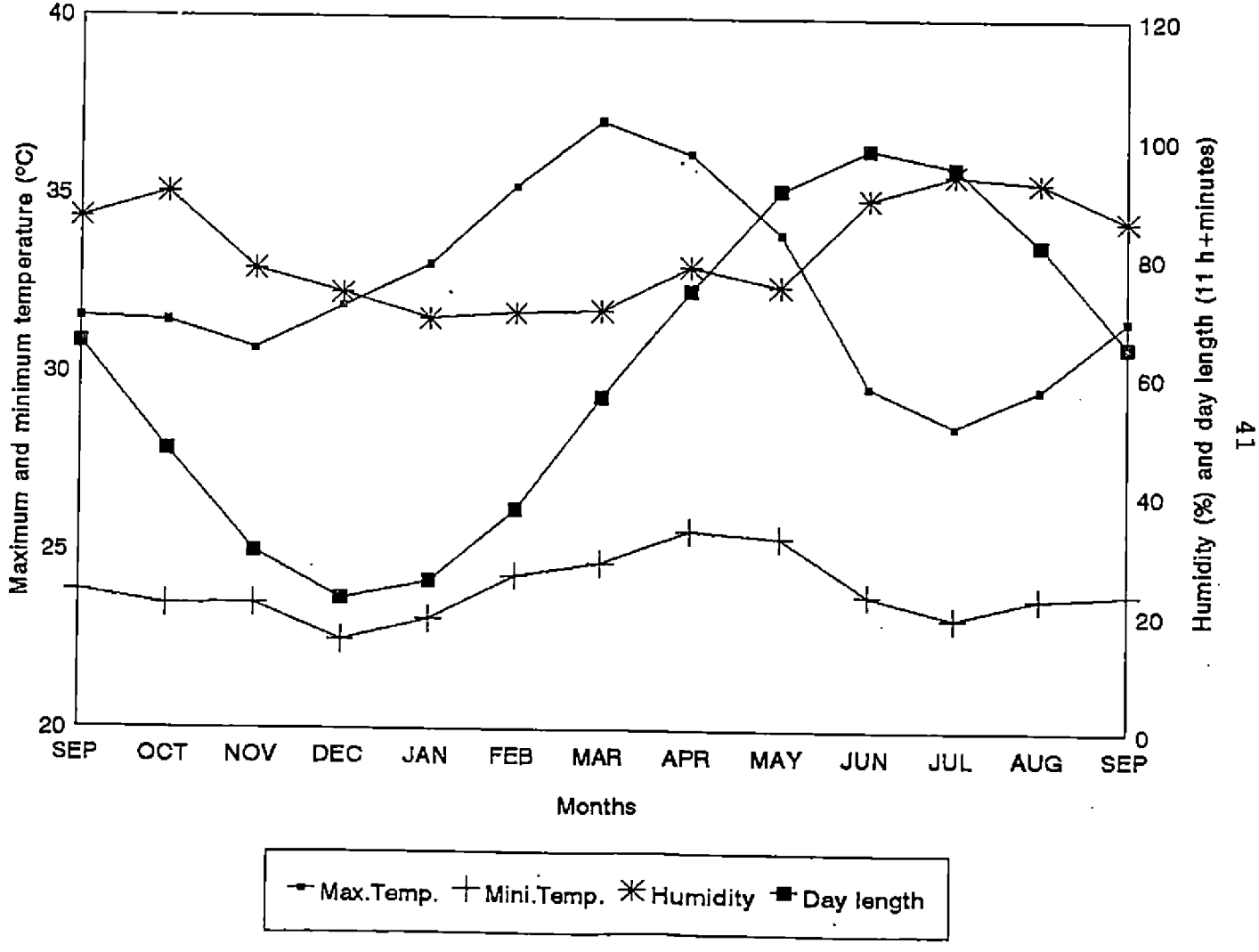


Fig.4.2 QUARTERLY AVERAGES OF MAXIMUM, MINIMUM TEMPERATURES HUMIDITY AND DAY LENGTH

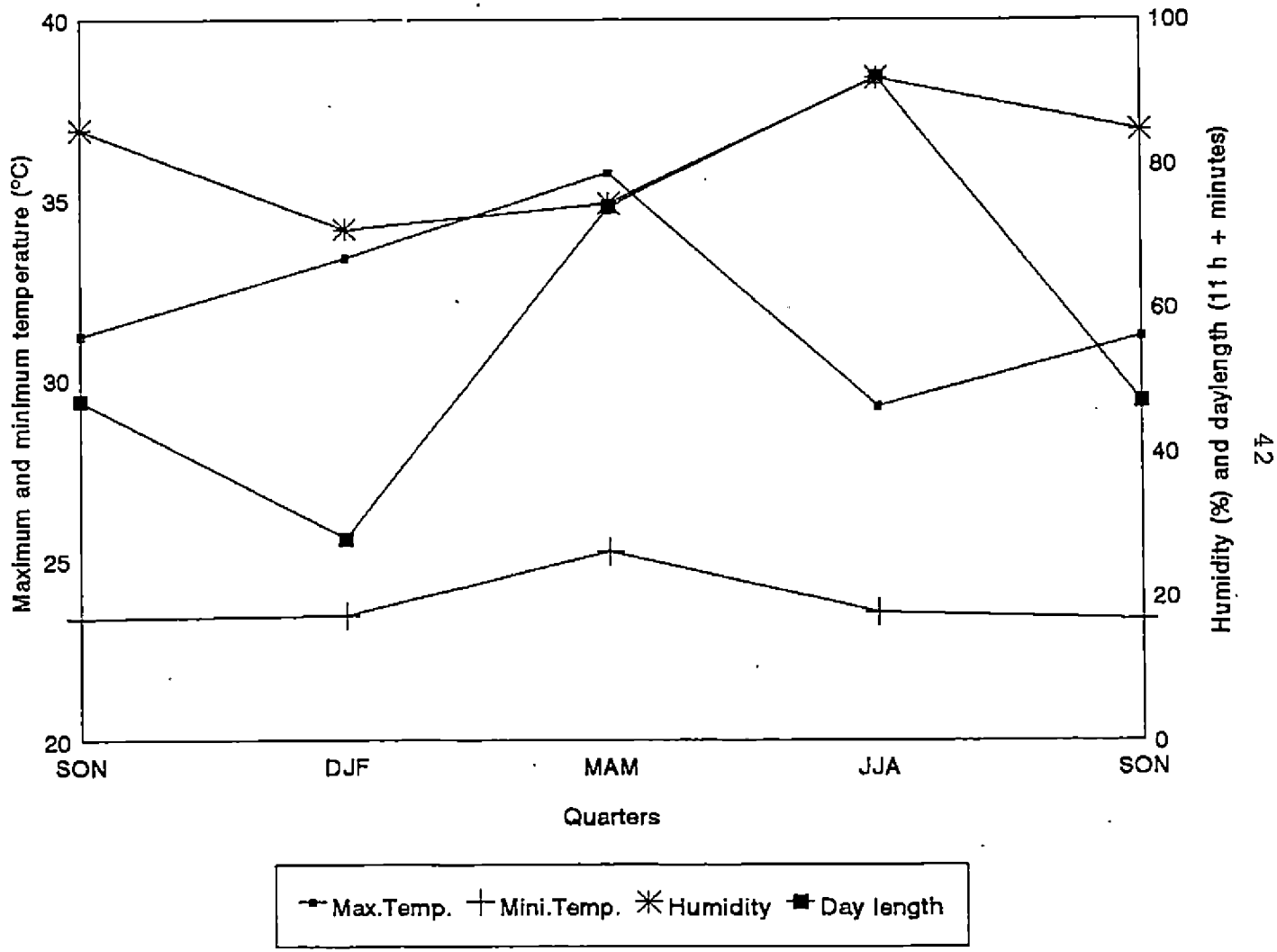


Table 3 Quarterly and half yearly averages of body weight and scrotal circumference

Quarter	Average body weight (kg)		Average scrotal circumference (cm)	
	Quarterly	Half yearly	Quarterly	Half yearly
SON	41.68		24.68	
		43.67		25.08
DJF	45.67		25.49	
MAM	45.51		25.49	
		43.57		25.08
JJA	41.63		24.59	

Table 4 Interrelationship of humidity and day length with quarterly average body weight and scrotal circumference

Quarter	Quarterly averages of			
	Humidity	Day length	Body weight	Scrotal circumference
SON	84.64	11.47	41.68	24.68
DJF	70.88	11.28	45.67	25.49
MAM	74.47	12.14	45.51	25.49
JJA	91.87	12.32	41.63	24.59

Table 5 Quarterly averages of testicular biweekly measurements

Quarter	Length of testes (cm)			Diameter of testes (cm)		
	Right	Left	Average	Right	Left	Average
SON	8.46	8.48	8.47	5.16	5.22	5.19
DJF	8.73	8.65	8.69	5.46	5.47	5.46
MAM	8.64	8.57	8.60	5.43	5.40	5.41
JJA	8.50	8.51	8.50	5.22	5.23	5.22
AVERAGE	8.58	5.56	8.57	5.32	5.33	5.32

Quarterly average diameter of the left and right testis followed the same pattern of variation as the length. Maximum length were in DJF and then there was a gradual reduction to reach the minimum length in September to November (SON). Though there was difference between the diameters of left and right testis between quarters, there was no significant difference in yearly average diameter between right and left. Correlation of humidity and day length with testicular length and diameter are shown in Table 6 and in Figure 4.3. to 4.6. They were found to maintain an inverse relationship.

