BIO-CLIMATOLOGICAL INFLUENCE ON PHYSIOLOGICAL NORMS OF SHEEP AND GOATS

By
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THESIS

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requirement for the degree of

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DECLARATION

I hereby declare that the thesis entitled **BIO-CLIMATOLOGICAL INFLUENCE ON PHYSIOLOGICAL NORMS OF SHEEP AND GOATS** is a bonafied record of research work done by me during the course of research 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.

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CERTIFICATE

Certified that the thesis entitled **BIO-CLIMATOLOGICAL INFLUENCE ON PHYSIOLOGICAL NORMS OF SHEEP AND GOATS** is a record of research work done independently by **Shri. Mahadevappa Gouri** under my guidance and supervision and it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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We, the undersigned members of the Advisory Committee of **Shri. Mahadevappa Gouri** a candidate for the degree **Master of Veterinary Science, in Livestock Production Management,** agree that the thesis entitled **BIO-CLIMATOLOGICAL INFLUENCE ON PHYSIOLOGICAL NORMS OF SHEEP AND GOATS** may be submitted by Shri. Mahadevappa Gouri in partial fulfilment of the requirement for the degree.

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Dedicated to

My mother and Late father

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Introduction

1. INTRODUCTION

Small ruminants ; the most versatile of all domestic animals, were the first food animals kept by man (Anonymous, 1974). Sheep and goats fit well into varying socio-economic systems of the world. India holds the largest number of goats in the world (118 million heads) and with 45 million sheep, stands fifth in the world (FAO, 1993).

Fifty seven per cent of the total animal meat produced in India consists of chevon and mutton. The contribution of these small ruminants in our milk production sector is also well acclaimed. The Pashmina, Mohair and different types of wool contributed to the fabric industry, is another economic resource from this sector. To the rural economy, the organic manure and the yield of skin and hide is a boon. Moreover, goats are bestowed with the unique ability to thrive under harsh climatic conditions due to their superior water conserving ability as well as nitrogen retention capacity. (FAO, 1993).

Bio-climatology ; a developing field under animal husbandry; implies the direct and indirect interrelationship between the geophysical and geochemical environments of atmosphere and the living organisms. The environmental stress evokes number of non-specific regulatory mechanisms resulting in general adaptation syndrome (Dutta *et al.*, 1996). The nature of an animal's life is shaped by environmental and hereditary forces. Various components of environment may either promote or impair animal performances by facilitating or inhibiting productive and reproductive process (Stanley, 1983).

The thermal environment has immediate as well as long term adaptive influences on animals. Environment is a prime limiting factor in animal production. There are many factors *viz.*, radiation, convection, conduction evaporation and precipitation involved in exchange of heat by animals and surrounding environment. (Campbell and Lasly, 1989).

The bio-climatological factors like ambient temperature relative humidity, solar radiation and wind velocity are important factors affecting animal comfort and performance through their effects on physiological mechanisms.

Several physiological norms are reported to be influenced by microclimate and seasonal variances. The extent to which these norms are influenced by the above factors in the tropical hot humid conditions is of great relevance to sheep and goat production in these regions. Similarly studies have lead to the estimation of potassium levels in the serum and classing animals as high potassium level (HKL) and low potassium level (LKL) (Nandakumaran, 1989). This trait is known to be associated with adaptability to hot climatic conditions.

As information on influence of climatic factors on the physiological reactions of sheep and goats in the hot-humid tropics are scanty, the present study was undertaken with the objective of comparing the reactions of *Ramnad white* breed of sheep and *Malabari* goats to climatic stress in the hot-humid tropical climate of Kerala. Another objective was to prepare an ethogram for sheep and goats under farm conditions.

Review of Literature

2. REVIEW OF LITERATURE

2.1 BIO-CLIMATOLOGY

Extensive work on the influence of climatic factors and heat-stress on cattle have been carried out (Bianca, 1961).

Field studies and climatic chamber experiments have shown that elements like ambient temperature, humidity, solar radiation and wind velocity influence the physiological functions of animals and impose severe restrictions on their productivity (Nauheimer-Thoneick *et al.,* 1988). The same workers observed that when the ambient temperature was 30°C, the respiration rate increased by 130 per cent while pulse rate decreased by 11.3 per cent. The rectal temperature increased to 40.3° C in early and 39.9°C in late lactations in a climatic chamber study in Holstein Friesien cows. Sheep and goats did not receive that much attention especially in hot-humid tropics. The effect of various climatic factors on physiological and production functions of sheep and goats are reviewed below.

2.2 PHYSIOLOGICAL NORMS

2.2.1 RECTAL TEMPERATURE

Increase in rectal temperature with increase in ambient temperature was observed by many workers as reviewed by Bianca (1965). Thomas and Razdan (1973) observed that rectal temperature in Sahiwal and their crosses with Brown Swiss varied significantly between colder and hotter months. It showed parallelism to the changes in ambient temperature and relative humidity. The correlation between ambient temperature and rectal temperature revealed positive relationship of higher order.

The rectal temperature of sheep and goats were measured by Singh *et al.* (1980). Goats registered a lower rectal temperature (37.6°C) than sheep (38.4°C) at an ambient temperature of 20°C. After exposure to 42.5°C for 30 minutes, the experimental animals showed increased sweating rates and rectal temperature. Further they reported that there was no significant difference in rectal temperature between sheep and goats.

The seasonal influence on rectal temperature was studied in *Muzaffaranagari* ewes and their crosses with *Dorset* and *Suffolk*. Rectal temperature was higher during rainy season followed by summer and winter (Vihan and Sahni, 1981).

Higher rectal temperature was observed in *Ramanov* than in *Aragon* rams when the ambient temperature was higher (Valls and Folch, 1982).

Igono *et al.* (1983) observed that, absolute mean rectal temperature was significantly higher during the winter than the hot dry season, in Yankasa sheep. Higher rectal temperature was measured in *Angora* goats than *Merino* sheep when exposed to full sun (Mc Gregor, 1985).

Arruda *et al.* (1984) reported that no significant differences existed between the breed types in their body temperature during morning hours. At 1400 Hr, kids and lambs of one breed had significantly higher body temperature than kids and lambs of the second breed.

Mean rectal temperature of non pregnant *Corriedale, Coimbatore* and their crosses were 38.9°C. Only diurnal variation was found to be significant (Misra *et al.*, 1985).

The rectal temperature of 11 *Finnish Landrace* ewes in Egypt were consistently and significantly higher than those recorded in 11 half sibs of the same breed. The difference was maximum during spring and lowest in autumn (Aboul *et al.*, 1987). Silanikove (1987) reported that sheep fully exposed to summer conditions showed a higher body temperature than their counterparts having access to shade.

The lambs housed in shaded area showed significantly lower rectal temperature than animals under unshaded area. Shorn lambs also had a significantly lower rectal temperature than unshorn lambs. *Barkis* breeds had a better heat tolerance than crossbreeds (Azamel *et al.*, 1987).

Ghosh (1987) reported that the normal body temperature regulation in goats appear to be similar to that of sheep. Increased respiration rate and heat loss due to water evaporation are the chief mechanisms for control of body temperature under hot conditions. Further, the greater number of goats in tropical and subtropical areas indicate that they are more heat tolerant. Even at 45 °C goats were able to perform better in these areas.

Jadhav *et al.* (1989) recorded rectal temperature in five breeds of sheep for one year. The results showed that the morning rectal temperature was significantly lower than evening recordings in all the breeds.

Study conducted on five breeds of goats showed that the average rectal temperature was highest in early summer season (39.2°C) and lowest in winter season (38.6°C). Difference between breeds were not significant (Kaushish *et al.*, 1990). Similarly Nazki and Rattan (1990), reported, significantly lower body temperature in winter (37.8° C) when compared to summer months (38.8°C) in sheep. Similar seasonal influence on rectal temperature of goats and sheep was also reported by Kaushish *et al.* (1989).

Kornel and Kumar (1990) reported that there was significant difference among breeds in rectal temperature at an ambient temperature of 45° C. *Nali* rams had the highest thermoregulatory ability.

The variations in rectal temperature in sheep breeds were reported by Monty *et al.* (1991). Guney *et al.* (1992) observed an increase in rectal temperature under high ambient temperature and humidity. Higher rectal temperature values changed from one week to another and altered with the day. Values of skin temperature, middle wool temperature and rectal temperature were more during summer than in winter in *Ossimi* sheep (Marai *et al.*, 1992).

The increase in rectal temperature after exposure to high ambient temperature was significant in all the breeds. Among sheep breeds it was lowest in *Nalis* and *Choklas* and highest in *Merino* (Gupta and Acharya, 1993).

Mc Crabb *et al.* (1993) reported that low temperature status (LRT) ewes had a rectal temperature of less than 39.8° C while high temperature status (HRT) ewes had a rectal temperature of more than 39.9° C.

The normal temperature for sheep during hot-humid season was 40.7° C in the morning and 41.2° C in the evening. In goats it was 38.2° C in the morning and 41.1° C in the evening. During cold-humid season in sheep it was 39.1° C in the morning 40.1° C in the evening and 37.7° C in the morning; 40.3° C in the evening for goats at the same period. In sheep and goats, higher morning rectal temperature was reported during hot-humid season when compared to cold-humid season. Increased rectal temperature readings were observed during afternoon hours over respective morning observations. This increase was more during cold-humid season than hot-humid season. Indicating that *Sahabadi* sheep are more thermostable compared to *Black Bengal* goats. (Ghosh and Pan, 1994 ; Dollah *et al.,* 1992).

Diurnal variations in rectal temperature has also been reported in goats and sheep. De-Silva and Minomo (1995) studied the rectal temperature of *Corriedale* sheep in tropical climate. The minimum rectal temperature averaged 39.55° C at 0500 Hr in summer and 38.87° C at 0600 Hr. The maximum rectal temperature was 40.03° C (1700 Hr) in summer and 39.33° C in winter (1830 Hr) respectively. The annual cycle showed a minimum in July and maximum in December.

Increase in rectal temperature during afternoon was higher in black goats followed by dark brown goats, light brown goats and white goats. But morning rectal temperature was not influenced by coat colour (Acharya *et al.*, 1995).

Abisaab and Sleiman (1995) observed that body temperature was influenced by environmental temperature and showed seasonal variations. Barghout *et al.* (1995) reported that in low ambient temperature shivering increased rectal temperature and skin temperature in *Baladi* kids.

Abdel-Baki *et al.* (1995) noted that there was no significant seasonal difference in rectal temperature in sheep. There was significant increase in skin temperature during summer compared to all other seasons in these experimental animals.

Sleiman and Abisaab (1995) observed that the body temperatures of Filial crosses were higher than *Awassi* Sheep during all seasons (39.41 Vs 39.31° C). Mohr (1996) reported that core temperature of sheep revealed regular rhythmic variation with stress. Diurnal variations in rectal temperatures was observed with changes in ambient temperatures during summer (Hassanin *et al.*, 1996).

The normal temperature in goat and sheep ranged from 38.5 to 39.7° C and 38.3 to 39.7° C respectively with an average of 39.1° C in both the species (Anonymous, 1996).

There is a relatively narrow zone of effective environmental temperature in which heat production of an animal is minimal or thermoneutral rate which is offset by net heat loss or gain from the environment without the aid of special heat conserving or dissipating mechanisms. The body temperatures of homeotherms are influenced by age, sex, season, time of day, environmental temperature, exercise, eating, digestion and drinking of water (Williams, 1997).

2.2.2 RESPIRATION RATE

The respiration rate (within a certain range) in ruminants increased with increase in ambient temperature (Bianca, 1965). Thomas and Razdan (1973) reported that Sahiwal and Sahiwal X Brown Swiss cattle had a similar respiration rate, but when exposed to hot climate the crossbreeds showed higher respiration rate.

The average respiration rate was higher during rainy season when compared to other seasons. This could be due to general stress of the hot humid climate during rainy season. Highly significant variation was observed in different seasons, breeds and timings in both male and female sheep (Vihan and Sahni, 1981)

Irrespective of season, the mean morning and evening values of respiration rates were 40.72 ± 1.33 and 59.46 ± 1.5 per minute. The diurnal variation and differences between seasons were highly significant for all the physiological parameters in *Russion Merino* sheep (Srivastava *et al.,* 1980).

Progressive increase in respiration rate was observed when the animals were taken to higher altitudes (Huang, 1980). In a study on the adaptability of native and crossbred sheep (Singh *et al.*, 1982), noted a decrease in morning respiration rate in purebreds during hot summer months in semi- arid zones. But the increase in respiratory rate per unit rise in rectal temperature was higher in crossbreeds.

Respiration rate increased with increase in environmental temperature. A greater increase was noted in *Ramanov* than in *Aragon* sheep (Valls and Folch, 1982). Increase in respiration rate was observed following increase in rectal temperature as a result of increase in environmental air temperature in the afternoon, which was a sign of thermal stress particularly in exotic breeds (Abdul, 1986).

Aboul *et al.* (1987) observed that the respiration rates of 11 *Finnish Landraces* in Egypt were consistently and significantly higher than those of 11 half sibs in Finland. The differences were highest during spring; 40-47 per minute and in autumn; 10-93 per minute.

Kaushish *et al.* (1990) reported that respiration rate was higher in *Jhakrana* goats (23.4 per minute) and lowest in *Beetal* goats (21.01 per minute). Seasonal variation was evident. Respiration rates in the afternoon was significantly higher in *Rambouillet* sheep. But it was lower in case of *St. Crox* and the *Karakul* sheep during the hot season. The respiratory rate elevated with ambient temperature. (Monty *et al.*, 1991).

Increased respiration rate is one of the first reactions of animals to environmental temperature stress. The elevation of respiration due to heat stress enables the animals to dissipate the excess body heat by vaporizing more moisture through expired air (Alnaimy *et al.*, 1992).

The average respiration rate recorded in individual ewes during different seasons varied from 22.0 to 69.0 per minute. The rates during winter, spring, summer and rain being 25.9, 35.4, 55.4 and 61.9 per minute respectively (Nazki and Rattan, 1990). Average respiration rates recorded during rainy and summer seasons were significantly higher than those recorded during winter and spring.

Guney, *et al.* (1992) observed respiration rate in different genetic groups of goats under subtropical conditions in Turkey. All genotypes were affected by rise in ambient temperature and humidity and the rates showed diurnal variations and changed from one week to another.

Marai *et al.* (1992) measured higher rate of respiration during summer than winter months. These reports were similar to the observations of Singh *et al.* (1982), Jager (1986), Esmail (1986), Silanikove (1987) and Nazki and Rattan (1990).

Roda *et al.* (1992) noted that respiration rate in three sheep breeds during summer and winter showed less variations than the other two wool bearing breeds. All the breeds were able to acclimatize to the different environmental conditions. *Santa* breeds showed a superior ability to acclimatize.

Siquera *et al.* (1993) and Singh *et al.* (1992) observed increase in respiration rate when the animals were exposed to heat stress.

Ghosh and Pan (1994) reported that the respiration rate of sheep varied significantly with species, season and time of recording. The respiration rate during morning was higher. Further the increase in respiration rate was 116.9% in goats and 48.31 % in sheep, during hot humid season. It was 53.66 and 12.74% for cold humid seasons in goats and sheep. The average normal respiration rate for sheep and goats were 70.5 per minute and 72.5 per minute in hot humid season and 50.6 per minute and 51.1 per minute in cold humid season respectively. Lee and Sasaki (1994) reported lower respiration rate during the cold periods than during periods in the warm environment. Respiration rate was significantly higher in summer than in any other seasons (El-Sherif, 1983 ; Shalaby, 1985; Abdel-Baki *et al.,* 1995).

Acharya *et al.* (1995) observed higher respiration rate in goats, during afternoon hours than morning hours. Colour of the coat showed an influence on respiration rate.

An experiment involving different breeds of sheep showed higher respiration rate when, exposed to elevated environmental temperature. Filial crosses showed increased respiration rate than *Awassi* sheep during different seasons. Seasonal variations were also evident. Further, the highest respiration rates were reached during the summer by young *Awassi* females (90.7 per minute) (Sleiman and Abisaab, 1995).

Abisaab and Sleiman (1995) recorded respiration rate of sheep at rest. The respiration rate was lower than the rate recorded after walking (52.4 vs 150.7 and 49.0 vs 140.6 per minute) for crossbreds and *Awassi* sheep respectively.

The normal respiratory rates for sheep under 18°C ambient temperature ranged from 20 to 34 per minutes, with a mean of 25 per minute. While under 10°C ambient temperature, it was 16-22 per minute with a mean of 19 per minute. (Williams, 1997; Anonymous, 1996).

Six fold increase in respiration rates were observed after exercise. It was significantly higher for males than females. Further the increase in respiration was observed with the increase in feed intake (Kasa *et al.*, 1995).

Hassanin *et al.* (1996) observed that rams developing hyperthermia during June to September period registered an increased respiration rate (103.9 40 per minute). According to them, the diurnal variations in respiration rate was correlated with ambient temperature. The same workers made an interesting observation in that lower respiration rate was recorded during day time compared to higher rates during night time. This might be the effect of huddling.

2.2.3 PULSE RATE

Mullick (1960), Razdan *et al.* (1968) and Thomas and Razdan (1973) indicated positive response of pulse rate to increasing ambient temperature. whereas Reik and Lee (1948 a, b) found no positive response of pulse rate to increasing ambient temperature. The experimental evidence indicative of a negative response of pulse rate to rise in ambient temperature (Kibler and Brody, 1949, 1950, 1951), have been reported mostly from climatic chamber studies.

The diurnal variation in pulse rate of *Russian Merino* sheep during summer, autumn, winter and spring seasons was reported (Srivastava *et al.,* 1980).

Singh, *et al.* (1982) observed an increase in morning pulse rate during summer only in the crossbred sheep. It was also reported that increase in pulse rate for a unit rise in rectal temperature was higher in crossbred sheep. Genetic groups had a significant effect on pulse rates in female sheep. Among various breeds of sheep compared *Dorset Horn* and *Suffolk* had the highest values for all physiological traits in all seasons (Vihan and Sahni, 1981).