Table 6 Interrelationship of humidity and day length with testicular length and diameter

Quarter	Humidity	Day length	Length of testes	Diameter of testes
SON	84.64	11.47	8.47	5.19
DJF	70.88	11.28	8.69	5.46
MAM	74.47	12.14	8.60	5.41
JJA	91.87	12.32	8.50	5.22

4.3. Physical attributes of semen

4.3.1. Volume

Monthly and quarterly averages of volume of semen during half years of long and short days are given in Table 7. Lowest volume in a quarter was 0.65±0.09 ml during JJA. Average volume for short and long day half years were 0.70 and 0.80 ml respectively. Volume of 350 samples collected for a period of one year varied from 0.2 to 1.8 ml and the average was 0.75±0.04 ml. Lowest monthly average volume was 0.65 ml during October and highest was 0.88 ml in June.

Fig.4.3 QUARTERLY AVERAGES OF HUMIDITY AND TESTIS LENGTH

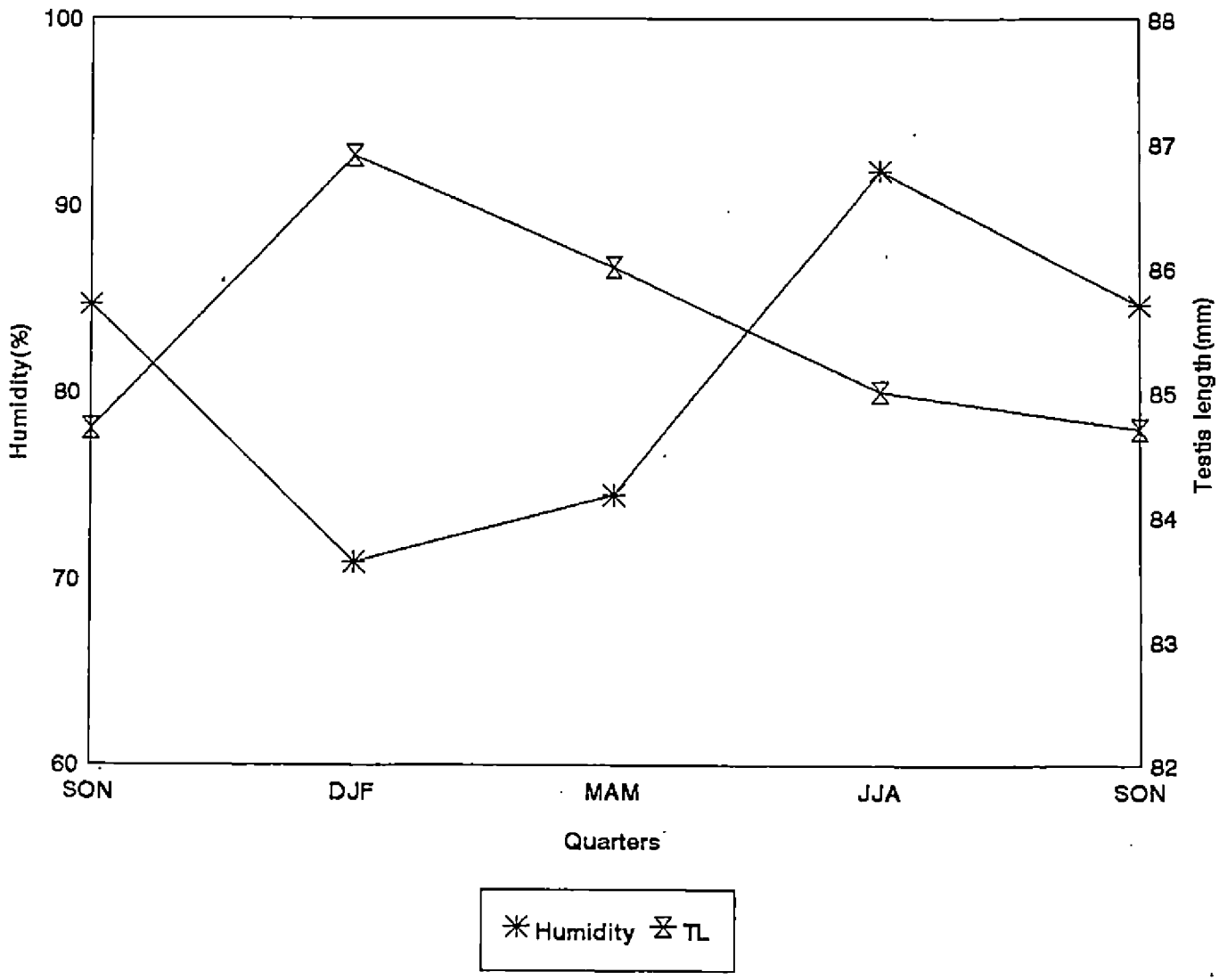


Fig.4.4 QUARTERLY AVERAGES OF DAY LENGTH AND TESTIS LENGTH

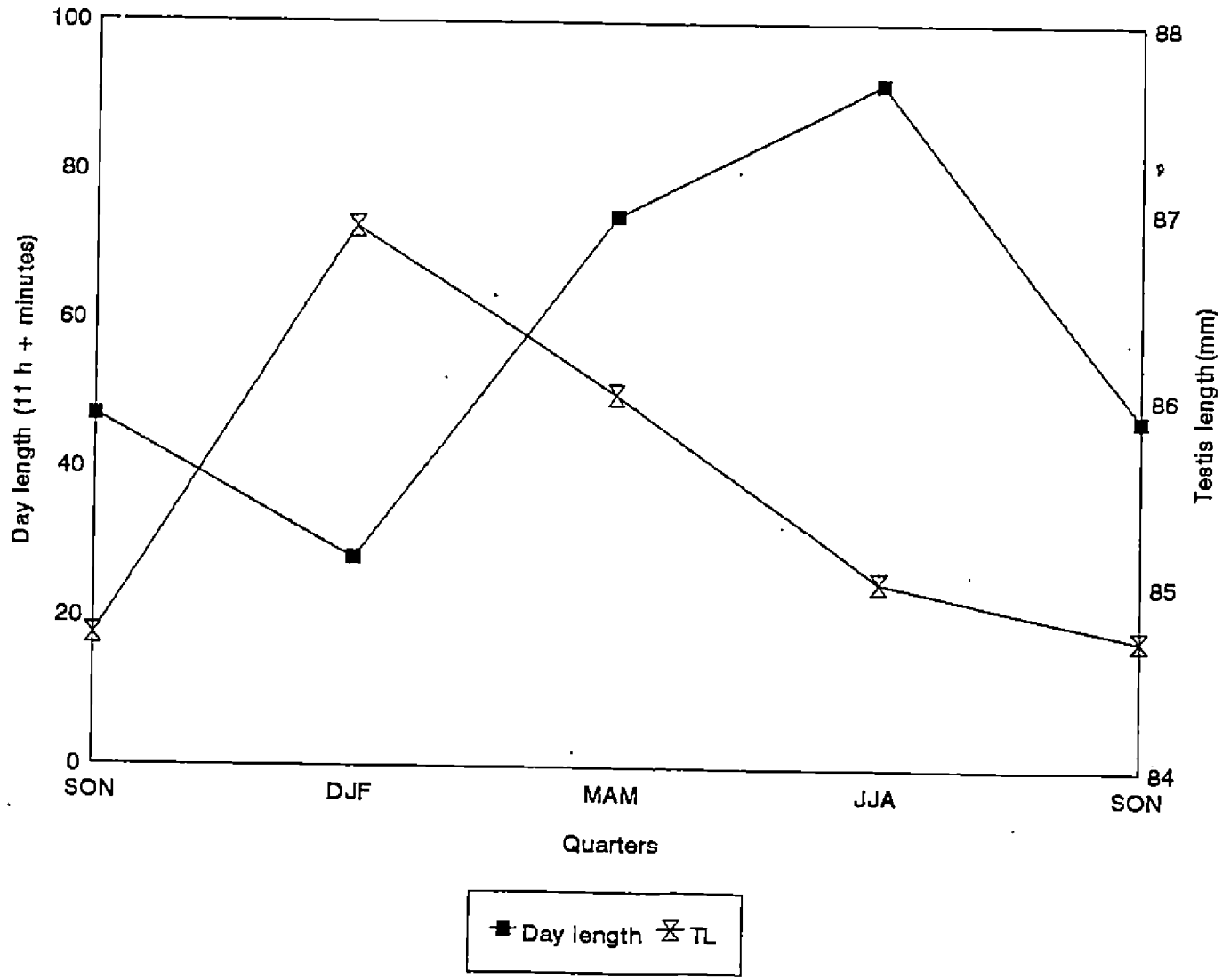


Fig.4.5 QUARTERLY AVERAGES OF HUMIDITY AND TESTIS DIAMETER

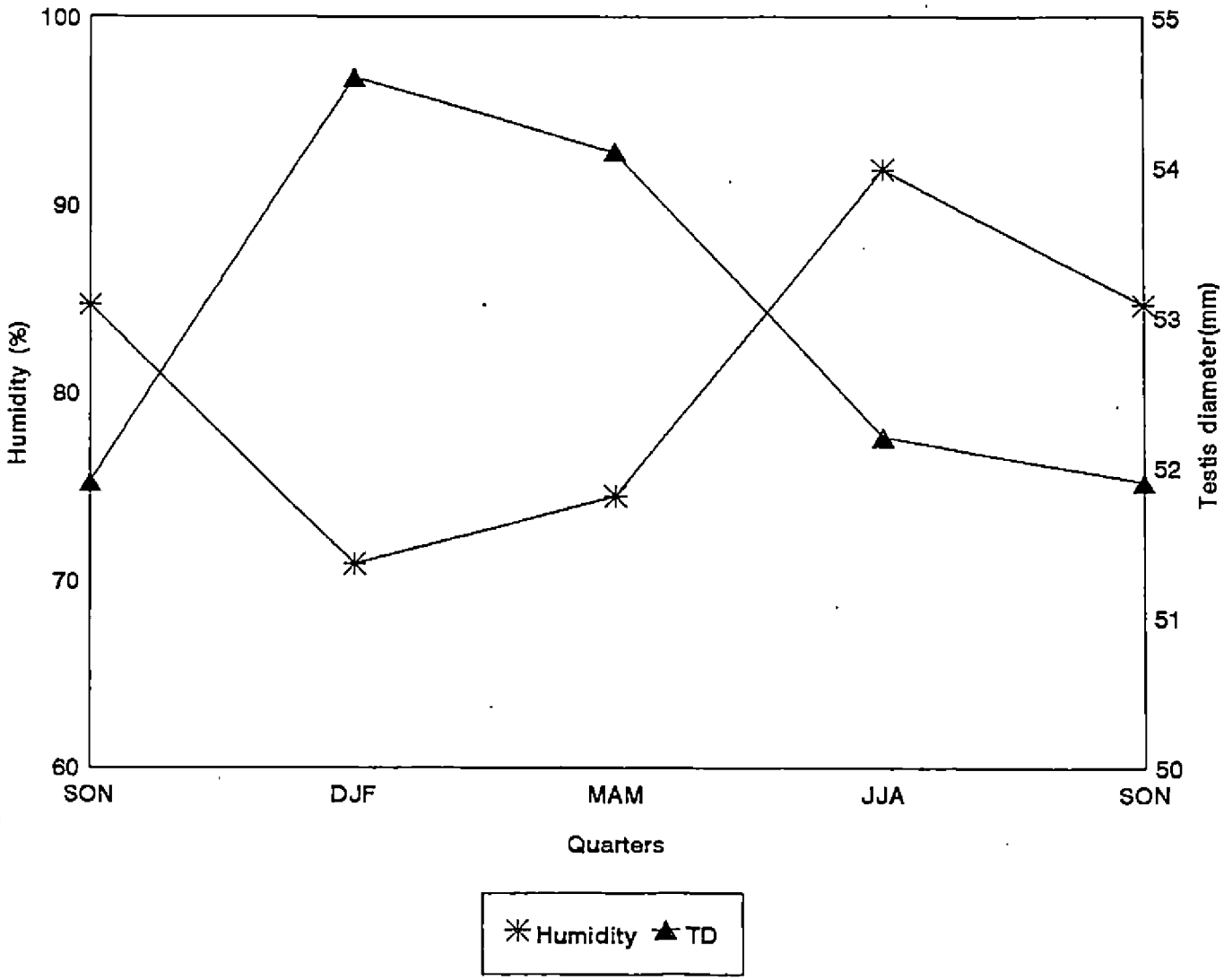


Fig.4.6 QUARTERLY AVERAGES OF DAY LENGTH AND TESTIS DIAMETER

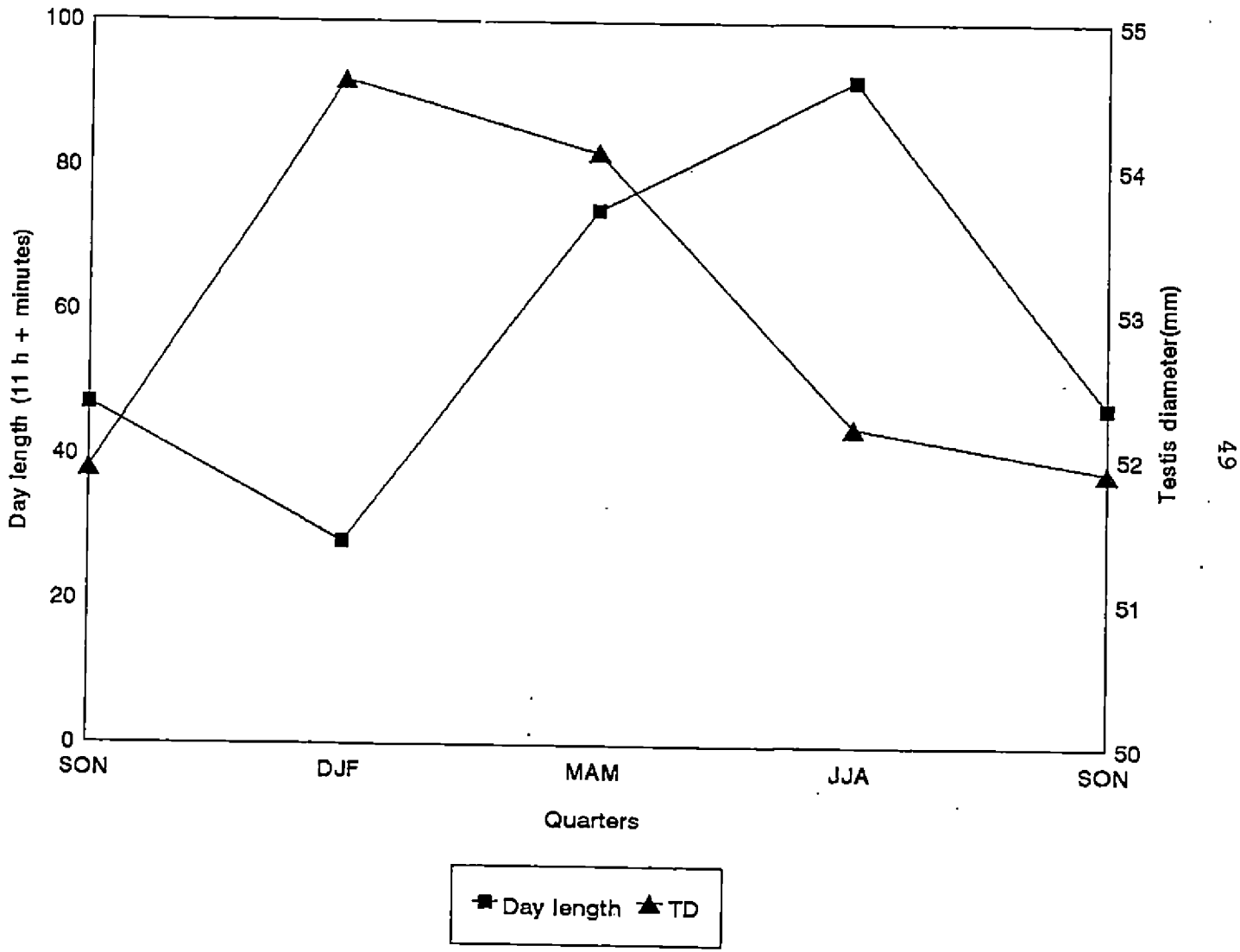