Misra *et al.* (1985) reported that the effect of genotype, month and time were highly significant ($P<0.01$) on pulse rate. Again the same authors reported that the mean pulse rate for *Corriedale, Coimbatore* and their crossbreds was 83.5 per minute.

Heart rates were recorded throughout the year in eight sheep and for six months during winter in twenty one sheep. It was found that there was significant differences in heart rate between seasons and between individuals during the year (Jager, 1986).

Kaushish *et al.* (1990) observed variations in pulse rate among breeds of sheep. During rainy season it was 94.9 per minute in *Marwari* goats and 85.8 per minute in *Sirohi* goats. Seasonal variation in heart rate from a minimum in December to a maximum (50 per cent higher) in June (46 per minute) were reported in sheep. This variation was linked with day length, basal metabolic rate, food availability, food consumption and the reproductive cycle. (Baldock *et al.*, 1988).

Pulse rates were significantly lower during winter (85.4 per minute) than in summer (96.0 per minute) in sheep. (Nazki and Rattan, 1990).

Alnaimy *et al.* (1992) observed an increase in pulse rate on exposure to high environmental temperature in sheep and goats. On the other hand Marai *et al.* (1991) reported that pulse rate does not always change applicable under high environmental temperature. Pulse rates in different genetic groups of goats were affected by high ambient temperature and humidity (Guney *et al.*, 1992).

Hooda and Nagvi (1992) reported a greater increase in pulse rate in cross breeds than in *Malapura* sheep, consequent to an exposure to high ambient temperature.

Rate of increase in heart rate on exposure to direct sun was higher in *Merino* rams than *Kutchi* and *Shirohi* goats. Further, the heat tolerance in growing females did not vary significantly ($P<0.05$) between breeds (Singh *et al.,* 1992).

Abdel-Baki *et al.* (1995) observed increased pulse rates in summer (73 per minute) and winter (69 per minute) followed by spring (64 per minute) and autumn (62 per minute). The variation in pulse rates per minute was very much identical in both goats and sheep under both hot humid and cold humid seasons (Ghosh and Pan, 1994).

Gupta and Acharya (1993) reported that the increase in pulse rate was lowest in *Nalis* and *Choklas*, and highest in *Merinos* under high ambient temperature.

Sleiman and Abisaab (1995) recorded increased heart rate in Filial crosses (116.3 per minute) than *Awassi* sheep during autumn (104.8 per minute) and spring (125.8 Vs 117.1 per minute). The young Filial males had higher rate of heart beats than young *Awassi* males during all seasons (122.4 Vs 105.2 per minute). Similarly, Abisaab and Sleiman (1995) observed that heart rate was influenced by environmental temperature and was higher during spring and summer than in autumn.

Acharya *et al.* (1996) reported that higher pulse rates were recorded in the afternoon over those recorded in the morning.

Heart rates were monitored continuously over several weeks in sheep. Animals kept individually or in groups revealed regular rhythmic variations which changed under conditions of stress (Mohr, 1996).

The normal heart rates in both sheep and goats in adult animals during resting was 70-80 beats per minute (Williams, 1997).

2.3 HAEMATOLOGICAL PARAMETERS

2.3.1 HAEMOGLOBIN:

The average normal values of haemoglobin were 10 g per cent and 11.5 g per cent in goats and sheep respectively (Benjamin, 1985).

Dutta *et al.* (1996) recorded haemoglobin level in *Assam* sheep in humid areas as 11.029 per cent. Haemoglobin levels in *Karakul* sheep were 7.7-14.8 g per cent. Further significantly higher values of haemoglobin were obtained during summer and winter (Baumgartner and Pernthaner, 1994). On the other hand, Alnaimy *et al.* (1996) reported decrease in haemoglobin concentration during heat stress.

Haemoglobin levels in autumn and spring lambing groups were 7.51 g per cent and 7.3g per cent respectively (Baranow *et al.*, 1994 a). Haemoglobin levels recorded in *Polworth* upto one year under varying temperature (10.5 to 46.5° C) sheep showed a decrease in haemoglobin levels when ambient temperature was more than 25° C. This was more evident in shorn than in unshorn animals (Silva *et al.*, 1992).

Pernthaner *et al.* (1993) measured normal haemoglobin levels in five breeds of sheep bi-monthly for one year in which the values ranged from 8.2 to 14.7g per cent. Significant differences due to breeds, age and seasons were found.

Haemoglobin concentrations were observed in *Patanwadi* sheep and its crosses with *Merino* or *Rambouillet* males. No significant difference between breed types were recorded. But, haemoglobin was higher in winter than in summer season

(Joshi *et al.*, 1991). Jager (1986) observed significant differences in haemoglobin levels during the year in clinically healthy *East Friesian* ewes.

Pospisil *et al.* (1987) reported that mean haemoglobin levels in *Cameroon* goats were 11.34 g per cent and ranged from 8.3 to 14.3 g per cent. Female goats had significantly lower values for haemoglobin compared to males. The same workers also reported significant seasonal variations in the heamoglobin levels.

The average values for haemoglobin in *Merino* ewes fed on balanced ration in winter and grazed during summer ranged from 10.13 to 12.13 g per cent (Jelinek *et al.*, 1986).

Chahal and Rattan (1981) recorded seasonal variations in levels of haemoglobin in adult *Corriedale* rams; values averaging 10.67, 11.70, 12.97 and 12.20 g per cent during winter, spring, summer and rains respectively. indicating significant seasonal differences between animals and also seasons and animal interaction.

Musinov (1979) observed that haemoglobin concentration in sheep was highest in autumn (12.29 g per cent). On the other hand, Chiboka and Thomas

(1981) reported that haemoglobin contents of five breeds of sheep were not constant and were affected by time of collection.

Kataria *et al.* (1990) measured concentration of haemoglobin in *Marwari* goats native to western part of Rajasthan in two different environment temperature *viz.*, when ambient temperature remained moderate and when it remained above 40°C. The haemoglobin levels during moderate ambient temperature was 12.5 ± 0.09°C. No significant increase was observed in the mean values of haemoglobin at higher ambient temperatures.

2.3.2 ERYTHROCYTE SEDIMENTATION RATE (ESR)

In sheep, the erythrocyte sedimentation rate at the end of one hour showed, one to 2.5 mm fall (Reda and Hathout, 1957). After a period of 24 hours 3 to 10 mm of settling have taken place (Bunce, 1954). In goats it was 2 to 3 mm only in 24 hours, and showed almost zero mm per hour due to absence of rouleuax formation in goats (Schalm *et al.,* 1975)

Sheep and goats, showed negligible erythrocyte sedimentation rate in one hour readings. (Schalm *et al.,* 1975; and Sastry, 1989). Xavier (1981) observed ESR in male and female buffaloes and values were 39.09±0.73 mm/hr and 37.32±1.65

mm/hr respectively. Further, the climatic variables showed some influence on ESR. Benjamin (1985) reported that the normal ESR in sheep and goats ranged from 3 to 8.25 and 2 to 2.5 mm/24hr respectively.

Rastagi and Singh (1990) measured ESR in mountain *Gaddi* goats. It was less than 1.0 mm/2hr, with a range from o to 1.0. The normal ESR in camel under hot-humid climate of Konkan region, was 1.58 mm/hr (Dalvi *et al.*, 1998).

2.3.3 POTASSIUM

2.3.3.1 Normal Values

Baranow *et al.* (1994,b) observed normal values of serum potassium for lambs born in the autumn, as 5.5 g/l (0.45m moles/l) a higher value when compared to those born in spring which showed, 4.9g/l (0.38m mole/l).

Lohle (1994) estimated the serum potassium in 130 goats, sampled at various times of the year. The values averaged 4.36 to 4.94 m. mol per litre.

The frequency of high potassium level (HKL) phenotype was 0.427 in lambs and 0.540 in ewes. The potassium concentrations in the lambs blood averaged 30.5 m.mol per litre in HKL phenotype and 9.3 m mol per litre in the LKL phenotypes (Lipecka *et al.*, 1994).

The normal values for plasma levels of potassium in human being were 3.5 to 5 mEq/l (Williams, 1995 ; Vasudevan and Sree Kumari, 1995)

2.3.3.2 Factors affecting potassium levels

The frequencies of potassium types in HK and LK were 86.75 and 13.25 per cent respectively in *Karakul* sheep. Further, the average blood potassium concentration in HK and LK sheep were 38.01 and 7.50 mEq/l respectively (Singh *et al.*, 1979).

Kandasamy (1979) reported that 58.4 per cent of sheep were of the high blood potassium (HK) type and 41.6 per cent LK type. The potassium levels were not significantly affected by age, sex, size or reproductive status.

Pran *et al.* (1981) observed that the mean potassium levels in whole blood of HK and LK sheep were 29.6 $\pm$0.37 mEq/l and 11.7 $\pm$12 mEq/l respectively. Gene frequency for HK type was 0.7 and for LK type 0.3.