Table 7 Monthly and quarterly averages of volume of semen during half years of short and long days

Month	Monthly average volume (ml)	Quarterly average volume (ml)	Half yearly average volume (ml)	Length of day
Sep	0.66			
Oct	0.65	0.65		
Nov	0.66			
			0.70	Short day
Dec	0.75			
Jan	0.75	0.75		
Feb	0.76			
Mar	0.83			
Apr	0.77	0.79		
May	0.78			
			0.80	Long day
Jun	0.88			
Jul	0.79	0.82		
Aug	0.80			

4.3.2. Colour

Colour of ejaculates varied from yellowish white to deep yellow and it was based on intensity, expressed from Y to YYYY and the yearly average was YY(Y). Between quarters intensity of yellow colour was more during DJF and it was lesser during MAM. Of the 350 samples collected no sample was discarded due to occurrence of an unusual colour.

4.3.3. H-ion concentration

Variations in pH of semen between months, quarters and half years are given in Table 8. Of the quarters, during DJF pH was 6.16±0.03, the lowest and it was 6.39±0.03 the highest, during JJA. During the short day half year pH was lower compared to the long day half year and the values were 6.19 and 6.32 respectively. Between months July and August recorded highest and the same average pH of 6.41 while in February it was 6.09, the lowest. Mean pH of 350 ejaculates was 6.25±0.02.