The mean whole blood potassium concentrations of HK and LK sheep were 29.6 $\pm$0.39 mEq/l and 11.7 $\pm$0.12 mEq/l respectively. There were no significant differences in HK frequency between *Mazaffarnagaris* and crossbreds (Bhat *et al.*, 1981).

The HK sheep had 8.97 mEq/l and LK sheep had 25.47 mEq/l of Potassium in blood and 51.83 percent of the sheep were LK type and season of birth had no effect on potassium concentration (Kumar, 1983). Thiagarajan and Stephens (1984) reported that the frequencies of the alleles for high and low potassium concentration (HK and LK) were 0.65 and 0.35 respectively in *Keezhakkaraisal* sheep.

Genetic group had no effect on the concentration of whole blood potassium in goats. The frequency distribution of potassium in pooled population showed a distinct bimodality on the basis of which the goats were classified into distinct types *viz.,* Low Potassium (LK : < 22 mEq/l) and High Potassium (HK : > 22 mEq/l) (Nandakumaran, 1989). It was observed that 76.39 per cent of the pooled population were of LK types.

Plasma levels for potassium (K+) were constant in Black goat exposed to a hot environment of 42° C $\pm$ 0.5° C with 76 per cent relative humidity when compared to unexposed animals (Sanyal and Sarkar, 1990).

Suzuki *et al.* (1991) reported potassium types in three crossbreds of sheep; the estimated gene frequencies were 0.51 and 0.49 for low potassium (LK) and high potassium respectively. Concentration in whole blood were 44.5 mg/dl in LK and 126.6 mg/dl in HK sheep.

Bhattacharya *et al.* (1995) observed higher values(5.52 $\pm$ 0.14 mEq/l) of serum potassium in summer. Srivastva and Gupta (1996) observed serum potassium levels in *Karakul* (exotic), *Marwari* (native) and their crosbred sheep in different seasons. The results indicated, higher values during Winter, followed by Autumn, Spring and Summer seasons.

2.4 BODY WEIGHT

The body weight, at birth and at 3 months interval upto 24 months of age were measured in *Beetals* and *Alpine* goat breeds (Nagpal and Chawla, 1984). They observed that season had a significant effect on birth weights in both, breeds and on some body weights upto 12 months in *Beetals* and to 15 months in *Alpines*. The effect of sex on body weight was evident at all ages, except *Alpines* at 3 months and both the breeds at 6 months. Similarly, Sanchez *et al.* (1984) reported significant seasonal effects on body and carcass weights in *Criollo* goats. This effect was highest during November to January, and February-April. For one year old animals body and Carcass weights of females were significantly higher in May - July and February to April periods respectively.

Body weight records of 1,641 observations of four cross bred goats were recorded at birth and at 3 months intervals upto 24 months (Nagpal and Chawla, 1985). The influence of season was more pronounced at early age in various crossbreds. It gradually decreased with advancement of age. This may be due to the availability of good quality of feeds in sufficient quantity to the does before parturition and to the kids after birth. Kids born in summer registered lower birth weight and gained less weight upto 6 months of age. Thereafter kids grew at a faster rates and attained higher body weight at 9, 12, 15 and 18 months of age, when compared to those born in winter. Data collected over a period of 11 years on 418 goats were analysed for body weight in which season of birth had a significant effect on body weight at birth, 6 months and 18 months of age. (Naik *et al.,* 1985).

Devendra (1987) reported that the major influences on the growth of goats was mature size of the sire and dam. The mature size of goats varied from 15 kg for small *Bengal* breeds to over 75 kg for *Jamnapari* goats. It was 25.35 kg in *Malabari* goats. Generally progeny of large breeds were heavier at birth and grow faster than the progeny of small breeds.

Prakasm *et al.* (1987) observed that in flock of *Tellichery* goats studied from 1981 to 1984, the birth, weaning and yearling weights averaged 2.22±0.01, 8.26±0.02 and 22.89±0.19 kg respectively for males and 1.81±0.01, 6.32±0.05, 16.61±0.04 kg for females.

The mature weights were 39.032±0.333 and 30.351±0.346 kg for *Jamnapari* and *Tellichery* respectively. Further in *Jamnapari* the gains in body weights were 69 g from birth to three months, 33 g from 3 to 6 months and 48 g from 6 to 12 months of age and in *Tellichery* the gains were 48, 48 and 28 g per day during the respective three stages (Krishnappa, 1993).

Schoeman (1990) reported that the lambs born in winter were 16.2% heavier than those born in spring and 20.9% heavier than those born in summer or autumn.

Kulkarni and Deshpande (1990) observed that the year and season of birth had a highly significant effect on body weight upto 6 months in both the sexes of *Merino* half-bred sheep. Daily voluntary feed intake and weekly live weight gain were measured in lambs of six breed types. The results suggested that variations due to seasons among breed types were evident. This should be considered when choosing a feeding or growth regime for a particular breed type. (Iason and Mantecon, 1991).

Pavon *et al.* (1986) recorded body weight in *Pelibuey*, *Pelibuey X Corriedale* and *Pelibuey X Suffolk* ewes aged 1-3 years. The body weight averaged 31±1.45, 36±0.5 and 37.1±1.6 kg respectively for the above ewes.

Body weight in *Marwari* rams and *Angora* goats were studied for an year (Sahani and Chand, 1989). Body weight in *Marwari* rams ranged from 29.80 $\pm$1.44 to 39.2 $\pm$1.16 kg with a total weight gain of 9.4 kg during the post monsoon months (Sept.-Feb./March). Body weight in *Angora* inheritance ranged from 31.4 $\pm$1.14 to 40.4 $\pm$1.34 and from 35.80 $\pm$ to 48.0 $\pm$ 0.83 kg respectively the total gains were 5.8, 6.2, 8.0 and 12.2 kg. Further it was reported that the body weight was lowest during the hot summer months and highest during winter and the monsoon season.

Nasholm (1990) measured body weights in 600 ewes, aged 6 months to 6 years. Body weights increased age up to 4-5 years and was significantly affected by season, flock size and breed. The adult male and female body weights in *Segurene* sheep averaged 72.70 $\pm$5.3 and 49.91 $\pm$2.9 kg respectively (Blanco *et al.*, 1990).

Ruvuna *et al.* (1991) recorded body weights at 2,3,4,5 and over 6 years of age in female *Somali* (Galla) and *East African* goats. It was found that breed and sex of the faetus had no significant effect on body weight of dam. The breed of female, year, type of birth, season and pregnancy status were significant. Body weight was 2 kg heavier in the cooler dry season than in the rainy warm season. *Somali* females were approximately 15% heavier than *East African* goats. The mature weight was 31 kg for *East African* goat and 35 kg for *Somali* goat.

The body weights at weaning were 21.1 and 22.6 kg and at 12 months 33.7 and 34.8 kg for *Dorper* and *Dorper X Red Masai* Crosses of sheep. It was reported that the sex, season of birth and breed type influenced 6 and 12 months body weights ($P<0.05$) (Inyangala *et al.,* 1991). Kulkarni and Deshpande (1991) reported that the female lambs born in summer were significantly heavier than those born in winter, spring or monsoon seasons.

Butler and Head (1992) observed growth rate in sheep from nine Tasmanian flocks. Maximum growth occurred in the spring when compared to autumn and winter. Least squares means of body weight for Jamnapari kids at birth, 3 months and 12 months were 3.13, 8.35 kg and 19.8 kg respectively. Kids born in the month of February were heaviest. Month of birth had a significant effect on body weight. (Kumar *et al.,* 1992).

Nasholm (1992) reported that body weights increased with increasing age up to 4-5 years and there were significant differences between flocks. Body weights of all types of ewes increased except heavy mutton ewes. This increase was attributed to improved management rather than genetic environment.

The body weights of *Ojalada* lambs were observed during winter, spring, summer and autumn. The birth weights averaged 3.36, 3.34, 3.58 and 3.44 kg respectively during the four seasons. Body weights at 30-50 days of age were 17.71, 12.55, 12.76 and 12.45 kg and that at 80-100 days of age were 25.36, 23.41, 21.73 and 23.70 kg respectively. (Maria *et al.,* 1992).

Bilaspuri and Singh (1993) recorded body weights for adult *Malabari* and *Beetal* goats. It was 39.3 kg in *Malabari* and 29.3 kg in *Beetal* goats (P<0.01). The body weights for adult male and female sheep were 42.0 kg and 25.6 respectively in the breeds of Deccan Plateau (Nimbkar, 1993)

Brown and Jackson (1995) observed lower mean litter weights during spring and autumn breeding seasons. Year, season of birth, sex and birth had a significant effect on body weight at all ages in sheep (Snyman *et al.,* 1995).

An adult body weight of *Malpura* sheep was 31.4 kg in Chittorger district of Rajasthan (Mehta *et al.,* 1995). No seasonal differences in body weights were apparent at the South Texas plains site.