Table 8 Monthly and quarterly averages of pH of semen during half years of short and long days

Months	Monthly average pH	Quarterly average pH	Half yearly average pH	Length of day (h)
Sep	6.22			
Oct	6.21	6.22		11.47
Nov	6.23			
			6.19	
Dec	6.20			
Jan	6.19	6.16		11.28
Feb	6.09			
Mar	6.19			
Apr	6.21	6.26		12.14
May	6.39			
			6.32	
Jun	6.37			
Jul	6.41	6.39		12.32
Aug	6.41			

4.3.4. Sperm concentration

Monthly average ratings/value of consistency, density and sperm concentration of semen samples collected are given in Table 9. Monthly average of consistency was creamy from February to July. Thick milky from August to January indicating a higher consistency during long day period compared to short day period. Figurative expression of density showed highest average rating during May and lowest in December. Corresponding to this, maximum monthly average sperm concentration of 4267.4 million/ml was in May and minimum of 2983.6 million/ml was in December. Monthly average of sperm concentration was higher during the period from February to July and lower during the remaining 6 months. Sperm concentration of 350 samples collected during the one year period varied from 390 to 7830 million/ml and the mean was 3600±144 million/ml.

Quarterly and half yearly averages of sperm concentration and sperms per ejaculate are shown in Table 10. Highest quarterly average sperm concentration of 4020.2±287.53 million/ml was recorded during MAM while lowest of 3338.5±287.53 million/ml was during SON. Half year of longer day length recorded a higher sperm concentration than shorter day length period and the respective values were 3790.40 and 3409.00 million/ml.

Table 9 Monthly averages of consistency, density of semen and sperm concentration

Month	Average consistency	Average density	Average sperm concentration million/ml	Day length
Sep	Thick milky	3.44	3481.9	
Oct	Thick milky	3.40	3267.4	
Nov	Thick milky	3.34	3266.4	
Dec	Thick milky	3.12	2983.6	Short day
Jan	Thick milky	3.44	3341.2	
Feb	Creamy	3.61	4117.1	
Mar	Creamy	3.60	3917.7	
Apr	Creamy	3.57	3875.7	
May	Creamy	3.65	4267.4	
Jun	Creamy	3.58	3886.6	Long day
Jul	Creamy	3.57	3661.4	
Aug	Thick milky	3.16	3133.9	

Table 10 Quarterly and half yearly averages of sperm concentration and number of sperms per ejaculate

Quarter	Average number of sperms in million			
	Quarterly		Half yearly	
	Per ml	Per ejaculate	Per ml	Per ejaculate
SON	3338.5	2115.5		
			3409.0	2325.3
DJF	3479.6	2535.2		
MAM	4020.2	3131.0		
			3790.4	2995.8
JJA	3560.6	2860.6		

Quarterly average of total number of sperm per ejaculate varied significantly ($P<0.05$) between themselves. Highest number of sperms of 3131.09±238.39 millions in an ejaculate was in the quarter MAM and lowest of 2115.54±238.39 millions was in SON. Average number of sperm per ejaculate for the 350 samples collected was 2660.6±133.96 millions. Half yearly averages of sperm per ejaculate during short and long days were 2325.3 and 2995.8 millions respectively.

4.3.5. Mass activity and initial motility

Quarterly averages of figurative conversion of mass activity are given in Table 12 together with the average initial motility and pH. Mass activity of 350 samples varied from + to ++++ and figurative and average was 3.31.

Monthly quarterly and half yearly averages of initial motility are given in Table 11. Average initial motility was lowest during August and highest during February and the values were 59.00 and 81.07 per cent respectively. Quarterly average initial motility for DJF was 80.04±1.74 and for JJA it was 68.24±1.74. Initial motility was better during short days than during long days. Quarterly average of initial motility maintained a negative correlation with pH (Table 12 and Figure 4.7).

4.4. Sperm morphology and viability

4.4.1. Sperm abnormalities

Monthly, quarterly and half yearly averages of abnormal sperm per cent are given in Table 13. Abnormal sperm per cent during April was 2.8 and during December it was 6.15. Between the half years sperm abnormalities were lesser during the period of long days.

Table 11 Monthly, quarterly and half yearly average of initial motility

Month	Monthly average	Quarterly average	Half yearly average
Sep	76.96		
Oct	70.67	72.13	
Nov	68.77		
			76.08
Dec	80.38		
Jan	78.67	80.04	
Feb	81.07		
Mar	76.09		
Apr	73.39	73.63	
May	71.42		
			70.93
Jun	70.73		
Jul	74.99	68.24	
Aug	59.00		

Table 12 Quarterly averages of mass activity, initial motility and pH

Quarter	Average mass activity	Average initial motility	Average pH
SON	3.34	72.13	6.22
DJF	3.41	80.04	6.16
MAM	3.36	73.63	6.26
JJA	3.15	68.24	6.39

Fig.4.7 QUARTERLY AVERAGES OF H-ION CONC. AND INITIAL MOTILITY

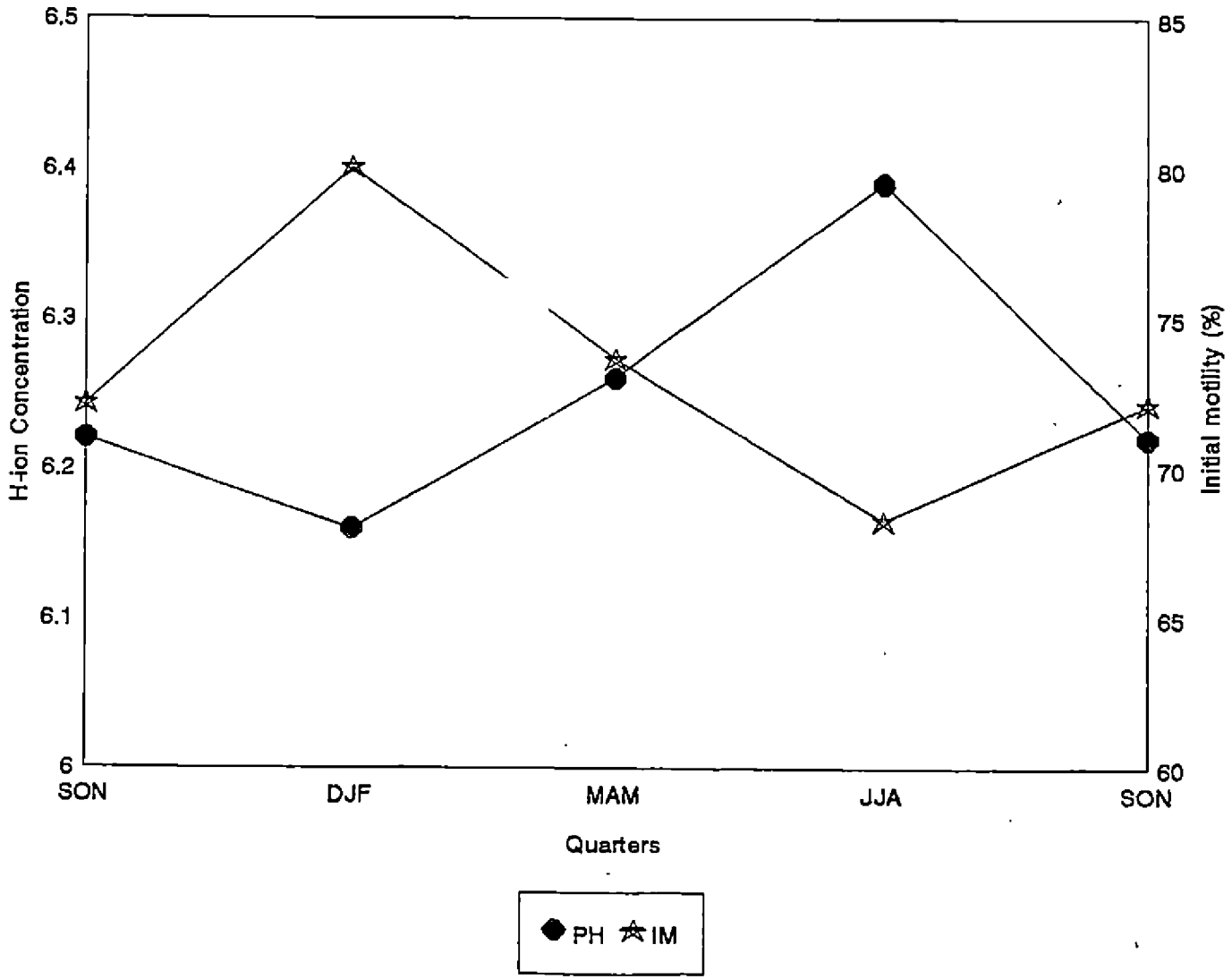


Table 13 Monthly, quarterly and half yearly averages of abnormal sperm per cent

Month	Average of abnormal sperm per cent		
	Monthly	Quarterly	Half yearly
Sep	5.25		
Oct	5.66	5.21	
Nov	4.72		
			4.69
Dec	6.15		
Jan	3.09	4.17	
Feb	3.29		
Mar	3.22		
Apr	2.80	3.51	
May	4.53		
			3.97
Jun	4.31		
Jul	4.30	4.44	
Aug	4.37		

Proportions of head, midpiece and tail abnormalities are given in Table 14. Head abnormality was 0.59 per cent, the lowest during DJF and was seen gradually increasing to the highest value of 0.86 per cent during SON. Sperm abnormality was found to have an inverse relationship with sperm concentration as given in Figure 4.8.