2.5 BODY MEASUREMENTS

Pattabiraman (1955) observed the measurements of *Tellichery* adult doe, as body length 66 cm, height 66 cm and girth 71.1 cm. According to Devendra and Mcleroy (1982) height at withers varied from 78 to 100 cm in *Jamnapari* and 65 to 70 cm in *Malabari* goats.

Devendra and Burns (1983) observed that *Jamnapari* breed was most popular and wide spread breed used for milk production in India and South East Asia. Males weighed about 68 to 91 kg. The height at withers of males and females was 91 to 127 and 76 to 107 cms respectively.

Manik *et al.* (1984) studied the body dimensions of adult cross-bred goats. The average chest girth of the goats were 74.18 cm ; body length 75.07 cm and height at withers 74.11 cm. The average body weight was 34.85 kg. In *Bengal* goats Patnaik and Mishra (1985) measured chest girth, height at withers and chest circumference at 3 monthly intervals. At 24 months body measurements were 47.76 cm, 55.23 cm and 59.47 cm respectively.

Misra (1985) while studying the home tract, population size, body size and physical conformation of Indian goat breeds reported that the body weight, length and heart girth of *Malabari* goats as 38.96 kg, 70.20 cm, 71.90 cm and 73.80 cm for males and 31.12 kg, 63.50 cm, 63.20 cm and 67.4 cm for females.

Pavon *et al.* (1986) observed that the body measurements for ewes aged three years, the body length averaged 69 $\pm$1.33, 71 $\pm$ 0.8 and 67 $\pm$ 1.4 cm; height at withers 63 $\pm$1.32, 53 $\pm$2.3 and 59 $\pm$1.0 cm and chest circumference 72 $\pm$1.19, 77 $\pm$ 1.5 and 73 $\pm$2.4 cm in *Pelibuey, Pelibuey X Corriedale* and *Pelibuey X Suffolk* breeds of sheep respectively. The effect of year of birth on body length and height at withers were established. The correlation's of body weight with chest circumference, body length and height at withers were 0.90, 0.77 and 0.67 respectively. Those of chest circumference with body length and height at withers were 0.90 and 0.75 respectively and that of body length with height at withers was 0.78.

Kalra *et al.* (1986) studied body dimension traits in 85 adult *Nali* ewes. The body length measured 65.76 cm ; wither height 65.34 cm; chest circumference 71.30 cm; and body weight 25.75 kg. The body weight was correlated with body length (0.44) body height (0.78) and chest circumference (0.95).

Pradhan (1987) estimated live weight of sheep and goats from physical measurements of the body. The correlation between the estimated and actual body weight measured on 100 goats and 250 sheep were 0.99 and 0.98 respectively. Data presented on various body measurements and their correlation's of *Spanish* breeds, revealed differences between sexes. The comparison of these measurements between breeds of goats revealed that they were fairly similar in *Spanish* breeds to those of *Murcia Granada* and *Malaga* goats (RodI-guez , 1990).

Singh *et al.* (1990) recorded body length, height at withers and chest girth in *Jamnapari* and *Beetal* goats. All linear body measurements were higher in older animals (6-12 months of age) than in younger ones (0-6 months of age). This indicated significant change in dimensions with increase in age. The interaction of genetic group with sex and age were not significant for all linear body measurements.

Some workers observed significant difference between the two sexes in different breeds of sheep. Blanco *et al.* (1990) observed that male *Segurena* sheep aged one to 10 years measured 74.85±0.8 cm in height at withers and 88.21±1.2 cm in chest circumference compared to 67.49±0.2 cm and 79.3±0.5 cm in girth in females of similar age.

On the other hand Koul *et al.* (1990) did not find much difference between the sexes in goats. They recorded body length as 28.5, 28.9 and 31.5 cm at birth, one year and 2 years respectively for males and 28.4, 28.9 and 31.5 cm for females in *Himalayan* goat breeds. Wither height recorded were 54.4, 50.6 and 64.5 cm in males and 53.0, 48.5 and 57.0 cm in females chest girth was 72.9, 66.2 and 84.7 cm and 65.5, 58.1 and 73.9 cm all groups. Similarly in *West African* dwarf goats the height at withers of male and females were 92.7 and 92.6 cm, body length 80.3

cm and 82,5 cm and chest circumference 86.00 cm and 86.9 cm (Seifert and Waschko, 1991). Body measurements of 10 *Ossimi*, 10 *Rahmani* and 10 *Ossimi X Rahmani* lambs did not show any significant difference between the genetic groups in body length or height at withers (Ibrahim, 1991).

Ifut *et al.* (1991) measured physical dimensions of *Nigerian* goats aged 20-36 months. The average body length, heart girth and wither height were 54.36, 59.58 and 44.52 cms respectively. The ratios of body length, heart girth and wither height decreased with increasing age. But the ratios of body length to the heart girth and withers height and that of withers height to heart girth remained fairly constant. It was found that body measurements appeared to approach mature dimensions by 22 months of age in females. The height at withers was 52.0 and 51.0 cm respectively for male and female *Chyangla* mountain goats The heart girth was 79.0 and 68.3 cm and body length measured 70.0 and 61.6 (Shrestha *et al.* 1992).

The *West African* dwarf goat showed similarity in its relative body proportions to the adult Northern goat, implying proportional miniaturisation (Itall, 1991). On the other hand, Pandeya and Solanki (1991) observed body weight and 10 linear body measurement of young and adult goats in five climatic zones of western India. The results showed that populations in different zones differed significantly for the traits measured.

Acharya (1992) reported on certain physical characteristics and body confirmation of female *Jamnapari* and *Malabari* goats. The values were 75.20, 75.20 and 76.10 cm in *Jamnapari* goats and 63.50, 63.20 and 47.40 cm in *Malabari* does.

The least squares means of body length, withers height and chest girth in *Jamnapari* kids were 46.0 cm, 47.7 cm and 44.9 cm at 3 months age and 61.0, 63.3 and 59.7 cm at 12 months age. The month of birth had a significant effect on all the traits (Kumar *et al.,* 1992). Bilaspuri and Singh, (1993) reported the morphometry of *Malabari* and *Beetal* goat breeds. The body length was 118.5 and 98.2 cm chest girth 91.5 and 82.5 cm and height was 86.5 and 80.1 cm respectively. It was found that all the parameters were higher in *Malabari* breed than *Beetals.*

The average pooled body dimensions in *Black Bengal* and *Ganjam* crossbreeds were measured at birth and at 180 days (Mahapatra and Nayak, 1996). The body length, wither height and chest girth were 38.79 $\pm$ 0.73 to 66.17 $\pm$1.76 cm, 34.4 $\pm$0.43 cm to 51.13 $\pm$1.51 cm and 30.06 $\pm$ 9.79 cm to 49.78 $\pm$1.37 cm at birth and at 180 days respectively. Chest girth had no significant correlation with body weight in different age groups. Body length was highly correlated with body weight in all the age groups. Withers height was also highly correlated with body weight except at birth. Meja and Cartillo (1991) reported correlation of body weight with height at withers chest circumference and the body length in kids.

Krishnappa (1993) observed body length, height at withers and heart girth at eight teeth stage, the respective measurements were 88.69±1.64 and 98.38±1.64 cm for *Jamnapari* and 75.56±1.22, 81.98±1.27 and 81.98±1.77 cm in *Tellichery* goats.

2.6 ETHOGRAM:

An ethogram is basically required in all animals, both domestic and wild ; to have a thorough understanding about their normal activities and to evolve scientific husbandry practices needed for their sustainable maintenance (Xavier, 1994).

Mountain sheep were capable of running at great speed over short distances, jumped rather than climbing, through cliffs in flight and were specialised to live on abrasive, dry, often dusty plains and can economise their energy expenditure in winter. Mountain goats also shared the same mountains with sheep. But, the goats were apparently phlegmatic climber adapted to steep, snow-and ice-covered cliffs and it showed rather wide variations in food habits (Valerius, 1971).

Squires and Daws (1975) studied dominance and leadership behaviour in separate flocks of *Merino* and *Border Leicester* sheep. In *Merino* group a small number of ewes shared responsibility for leadership. In *Border Leicester*, leaders were drawn from a larger pool of individuals. Both the breeds showed high positive correlation between ewe's leadership score and dominance value. More dominant ewes were found in front of a moving group and the more submissive ewes, at the end .

Kilgour *et al.* (1975) reported breed differences in grazing and dispersal behaviour of sheep. Under poor feed conditions, some breed groups were reluctant to disperse and locate suitable grazing. Further, they reported that such behaviour could limit adaptability of breeds to extensive grazing management systems and environments.

Diurnal differences in grazing patterns were studied in *Leicester, Dorset Horns* and *Romney* breeds of sheep in response to the environment. *Border Leicester* were more sensitive to the changes in environment, whereas, *Dorset Horns* were least sensitive (Dudzinski and Arnold, 1979).

Winter *et al.* (1980) reported that breeds differed little in grazing habits in more moderate seasons. Exotic cattle breeds decreased their grazing time when compared to the *Bos indicus* types, and sought shade up to 90% of the day. But the Sahiwal and local heifers maintained grazing times and practised little shadeseeking behaviour. Arnold *et al.* (1981) observed ranging behaviour in different breeds of sheep. Results, indicated that three breeds differed substantially in their social organisation.