Fig.4.8 QUARTERLY AVERAGES OF SPERM CONCENTRATION AND ABNORMALITY PERCENT

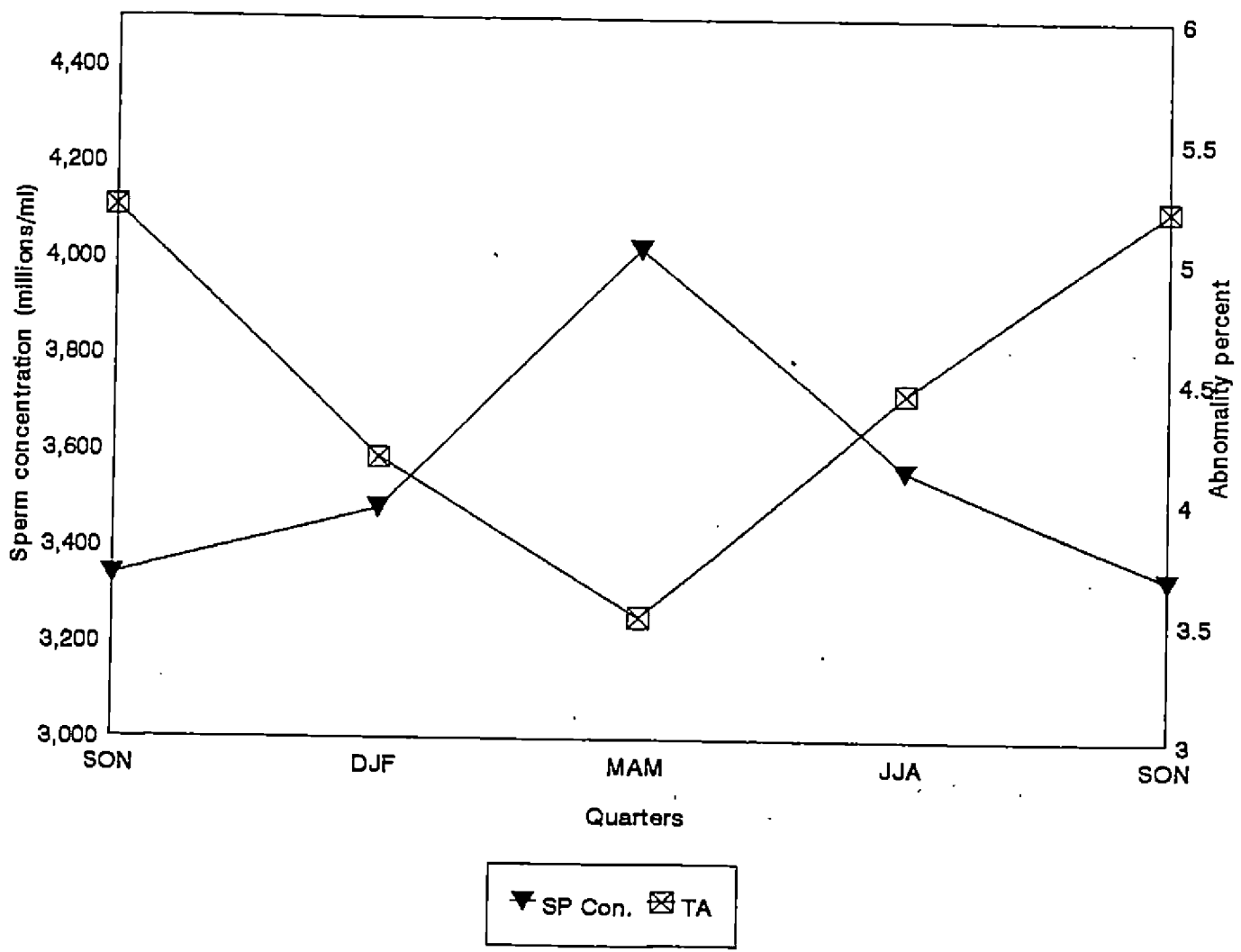


Table 14 Quarterly averages of sperm abnormalities of head, midpiece and tail

Quarter	Percentage of abnormality of			
	Head	Midpiece	Tail	Sperm
SON	0.86	4.08	0.27	5.21
DJF	0.59	3.23	0.35	4.17
MAM	0.70	2.52	0.29	3.51
JJA	0.80	3.16	0.48	4.44

4.4.2. Sperm vitality

Monthly, quarterly and half yearly averages of live sperm per cent are given in Table 15. Highest proportion of live spermatozoa of 87.88 per cent was during December and lowest of 70.75 per cent was during August. During DJF the live sperm per cent was 86.81 and during JJA it was 79.14. Also it was higher during the short day half year. Correlation of humidity and day length with body weight, dead sperm per cent and pH given in Table 16, was found to have a positive relationship.

Table 15 Monthly, quarterly and half yearly averages of live sperm per cent

Month	Average of live sperm per cent		
	Monthly	Quarterly	Half yearly
Sep	83.85		
Oct	81.85	83.14	
Nov	83.74		
			84.97
Dec	87.88		
Jan	86.14	86.81	
Feb	86.42		
Mar	85.54		
Apr	83.50	84.67	
May	84.98		
			81.90
Jun	83.26		
Jul	83.43	79.14	
Aug	70.75		

Table 16 Interrelationship of quarterly averages of humidity and day length with body weight, dead sperm percent and pH of semen

Quarter	Quarterly averages of				
	Humidity (per cent)	Day length (h)	Body weight (kg)	Dead sperm (per cent)	pH of semen
SON	84.64	11.47	41.68	16.86	6.22
DJF	70.88	11.28	45.67	13.19	6.16
MAM	74.47	12.14	45.51	15.33	6.26
JJA	91.87	12.32	41.63	20.86	6.39

4.4.3. Sperm metabolism by MBR test

Quarterly averages of MBR time together with respective averages of life sperm percentage are given in Table 17. Maximum time taken for MBR was during MAM and the minimum was during DJF.

Table 17 Quarterly averages of MBR time and live sperm per cent

Quarter	MBR time (sec)	Live sperm per cent
SON	266.42	83.14
DJF	257.04	86.81
MAM	295.92	84.67
JJA	288.65	79.14

4.4.4. Sperm resistance to hyperosmotic medium

Quarterly average of R value among other details are given in Table 18. Average R value during JJA was 148.96±20.3 ml, the highest. Lowest value of 57.22±20.31 ml was during DJF. Average R value of the 350 samples was 84.75±12.39 ml.

Correlation of humidity and day length with R value, initial motility and motility at 24 h storage are also given in the Table 18. R value and day length as well as humidity were found to have a direct correlation. Whereas initial motility, live sperm per cent and motility at 24 h storage maintained an inverse relationship with them (Fig.4.9).

Table 18 Interrelationship of quarterly averages of humidity and day length with R value, initial motility and motility at 24 h storage

Quarter	Quarterly averages of				
	Humidity	Day length	R value	Initial motility	Motility at 24 h storage
SON	84.64	11.47	79.89	72.13	47.16
DJF	70.88	11.28	51.22	80.04	48.64
MAM	74.47	12.14	58.96	76.64	46.45
JJA	91.87	12.32	148.96	68.24	41.30

4.5. Sperm preservation and storage

Quarterly averages of motility of extended semen stored in refrigerator for 24 and 48 h are given in Table 19. Between quarters there was no difference in the motility on storage for 24 and 48 h. Decline in motility on storage was found to be fast. Average motility on 24 and 48 h storage was 45.89 and 28.13 respectively.