ShillitoWalser and Hugue (1981) studied dispersion and association of sheep in a mixed flock of three different breeds. It was observed that within one hectare pasture, the breeds showed preferences for different areas and difference in grouping strategies were also observed. They concluded that there were breed differences in social behaviour.

Winfield *et al.* (1981) reported conflicting results in four breeds of sheep. Sheep had a clear preferences for other sheep with whom they already were familiar, but they had no particular preference for familiar sheep of their own as opposed to other breeds. Also no one breed showed a preference for (or against) any breeds.

Shillito Walser *et al.* (1981) observed vocal recognition between ewes and lambs of different breeds. *Border, Leicester, Jacob* and *Soay* sheep all responded vocally more often to bleats of their own lambs than to those of aliens. Further, it was reported that the *Jacob* breeds were the most vocal group and *Soays* the least vocal. In another experiment (Shillito Walser *et al.* 1982) animals were studied for their visual contact with one another. The results showed ewes of all breeds bleating more frequently in response to their own, compared to alien lambs bleats, but *Dalesbred* ewes were more discriminating in this ability than ewes of other breed.

Stricklin (1983) studied dominance and spacing behaviour of maternal-linkage families in a mixed herd of *Angus* and *Herefords*. It was found that *Angus* ewes dominated *Herefords*, and that in groups, *Angus* tended to occupy central positions, whereas, *Herefords* were found in the periphery of the group.

Goats differ fundamentally from sheep and other livestock in their sensory physiology feeding behaviour and in several morphological traits that appear to render them particularly well adapted to utilization of leaves, buds, and fruiting bodies of woody plants. They were highly flexible in their feeding habits and seem particularly responsive in exploiting ephemeral types of feed seasons, months and stocking rate. Goats select more browse than sheep. Goats appear to be extremely flexible and opportunistic in their dietary habits. (Malechek and Provenza, 1983).

Wemmer *et al.* (1983) formulated an ethogram in Pere David's deer herds at the Brookfield Zoo and the National Zoo's Conservation and Research Centre which describes behaviour patterns on the basis of mechanics and structure. They noted occurrence of behaviour patterns of adult and immature deer, and classified each pattern into one or more functional categories. Adult males and females shared 43 of 83 patterns (52%) and that social behaviour accounts for 21 of these 43 patterns

(49%) in both sexes. Twenty-two patterns were classified as having primarily comfort, grooming, or protective functions and nine patterns were involved with feeding, elimination, and locomotion. Further, six of the 12 exclusively female patterns were agonistic; one pattern was sexual. Three of the remaining five patterns were involved in mother-young interactions and the other two patterns were of unknown function.

Roy and Nagpaul (1984) reported that both Karan Swiss and Karan Fries dairy cows were more docile than Murrah buffalo cows. An experiment on crossbred ewes showed that, Sire breeds had no effect on daily grazing time or estimated distance travelled. Further it was reported that the groups did differ in site preferences within the pasture (Hohenboken,1986)

Goats were selective in their ingestive behaviour compared to sheep. Further, during feeding in ranges; both sheep and goats exhibited investigative and eliminative behaviour and bleating (Das *et al.*, 1990). The behaviour of solitary and group living Pudu (*Pudu pudu*) and Red brocket (*Mazama americana*), was studied for 546 hours in captivity at the Isla Victoria Breeding Centre, Nahuael Huapi National Park, Argentina and the New York Zoological Park. Forty behaviour patterns were recorded and described. It was found that the behaviour of these two species resemble that of most of other cervids, but several patterns were unique to each species. The communication repertory of pudu and brocket include primarily visual and olfactory patters and both share a suite of behaviour characteristics with other small solitary forest ruminants (MacNamara and Eldridge, 1990).

Turner (1990) Studied differences in time-budgeting by a Roe deer population of various group sizes along the sectors of environmental gradients. It was found that the animals from each sector were capable of changing their behaviour to approach that of animals in second sector. Barrette (1990) made a comparative study of behaviour and ecology of Cherratains, Musk Deer and morphologically conservative deer. The results showed that animals living in a solitary yet social life, were probably non-territorial yet sedentary on a limited home range and were polygynous. Clear and complete image of life history characteristics were infact a gross oversimiplication of the ecology and behaviour of a group of animals where each species were unique and apparently very adaptable.

Boval *et al.* (1992) recorded grazing , ruminating and resting activities in goats, every five minutes during a 60 hour observation period. The main daily activity was grazing (56.3%), during day time (from 5.30 AM to 6.00 PM), with a peak grazing, at 4.00 PM. During night, ruminating and resting were the important activities; (34.0 and 44.0 % respectively). Further, rumination increased significantly between midnight and early morning hours. *British Saanen* goats were observed for feed intake, ruminating, resting and sleeping. It was noted that, generally during the day times their feed intake, standing and number of excretory activities were greater than that of night time. Further, the times of ruminating and sleeping in the night time was longer than the day time (Gangyi *et al.,* 1992).

Carbonaro *et al.* (1992) studied feeding behaviour and feed intake of indigenous goats primarily on natural vegetation over a period of one year. The results showed that grazing was the main method of feeding in all seasons, accounting for over 80% of all the forage ingested.

Seasonal variation in the preference of a herd of dairy goats was observed when grazing. grass, trees and shrubs or acorns. Grass accounted for 70% (1478 mouthfuls), 76% (4221 mouthfuls) and 65% (2228 mouthfuls) of the selections made in the autumn-winter, spring and summer seasons, respectively. (Sanchez *et al.* 1993).

Fedele *et al.* (1993) observed that goats had a high preference for grasses. In summer they preferred forbs and legumes were less preferred. Further, both *Maltese* and *Rossa Mediterranean* breeds showed a different behaviour in selecting plant species.

An experiment on effects of group size on grazing time in sheep showed influence of social environment. It was found that sheep in smaller groups spent less time grazing than sheep in larger groups. But, there was no relationship between group size and inter-meal intervals. Animals in groups of one and two tended to have shorter meals than those in larger groups (Penning *et al.,* 1993).

Activity patterns and time budget of wild animals studied by Menon and Poirier (1996) showed that, the largest proportion of time spent in each day was for ranging (34%). The second most common activity was foraging (23.7%), followed by feeding (17.9%) resting (16%) and 8.4% for other activities. Anonymous (1996) observed that cattle and sheep grazed mostly light. Goats spent more time in browsing than grazing.

Materials and Methods

3. MATERIALS AND METHODS

A bio-climatological experiment was designed for a period of twelve months and was carried out by utilising sheep and goats, maintained in the Kerala Agricultural University, Sheep and Goat Farm, College of Veterinary and Animal Sciences, Mannuthy. Geographically, Mannuthy is situated at 76^0, 16 ' East-longitude ; 10^0 32' North- latitude and altitude being 22.25 metres above the MSL. The period of study was from August 1997 to July 1998.

3.1 SELECTION OF EXPERIMENTAL ANIMALS

Fifteen adult female Ramnad white sheep and fifteen adult female Malabari crossbred goats were randomly selected from the farm stock, for the experiment.

3.2 HOUSING OF ANIMALS

The experimental animals were housed together in an identical conventional type goat shed. The shed was located in east-west direction, with cement- concrete floor, about 0.1 m above the ground level. It had good drainage facility. The roof was made of asbestos-cement sheet. The shed was well lighted and ventillated.

Wooden platforms were provided with stand and hay rack was fitted in the middle of the shed, for feeding of hay.

3.3 FEEDING MANAGEMENT

The animals were group fed on a commercial pelleted compounded feed in the morning at 8.30 a.m. and were let out for grazing in fairly good fodder plots for 2hrs. They were offered *ad libitum* grass and hay in the afternoon hours when they return to their respective sheds after grazing, fresh drinking water was provided within the shed.

3.4 ENVIRONMENTAL VARIABLES

3.4 AMBIENT TEMPERATURE

By using a maximum, minimum thermometer the maximum and minimum temperatures inside the animal shed were recorded daily in the morning and evening.

3.5 DRY AND WET BULB TEMPERATURE

Dry and wet bulb thermometers were installed inside the animal shed and the recordings were taken twice, morning and again in the evening. The daily maximum, minimum temperature (^{0} C), relative humidity (%), and rainfall (mm), wind velocity (Km/hr) and sunshine (hours of bright sunshine), were obtained from the nearby Kerala Agricultural University Mateorological laboratory located in the compus.

3.6 PHYSIOLOGICAL VARIABLES

3.6.1 RECTAL TEMPERATURE

The recal temperature of all the experimental animals were recorded during early morning and evening hours using a standard clinical thermometer during three consecutive days in every week for one year.

3.6.2 RESPIRATION RATE

The respiration rate of the experimental animals were recorded by observing the rise and fall of the chest region for a minute during the early morning and evening hours, without disturbing the animals. This was done before recording the rectal temperature and heart rate. Recordings were taken for three consecutive days in a week for different seasons of the year.

3.6.3 HEART RATE

Early morning and evening heart rate was recorded using a stethescope for three consecutive days a week for one year.

3.7 HAEMATOLOGICAL PARAMETERS

3.7.1 HAEMOGLOBIN

Animals were bled from the jugular vein at monthly intervals. EDTA was used as anticoagulant. The heamoglobin level was estimated by Sahli's acid heamatin method (Schalm, 1975).

3.7.2 ERYTHROCYTE SEDIMENTATION RATE

The Erythrocyte sedimentation rate was estimated by Wintrobe method (Benjamin, 1985). The samples of blood, soon after collection, were filled into the Wintrobe hematocrit tube upto 'O ' mark on the left scale. The tubes were set in a vertical position in an appropriate rack. The upper level of sedimenting erythrocytes was recorded in millimeters on left scale, for 24hours.

3.7.3 SERUM POTASSIUM

Whole blood without adding anti-coagulant was collected at monthly intervals from all the experimented animals. The serum was seperated and used for estimation of serum potassium values with the help of a flame photometer(Parkin Elmer, Model 3110).

3.8 MORPHOMETRY

3.8.1 BODY WEIGHT

Body weight of sheep and goats were recorded individually at monthly intervals, before offering feed and water, using a platform balance.

3.8.2 HEIGHT

The height at withers was measured once in a month for a period of one year using standard measuring rod and was recorded in cms.

3.8.3 CHEST GIRTH

The chest girth was measured in centimeters just behind the elbow using a standard measuring tape. The measurements were recorded once in a month for twelve months.

3.8.4 BODY LENGTH

The distance from the point of shoulder to the pin bones; *i.e.* the body length of the animal was recorded in cms using standard measuring rod. Monthly recordings were taken for a period of one year.

3.9 STATISTICAL ANALYSIS

The data generated were statistically analysed (Snedecor and Cochran, 1969).

3.10 ETHOGRAM

In short, the ethogram means a detailed description of the behavioural features of a particular species. While selecting measures for a particular study, it is useful to know the array of behaviours which the animal is capable of showing. A largely complete description of such an array is called ethogram.(Fraser and Broom, 1990).

Categories of behaviour that typify the species; arranged and the catalogue of description of the discrete species typical behavioural pattern that forms the basic behavioural repertoire of the species is the ethogram (Manning and Batison, 1988).

Observations on behavioural patterns in fifteen adult female sheep and goats were made for a total period of 700 hours A descriptive catalogue of all the behavioural patterns exhibited-by adult female sheep and goats, under the farm conditions, were-made.

A continuous behavioural inventory was prepared with an average six hour observation a day. Human interference was avoided as far as possible.

The following are definitions of behaviour categories based on observation made:

I. Gaits:

The limb coordination's used in locomotion.

II. Animal oriented movements

Body movements towards or away from another animal, or in response to the motion of another animal.

III. Visual Patterns

a). Animal oriented non- contact patterns: Distinctive motions or postures of the body or its visual patterns may or may not involve contact with, or be oriented in space toward, another animal.

b). Animal oriented contact patterns : Movements in which a part of the body is brought into contact with the body of a conspecific.

IV. Object and Self oriented contact patterns.

a). Object oriented patterns : Movements in which a part of body is brought in contact with some inanimate part of the surrounding environment.

b). Self oriented contact patterns : Movements that bring an appendage or body region into contact with another part of the body.

V. Vocal and Non-vocal patterns.

a). Vocal patterns : Vocalizations - bellowing, Bleating etc.

b). Non-vocal auditory patterns : Producing non-vocal sounds. e.g. Tooth grinding , Rumination sounds, Sneezing.

VI. Stretching patterns

Short term tonic postural adjustments.

VII. Stationary body positions and stances

Postures of usually long duration associated with periods of rest and activity.

VIII. Feeding, digestive and elimination patterns

a). Feeding and digestive patterns : Behaviour associated with the intake and initial processing of food.

b). Elimination patterns : Voiding of solid and liquid wastes.

Results

4 RESULTS

4.1 CLIMATOLOGICAL VARIABLES

The climatic data from August 1997 to July 1998 (experimental period) are presented in Table 1. The mean maximum and minimum temperatures for the whole experimental period were 32.40±0.71° C and 23.77±0.22°C respectively with the highest mean ambient temperature of 31.10° C recorded during April and the lowest mean of 25.86° C during August. Diurnal relative humidity averaged 88.08 ± 1.53% and 63.58±3.38%. Whereas, the highest values of relative humidity (88.08%) was recorded during July and the lowest (63.68%) during February, with the overall mean of 75.85±2.41%. The highest wind stroke of 6.63±0.60 km/hr in 24 hours was recorded during January and the lowest during May 2.54±0.12 km/hr), with a mean of 3.61±0.14 km/hr. Maximum hours of bright Sunshine in a day (10.01±0.14 hrs) during March and the minimum of 3.27±0.47 hrs was recorded during July, with an overall mean of 7.06+0.65 hrs. Similarly rainfall recorded in June was 28.96± 4.96 mm, the highest. There was no rainfall during January and February. The overall average rainfall during the experimental period was 8.64±2.80 mm. The monthly changes in ambient temperature and relative humidity are graphically presented in Fig. 1.

4.2 PHYSIOLOGICAL NORMS

4.2.1 RECTAL TEMPERATURE

Monthly means of morning and evening rectal temperature of sheep and goats recorded during the experimental period are presented in Table 2 and 3 respectively. The morning rectal temperature of sheep ranged from 38.5° C to 38.98° C with a mean of 38.78±0.04° C. The corresponding values in the case of goats were 38.44±0.03°C to 39.02±0.01° C with a mean of 39.69±0.05° C. In goats the evening rectal temperature ranged from 39.32±0.02° C with a mean of 39.67±0.07° C. Monthly changes in climatic variables and rectal temperature of sheep and goats are represented in Fig. 2 and 3.

When compared (t-test), significant difference ($P<0.05$) between sheep and goats in rectal temperature was observed during the morning hours (Table 16). Highly significant ($P<0.01$) diurnal variation in rectal temperature was observed in sheep and (Table 17 and 18). Rectal temperature of sheep ranged from 39.33°C during January and March to 39.42°C C during April, when the ambient temperature was highest.

In the case of goats the highest rectal temperature was observed in March (39.56° C) and lowest in the month of June (38.92° C). The relative humidity also had a significant influence on rectal temperatures of both sheep and goats (Table 15).

The coeffcient of correlation of rectal temperature to ambient temperature and relative humidity were 0.739 and 0.619 in sheep and 0.703 and 0.413 in goats. These values were highly significant (P<0.01) in both the species (Table 16). Regression analysis of the rectal temperature and climatic variables (Table 19) showed highly significant difference (P<0.01) in goats and significant difference (P<0.05) in sheep.

4.2.2 RESPIRATION RATE

The monthly means of diurnal respiration rates of sheep and goats are presented in Tables 4 and 5 respectively. The respiration rates in sheep during morning hours ranged from 24.21±0.51 to 31.49±0.65 per minute, with a mean of 28.14±0.75 per minute. The corresponding values in the case of goats were 24.67±0.41 to 31.89±0.47 per minute with a mean of 28.49±0.71 per minute. The evening respiration rates ranged from 35.84±0.55 per minute to 79.76±1.29 per minute with a mean of 53.88±4.72 per minute in the case of goat. The corresponding values in case of sheep were 34.25±0.81 to 73.46±1.13 per minute, with a mean of 49.59±3.63 per minute. The mean monthly respiration rate, irrespective of time of recordings, ranged from 30.13 per minute to 52.91 per minute in sheep with a mean of 38.86+2.87 per minute whereas in goats this ranged from 30.90 to 55.83 with a mean of 41.19+3.52 per minute.

The highest respiration rates in sheep (43.43, 45.37, 48.83 and 52.91 per minute) were observed, when the ambient temperature was within the range of 29.04°C to 31.10°C during February, March, April and May, respectively. The corresponding respiration rates recorded in goats during the above months were 48.55, 54.22, 55.83 and 52.58 per minute. The respiration rates recorded were lowest ; *i.e.,* 30.59 per minute in sheep and 30.96 per minute, in goats when the ambient temperature was lowest, *i.e.,* 25.86°C during August. Similarly the relative humidity also had a significant influence on respiration rates in both sheep and goats. The monthly changes in respiration rates and climatic variables are represented in Fig. 4 and 5.

Highly significant difference ($P<0.01$) was observed in sheep and goats, between morning and evening respiration rates (Table 17). Respiration rates did not vary between sheep and goats and were non-significant (Table 16). Highly significant correlation coefficient ($P<0.01$) between ambient temperature and respiration rates of sheep and goats were noted (0.794 and 0.749). Similarly highly significant ($P<0.01$) negative correlation was observed between relative humidity and respiration rates (Table 15). However, the regression coefficients of respiration rates on climatic variables were non-significant in sheep (Table 18). The regression coefficients between ambient temperature and respiration rates were highly significant ($P<0.01$) in goats, but it was non-significant between relative humidity and respiration rates.