Fig.4.9 QUARTERLY AVERAGES OF INITIAL MOTILITY, LIVE SPERM PERCENT AND R VALUE

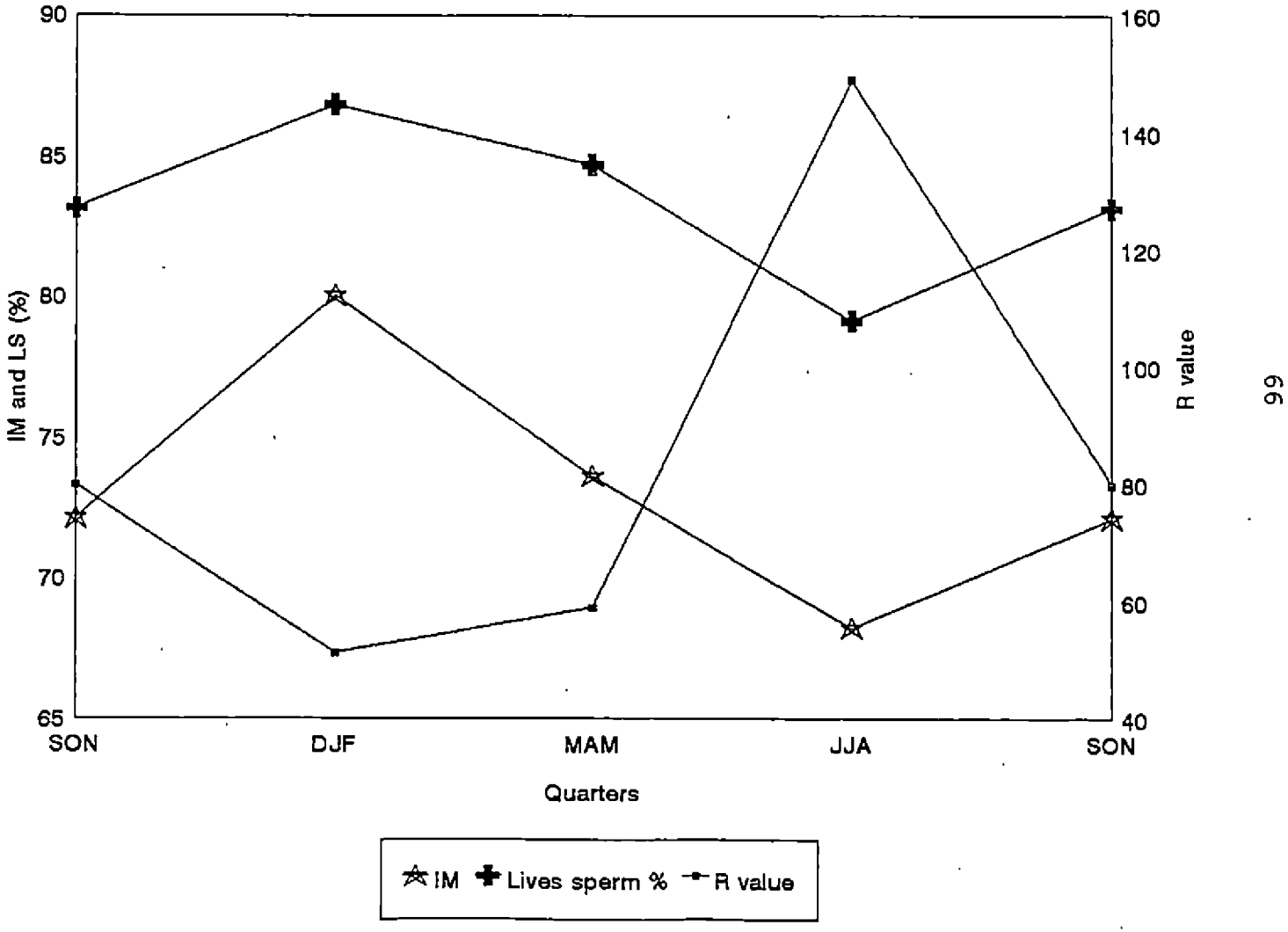


Table 19 Quarterly averages of initial motility and motility at 24 and 48 h storage

Quarter	Initial motility	Motility at	
		24 h	48 h
SON	72.13	47.16	30.15
DJF	80.04	48.64	26.30
MAM	73.63	46.45	28.10
JJA	68.24	41.30	27.98

4.6. Season and fertility

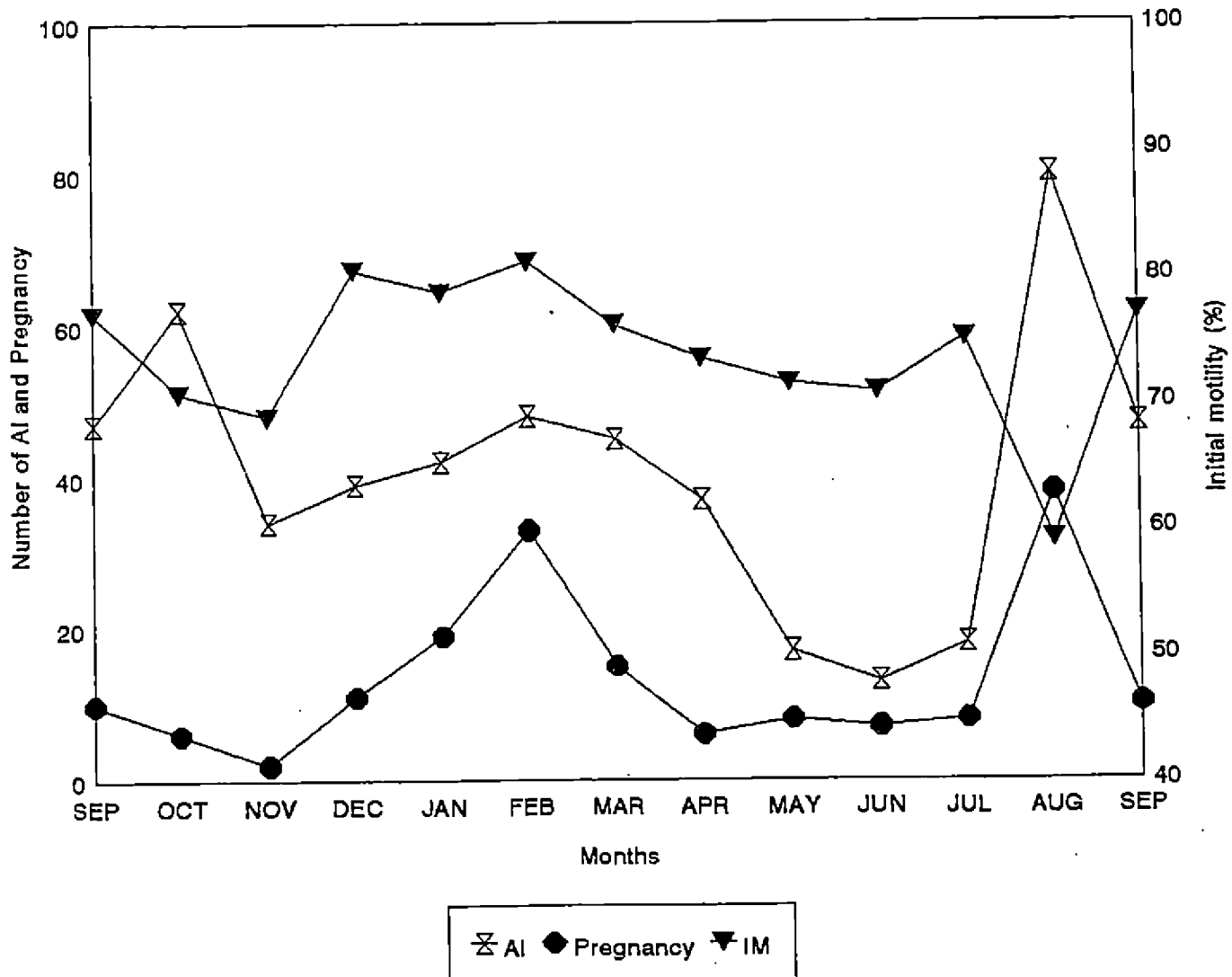
Monthwise total number of artificial insemination(AI), non-return to AI, pregnancy confirmed by clinical examination at 90 days post breeding, percentage of non-return and pregnancy are given in Table 20. Number of AI was low during the months of May to July, but good success rate was obtained in these months. Success rate was low during the months of SON though number of AI was moderately higher. It was lowest during November and highest during February.

Table 20 Monthwise total number of AI, NR, pregnancy and their percentages

Month	Total number of			Percentage of	
	AI	NR	Pregnancy	NR	Pregnancy
Sep	47	13	10	27.65	21.27
Oct	62	9	6	14.51	9.67
Nov	34	6	2	17.64	5.88
Dec	39	9	11	23.07	28.20
Jan	42	14	19	33.33	43.18
Feb	48	34	33	70.83	68.75
Mar	45	21	15	46.66	33.33
Apr	37	16	6	43.24	16.21
May	17	11	8	64.70	47.05
Jun	13	9	7	69.23	53.84
Jul	18	7	8	38.88	44.44
Aug	80	43	38	53.75	47.50

Pattern of variation in monthly average of initial motility of semen, total number of AI and pregnancies in respect of AI during a month are shown in Figure 4.10. While initial motility was maintaining more or less a direct correlation with AI and pregnancies from Sept to July, the relationship became inverse in the succeeding month.

Fig.4.10 MONTHLY AVERAGES OF INITIAL MOTILITY AND MONTHWISE AI AND PREGNANCY



Number of births, kids born and average kid crop during the period of study are given in Table 21.

Table 21 Monthwise data of birth, number of kids and kid crop

Month of birth	Number of birth	Kids born	Kid crop
Sep	7	10	1.43
Oct	7	11	1.57
Nov	8	14	1.75
Dec	12	16	1.33
Jan	35	52	1.48
Feb	6	7	1.16
Mar	7	10	1.42
Apr	1	1	1.00
May	12	15	1.25
Jun	21	32	1.52
Jul	34	52	1.52
Aug	11	15	1.36

Maximum birth occurred during January and July which was corresponding to the peaks in number of AI and conception during August and February. Average number of kids per birth remained low during February and April and it was highest during October and November.

DISCUSSION

DISCUSSION

5.1. Morphometry

Body weight of the billy goats was found to have a positive correlation with scrotal circumference which fully concurs with the report of Machado *et al.*(1991). Testicular length and diameter were also found to maintain a positive correlation with body weight and scrotal circumference as has been reported by Mahmood *et al.* (1988, 1989) and Chauhan and Israel (1992). But the positive correlation of ejaculate volume and semen characteristics with body weight, scrotal circumference and testicular size reported by Chauhan and Israel (1992) and Borgohain *et al.* (1983) was not seen in the present study. Whereas a negative correlation between live and abnormal sperms and body weight reported by them was seen in the present study also.

There was no significant seasonal variation in live weight but the animals maintained a higher body weight during DJF and MAM than the other two periods. Latter period is the time when the quantity and quality of the fodder available are generally better in the region. Influence of it probably not felt because the experimental animals were under an intensive system of management. While Walkden-Brown and Restall (1992) did not find any seasonal variation in live weight, scrotal circumference, testis weight and other

parameters. Walkden-Brown *et al.* (1992) reported summer peak in body weight and testis size and autumn peak in reproductive hormones. In the present study also relatively higher body weight was seen when the day length was increasing.

Body weight and scrotal circumference were also found from Table 4, to maintain an inverse correlation with humidity and daylength. This was contrary to the report of decrease in body weight during period from October to January by Ahmed and Noakes (1993). Result of the present study concurred with Misra (1983) that there was non-significant difference in body weight between summer, monsoon and spring and the body weight was significantly greater in winter. He attributed it for the significant effect of season on body weight.

Length and diameter between the right and left testis had no significant difference. Mahmood *et al.* (1988 and 1989) and Baishya *et al.* (1985) also could not find significant difference in length, width and thickness of right and left testis. While quarterly averages of length of testes did not show any significant seasonal variation, averages of testicular diameter varied significantly ($P<0.05$) between quarters which is in agreement with the report of Walkden-Brown and Restall (1992). Highest testicular diameter was recorded during DJF and thereafter it gradually decreased to the lowest in SON concurring with report of Mukherjee *et al.* (1960) and Jindal (1984).

5.2. Physical attributes of semen

5.2.1. Volume

Volume of semen collected during the period of study varied from 0.2 to 1.80 ml with an average of 0.75 ml and that was well in consonance with the volume reported by Igboeli (1974) and Vinha (1975 and 1979). Between the four seasons minimum volume was during the period from September to November and maximum volume was during the period from June to August while the variation in volume noticed between seasons in this study was well in agreement with the report of Ibrahim and Yousri (1992) and Singh and Purbey (1994), it disagreed with the report of Igboeli (1974), Ahmed and Noakes (1993) and Patil and Raja (1978). Patil and Raja (1978) noticed the highest volume during October to November. In the present study though there was difference in volume between seasons, it was not significant as has been reported by Vinha (1975 and 1979) and Mittal (1985).

The increase in volume during JJA is attributable more to the rainy season than photo-period, when the quality of feed becomes better as has been observed by Jainudeen and Hafez (1993).

Between short day and long day half years the average volume obtained during the latter was more though not significant and it fully concurred with the findings of Mittal (1985 and 1986).

5.2.2. Colour

Colour of semen collected during the period varied from yellowish white to yellow and it agreed with the colour reported by Igboeli (1974) and Ahmed and Noakes (1993). Yellow colour was noticed from June through February in a gradually increasing shade and the maximum yellowish colour was during DJF. Then it changed to yellowish white during MAM. This obviously appears to be dependant on the green fodder availability of the region and this finding is in agreement with that of Ahmed and Noakes (1993).

It also appears that intensity of colour was more when the volume was relatively lesser. The volume increased at a time when the fodder quality was inferior contributing to the more bleached appearance of the semen. Volume was greatest during JJA when the colour of the semen became gradually more yellow, this in every probability might be due to the superior quality of green fodder.

This appeared to have a correlation with the increase and decrease in day length. The increasing trend in sperm concentration is evident from January but it becomes more apparent from February to June, Declining trend is also seen becoming evident from the month of July. As the descendent day commenced concurrent with that a decline in sperm concentration also occurred and the trend was maintained during the short day period. This is well in accordance with the findings of Vinha (1975 and 1979) wherein he has found that as sperm concentration was highest during summer and it was lowest during winter.

The highest monthly average sperm concentration was obtained in the month of May and lowest in the month of December. Elwishy *et al.* (1970) found highly significant monthly and seasonal differences in sperm concentration. In the present study also there was marked differences between the monthly averages of sperm concentration and also between seasons and between long and short day half years and it was generally higher during long day period.

Total number of sperms per ejaculate between two seasons of the short day period was significantly lower than the two seasons of the long day period. Such a seasonal difference is also seen recorded by Mann (1980), comparing the number of sperms per ejaculate during the periods March to August and

September to February. The present finding also agrees with Machado *et al.* (1991) where in he has reported a significantly higher sperm concentration during rainy season which usually is the long day period. But this is contrary to the report of Perezllano *et al.* (1992) where in they obtained greater number of sperms per ejaculate during descendant photo-period.

The present findings even in the months in which highest and lowest sperm concentration, was found to agree with Ahmed and Noakes (1993). Patil and Raja (1978) also obtained maximum sperm concentration during monsoon, a long-day period. Sinha *et al.* (1981) obtained higher sperm concentration in Jamnapari bucks during summer. Similar observations were made in Anglo-Nubian bucks by Vinha (1975 and 1979) wherein also sperm concentration was highest during summer.

5.2.5. Mass activity and initial motility

Best mass activity and motility were obtained during DJF, during this period the volume, number of sperm per ejaculate and sperm concentration were relatively lesser, while pH of the semen during this period was lowest. Relatively higher mass activity and motility were obtained during the period of short day and it was highest during DJF and significantly ($P<0.05$) varied between seasons, fully concurring with report of Corteel (1975). Whereas it has

only partially agreed with the findings of Vinha (1975 and 1979) in respect of the lowest motility in summer reported by him. He obtained highest motility in spring which was contrary to the findings in the present study. Mann (1980) did not find any difference between seasons in motility of sperms in African dwarf Bucks kept in Germany.

Ibrahim and Yousri (1992) and Ahmed and Noakes (1993) reported that they obtained better mass activity and motility during short day period whereas Tuli and Holtz (1992) and Singh and Purbey (1994) reported higher mass activity and motility during winter as well as summer that naturally happens to be short day period and long day period respectively. Patil and Raja (1978) also recorded the highest motility during post-monsoon period ie., short day period, and also they have found that it was lowest during winter. It was during the same period highest motility was recorded in the present study.

Mittal (1986 and 1987) reported significantly lower motility during summer in exotic crossbreds while he could not find any significant seasonal variation in indigenous bucks. The reason why the present finding in motility disagreed with the report of Patil and Raja (1978) may be attributable to the breed difference. Reddy *et al.* (1989) also obtained with local bucks of Tirupati, highest motility during winter and during north-east monsoon, the short day periods.

Motility was also seen maintaining a negative relationship with humidity. The humidity was lowest during DJF when the motility was highest. The motility having been found maintaining better correlation with humidity and daylength it is inferred that the humidity influences in varying the motility between seasons. Elwishy *et al.* (1970) found that relative humidity adversely affect semen characteristics than other climatic variables.

5.3. Sperm morphology and viability

5.3.1. Sperm abnormalities

Sperm abnormality during the period of study was not of any significance since the overall mean of it was only 4.33 per cent. Maximum monthly average sperm abnormality recorded was 6.15 per cent during December and minimum was 2.80 per cent during April. There was no significant seasonal variation as has been reported by Sahni and Roy (1972), Fischer and Mann (1979) and Reddy *et al.* (1989). Whereas it was contrary to the report of seasonal variation in Malabari goats by Patil and Raja (1978).

Though there was no seasonal variation individual variation between bucks as has been reported by Fischer and Mann (1979) has been seen but that

also was non-significant and it was also in consonance with the report of Borgohain *et al.* (1983). Vinha (1975 and 1979) reported highest percentage of abnormal sperms in spring and lowest in autumn and winter whereas Patil and Raja (1978) found that the abnormality was more during summer. Contrary to the reports a relatively higher abnormality was seen during the short-day half year in the present study. It was also found to have an inverse correlation with sperm concentration. Of the abnormalities involving the three structural components of the sperm, middle piece abnormality was comparatively higher and they were mainly the proximal and distal protoplasmic droplets. Roca *et al.* (1992) also reported that the distal protoplasmic droplet was the most frequently occurring sperm abnormality in buck semen. They attributed age of the buck as the factor influencing the occurrence of the condition, than the seasons.

5.3.2. Sperm vitality

Significant seasonal variation was seen in the per cent of live sperms. It was highest during DJF fully concurring with the report of Mittal (1986 and 1987) wherein he found a higher proportion of live spermatozoa in cross bred bucks during winter. Tuli and Holtz (1992) also found higher percentage of live sperms during November to January. Patil and Raja (1978) did not find any significant variation in per cent of live sperms between seasons in Malabari

bucks, while significant variation in it has been reported by Mittal (1982) in Barbari bucks between seasons.

Chauhan and Israel (1992) reported a positive correlation between per cent of dead sperms and body weight but in the present study a negative correlation as shown in Table 16 was noticed. As the body weight declines from its peak in DJF proportion of live sperm also declines and as the body weight starts increasing after JJA the proportion of live sperms was also seen increasing. According to Ahmed and Noakes (1993), dead sperms

were highest during May in British bucks while highest proportion of dead sperms were observed during August in the present study.

Dead sperm proportion was seen to maintain a positive relationship with humidity. Highest proportion of dead sperms was observed during JJA when the humidity was highest. Elwishy *et al.* (1970) also reported that humidity adversely affects semen characteristics more than the other climatic variables.

5.3.3. Sperm metabolism by MBR test

There was non-significant variation in MBR time between seasons. This was well in accordance with the non-significant variation in exotic crosses of

Jamnapari and Beetal reported by Mittal (1986 and 1987). Maximum MBR time was recorded during MAM and there was a gradual reduction to reach the minimum MBR time during DJF. Ozan (1961) reported a significant negative correlation between number of live ram spermatozoa and MBR time. Such a relationship was not seen in the present study.

5.3.4. Sperm resistance to hyperosmotic medium

Sperm resistance and survival is reported to be greater in spring than in summer by Aslanjan and Lisovaja (1963). In the present study also it was during the same period the sperm resistance was found to be greater and lesser respectively. R value was found to maintain a negative correlation with initial motility and live sperm per cent as evident from the Figure 4.9. Highest quarterly average R value was recorded during JJA and it varied significantly with values during DJF and MAM. Quarterly averages of R value and humidity as well as day length were found to maintain a positive correlation as could be seen in Table 18.

5.4. Sperm preservation and storage

Motility of extended buck semen was found to suffer a steep deterioration of about 40 per cent of the initial motility on storage for 24 h

thereby the number of motile sperm was reduced to less than 50 per cent rendering it not satisfactory for use. On further storage the deterioration was found to be still faster. Singh *et al.* (1982) also reported that hours of storage have a highly significant effect on motility of buck semen stored at 5°C.

There was no seasonal variation seen in the motility at 24 and 48 h storage. This was contrary to the report of Elwishy *et al.* (1980) wherein they found that motility and viability of extended semen stored at 5°C, to have a monthly and seasonal variation. Johnson *et al.* (1970) found that semen collected during the summer months did not maintain motility during storage as in other seasons. Such an influence was not seen in the present study during the summer months.

5.5. Season and fertility

Total number of inseminations done each month during the period of study as given in Table 20, varied between months and it had peak and valley of 80 and 13 in August and June respectively. Though the number of inseminations was low in June there was a good success rate of 53.84 per cent on the basis of 90 day clinical examination. Highest success rate of 68.75 per cent was recorded in February when the number of insemination was also high. Success rate of insemination during August was 47.5 per cent. From the pattern of birth that has occurred during the year with two peaks, one during

June-July and other during December-January which well coincided with the moderately high conception rate of breeding during January-February and July-August. The conception does not seem to have any correlation with any of the semen parameters that was studied. The period of peak conception in the present study varied from the period reported by Prasad *et al.* (1981) and agreed with one of the peak reported by Krishnakumar (1992).

As is usual with mammalian species, the female appears adjusting the reproduction according to the food availability and environmental temperature of the region since they have a much greater energy investments than the male in the reproductive process. This is also evident from the low success rate and low birth particularly during April when the environmental temperature was high, also the low success rate during SON though the number of insemination were reasonably high. Fertility remains low during this time to reduce/avoid birth during February, March, April and May when there is dearth of food.

The nannies, that were under semi-intensive system of management, would have been consuming the flowering plants because SON is the time in which most of the herbs are flowering. The oestrus as well as conception during the period would have been influenced by the phytooestrogens, which may be one of the many mechanisms of the nature to adjust the reproduction in accordance with the climate.

Kid crop was also found to be higher during June to November when the food availability was better compared to rest of the time.

The billy goats were found to breed equally well during all seasons of the year. There was no significant variation in semen characteristics also between seasons. Jainudeen and Hafez (1993) said that indigenous goats in tropical zone breed throughout the year with restricted sexual activity attributable to the high environment temperature and lack of feed. The maximum environmental temperature recorded in the present study was 39°C. It is relatively low compared to rest of the tropical zone. Lack of feed was not experienced because the animals were maintained under intensive system of management. Probably because of these reasons restricted sexual activity was not apparent in the present study. They further said that variation in length of day is lesser in tropical zone and hence the effect of photoperiodicity in less apparent. In the present study also though there is no significant variation due to effect of season in the semen characteristics, there are indication in parameters as the percentage of live sperms, initial motility and R value to suggest that they are influenced by day length and humidity.

Variation in conception rate between periods within an year was not found to be related to the variations in semen characteristics since during the two peaks of higher conception no specific semen characteristic common to both

these periods and attributable to fertility was discernable. This prompts one to conclude in the manner Bishop (1955) observed that the amount of variation in fertility that can be accounted by variation in related semen characteristic is small and also to endorse views of Lindord *et al.* (1976) laboratory tests are inadequate as methods for predicting fertility of semen sample but can be used for setting limits, outside which poor samples can be discarded.

SUMMARY

SUMMARY

Daily record of maximum and minimum temperature, humidity and day length was maintained for a period of one year. Simultaneously biweekly morphometry such as body weight, scrotal circumference and length and diameter of testis of seven billy goats, was conducted together with a weekly study of semen parameters such as volume, colour, pH, consistency, density, sperm concentration, mass activity, initial motility, sperm abnormality, vitality, metabolism and resistance to hyperosmotic medium.

The semen was extended in milk antibiotic extender and it was used for insemination on the day of collection. An aliquot of the extended semen was stored in refrigeration temperature to study the effect of storage at the temperature for 24 and 48 h. The result of Artificial Insemination on the basis of non-return and clinical examination at 90 days was also adduced.

Monthly averages of maximum and minimum temperature, humidity and day length were derived and on the basis of which the period of study of morphometry, semen parameters and fertility of goats, was divided into four seasons for the purpose of analysis to find out the effect of season on the above said parameters.

There was a non-significant increase in body weight during the period of study. Concurrent with the increase in body weight there was increase in

scrotal circumference and length and diameter of testis. Mean body weight, scrotal circumference and length and diameter of testis were 43.62±1.11 kg, 25.08±0.12 cm, 8.57±0.07 cm and 5.32±0.03 cm respectively. But for diameter of testis, the variation occurred between seasons were not significant. The difference in the measurements between right and left testis was also not significant. The variations in body weight, scrotal circumference, and testicular length and diameter were found to maintain an inverse relationship with the variations in humidity and day length between seasons.

Of the semen parameters studied volume, colour, consistency, density, sperm concentration, mass activity, abnormal sperm percent and methylene blue reduction time did not vary significantly between seasons. Mean volume of the semen was 0.75±0.04 ml. Monthly mean sperm concentration varied from 3338.5±287.53 to 4020.2±287.53 millions/ml between quarters. It was seen that the higher sperm concentration was during the long day period than the short day period. Abnormal sperm per cent varied from 3.51 to 5.21 between seasons and the mean was 4.33. Though not significant, it was lesser during the long day period. Mean MBR time was 277.1±14.27 seconds.

The parameters such as pH of semen, number of sperms per ejaculate, initial motility, live sperm per cent and R value significantly varied between seasons. Monthly mean pH varied from 6.16±0.03 to 6.39±0.03, and higher

pH was seen during JJA when the volume also was higher. Total number of sperms per ejaculate was significantly lower during SON than MAM and JJA. Average initial motility and live sperm per cent were significantly higher during DJF than during JJA and SON. R value was significantly higher during JJA than rest of the three periods. Between the latter there was no significant difference. R value was also found to maintain a direct relationship with varying humidity and day length between seasons.

Motility of extended semen on storage under refrigeration for 24 and 48 h, did not significantly vary between seasons. Deterioration in motility on storage was found to be faster during all seasons of the year.

Success rate of AI could not be correlated with any of the significant or non-significant variations in semen parameters. Kid crop was found to be higher during June to November when the feed availability is greater. There were two peaks of conception and corresponding to it, two peaks of birth in a year. The reproductive pattern however, appeared more as an adjustment by the female to the environment with little male involvement. The male was found to breed throughout the year and none of the semen parameters appeared to have correlation with conception.

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SEASONAL FERTILITY OF BILLY GOATS

By

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ABSTRACT OF A THESIS

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ABSTRACT

Biweekly data on body weight, scrotal circumference, testicular length and diameter and weekly data on semen parameters as volume, colour, pH, consistency, density, sperm concentration, mass activity, initial motility, sperm abnormality, vitality, metabolism and resistance to hyperosmotic medium of seven billy goats were observed for a period of one year. The data was grouped into four pertaining to four seasons arrived at on the basis of a simultaneously kept daily record of maximum-minimum temperature, humidity and day length. It was statistically analysed to find out that the differences between seasons were significant to be attributed to the environmental variables.

Mean body weight, scrotal circumference and testicular length and diameter were 43.62±1.11 kg, 25.08 ±0.12 cm, 8.57±0.07 cm and 5.32±0.03 cm respectively. There was no significant difference between the seasons except in testicular diameter and they were found to maintain an inverse relationship with day length and humidity.

Mean volume, pH, initial motility, sperm concentration, total number of sperm per ejaculate, live sperm per cent, abnormal sperm per cent, MBR time and R value were 0.75±0.04 ml, 6.25±0.02, 73.51±0.98 per cent, 3600±144 millions/ml, 2660.6±133.96 millions, 83.44±0.76, 4.33±0.43, 277.1±14.27

seconds and 84.75±12.39 ml respectively. There was no significant difference between seasons in these parameters except pH, initial motility, live sperm per cent and R value. They were found to have a significant difference between seasons and were found to maintain either direct or indirect relationship with humidity and day length.

Semen on extension with milk antibiotic extender and on storage under refrigeration was found to fast deteriorate rendering it unusable in 24 h.

Semen on the day of collection and extension, was used for artificial insemination and result of insemination was found to be independent of the significant or nonsignificant seasonal differences of semen parameters. But, during the period of study, there were two peaks in conception and two peaks in birth corresponding to it. The pattern appeared to be an adjustment of reproduction by the female to the varying food availability and climate with little involvement of the male.