4.2.3 HEART RATE

The mean monthly heart rate in sheep during morning hours ranged from 62.19±0.73 to 69.39±0.89 with a mean of 66.54±0.62 per minute (Table 6). The corresponding heart rate in goats during morning were 63.65±0.43 to 79.61±0.38 per minute with the mean of 73.61±1.43 per minute. The evening heart rate in sheep ranged from 78.07±0.48 to 96.20±0.88 per minute with a mean of 87.72±1.66 per minute. In goats these ranged from 86.63±0.9 to 103.25±0.96 per minute with a mean of 81.64±0.43 (Table 7).

The highest mean heart rate recorded in sheep was 82.79 per minute when the environmental temperature was a maximum of 31.10°C during April and it was 91.17 per minute in goats during March. The lowest heart rate of 70.13 per minute in sheep and 72.65 per minute in goats were observed, when the environmental temperature was 26.39°C during July. This showed that heart rate and environmental temperature were positively correlated. Highly significant ($P<0.01$) diurnal differences in heart rates were noticed between species. Similarly, highly significant ($P<0.01$) diurnal difference was also observed (Table 16 and 17).

Highly significant ($P<0.01$) correlation was observed between heart rates and environmental temperature in both sheep and goats (Table 15). The regression coefficients of heart rate on climatic variables also were significant ($P<0.01$), (Table 19). The influence of environmental temperature alone was non-significant on heart rate of sheep and goats. The monthly changes in environmental temperature as well as relative humidity and heart rate in sheep and goats are graphically presented in Fig. 6 and 7.

4.3 HEAMATOLOGICAL PARAMETERS

4.3.1 HAEMOGLOBIN

The mean monthly haemoglobin levels in sheep and goats are presented in Table 8. It ranged from 9.35±0.12 g to 12.77±0.24 g with an overall mean of 11.34±0.41 g per 100 ml of blood in sheep. The corresponding figures in the case of goats, were 9.52±0.14 g to 11.60± 0.20 g and overall mean of 10.52+0.24 g per 100 ml of blood.

Highly significant differences ($P<0.01$) between months in the haemoglobin levels of sheep and goats were observed (Table 19). Highly significant ($P<0.01$) correlation was observed between relative humidity and haemoglobin levels in both the species (0.771 for sheep and 0.766 for goat). Regression analysis (Table 24) revealed highly significant relationship ($P<0.01$) between haemoglobin levels and climatic variables in both the species. The monthly changes in haemoglobin levels of sheep and goats and climatic variables are represented graphically in Fig. 8 and 9.

4.3.2 ERYTHROCYTE SEDIMENTATION RATE

The mean monthly erythrocyte sedimentation rate(ESR) in sheep and goats are presented in Table 9. It ranged from 3.09±0.06 mm/24 hr to 3.30 ±0.08 mm/24hr in sheep. The corresponding figures were 2.07±0.10 mm/24hr to 2.29±0.07 mm/24hr in goats. The mean values were 3.18±0.03 mm/24hr in sheep and 2.16±0.03 mm/24hr in goats.

Highly significant difference ($P<0.01$) between sheep and goats were observed in ESR (Table 16). Air temperature and ESR did not have any significant correlation (Table 15) whereas relative humidity had a significantly ($P<0.01$) negative correlation with ESR in both species sheep and goats. Regression analysis (Table 20) showed a significant difference between ESR and climatic variables in sheep and goats. Monthly variation in ESR and climatic variables are presented in Fig. 10 and 11

4.3.3 SERUM POTASSIUM

Table 10 presents mean monthly figures of serum potassium levels in sheep and goats. In sheep, it ranged from 5.31±0.21 to 7.23±0.13 with a mean of 6.43±0.18 mEq/l. The corresponding ranges 5.39±0.26 to 7.57±0.23 with a mean of 6.22±0.18 mEq/l in goats. The monthly variation in serum potassium levels in sheep and goats were non- significant (Table 16).

Highly significant ($P<0.01$) negative coefficients of correlation were found between environmental temperature and serum potassium levels. However, highly significant ($P<0.01$) positive coefficient of correlation were observed between relative humidity and serum potassium levels (Table 16). The regression analysis (Table 20) showed highly significant ($P<0.01$) relationship between the serum potassium levels and the climatic variables in both species. Monthly changes in climatic variables and serum potassium levels for sheep and goats are presented in Fig. 12 and 13.

4.4 BODY WEIGHT

The mean monthly body weight of sheep and goats are presented in Table 11. The mean monthly body weight of sheep increased from 21.50±0.91 at the beginning to 24.73±0.86 kg with a mean of 23.46±0.28 kg and an overall gain of 3.23 kg during the experimental period. The figures in goats were 24.68±0.93 to 27.22±0.73 kg and 26.08±0.19 kg with a gain of 2.54 kg respectively. Decrease in body weight were recorded in both sheep and goats when the environmental temperature was highest. The analysis of variance of body weight revealed significant ($P<0.01$) difference between sheep and goats and also between months. But, the correlation's between climatic variables and body weight of sheep and goats were non-significant (Table 15). Similarly regression analysis also revealed no significant relationship between the two variables (Table 21) The monthly changes in body weight and climatic variables are presented in Fig. 14 and 15.

4.5 BODY MEASUREMENTS

4.5.1 HEIGHT

The mean monthly height of sheep and goats are presented in Table 12. The average body height at withers was 68.89±0.21 cm in sheep and 65.29±0.32 cm in goats. Analysis of variance revealed that significant difference ($P<0.01$) existed between sheep and goats and also between months. Regression analysis (Table 21) showed that there were no significant relationship between height and environmental variables.

4.5.2 GIRTH

The mean monthly body girth measurements of sheep and goats are presented in Table 13. The table revealed significant difference ($P<0.01$) between sheep and goats. There were no significant differences due to months. The mean girth recorded were 70.18±0.11 cm in sheep and 67.61±0.19 cm in goats. There were no significant relationship between climatic variables and girth values (Table 18). Similarly, the regression analysis (Table 21) of girth on climatic variables was also non-significant.

4.5.3 LENGTH

The mean monthly body length measurements of both sheep and goats are presented in Table 14. There was a significant difference ($P<0.01$) between the values of sheep and goats as well as between months. The mean body length of sheep was 61.72±0.19 cm and in goats, 63.51±0.28 cm. The coefficient of correlation revealed non-significant relationship between climatic variables and body length in both the species. The regression coefficients were also not significant at 5 per cent level.

4.6 SEASONAL VARIATIONS

4.6.1.1 CLIMATIC VARIABLES

The seasonal changes in ambient temperature, relative humidity, wind velocity sunshine and rainfall are presented in Table 22. Mean ambient temperature recorded was highest during hot and dry season (30.08°C) and lowest during cold and wet (26.16±0.26°C) But, the relative humidity was lowest during hot and dry (67.07±1.33%) and highest during cold and wet season 86.86±0.89%. Warm and dry season showed maximum wind velocity (6.34±0.82 km/hr) and it was minimum during cold and wet season (2.79 ±0.19 km/hr). Hours of bright sunshine were maximum during hot and dry season (9.50+0.19 hrs) and cold and wet lowest during cold and wet 3.41±0.54 hrs. The highest rainfall occurred during cold and wet season (24.50±3.41 mm), while the lowest during hot and dry season (0.85±0.62 mm).

4.6.2 PHYSIOLOGICAL NORMS

4.6.2.1 RECTAL TEMPERATURE

The seasonal mean morning and evening rectal temperatures of sheep and goats are presented in Table 23. The morning and evening rectal temperatures were highest during hot and dry season and lowest during cold and wet season. The morning and evening rectal temperatures of sheep and goats were also high during hot and dry season and low during cold and wet season. The highest ambient temperature was registered during hot and dry season and lowest during cold and wet season.

Highly significant differences ($P<0.01$) were observed in rectal temperature of sheep and goats between the seasons (Table 25). Coefficient of correlation between ambient temperature and rectal temperature was significant ($P<0.05$) during cold and wet season. The correlation between relative humidity and rectal temperature of sheep was significant ($P<0.05$) and negative during hot and dry season, whereas, the ambient temperature showed highly significant ($P<0.01$) influence on rectal temperature during warm and wet season but influence of relative humidity was non-significant. Highly significant ($P<0.01$) negative correlation was noticed between relative humidity and rectal temperature during cold and wet and warm and wet seasons. However no significant correlation between rectal temperature could be observed during these seasons.

Highly significant ($P<0.01$) relationships between climatic variables and rectal temperature were observed during hot and dry season. The results of regression analysis of rectal temperature on ambient temperature and relative humidity are presented in Tables 26 and 27 respectively. The seasonal changes in rectal temperature and climatic variables for sheep and goats are presented in Fig. 16 and 17.

4.6.2.2 RESPIRATION RATE

Seasonal changes in mean morning and evening respiration rates in sheep and goats are presented in Table 23. The diurnal respiration rate in sheep were highest during hot and dry season (30.88± 0.65 in the morning and 61.29±3.16 per minute in the evening). This season also had the highest air temperature of 30.0±0.35°C. The respective values were lowest during cold and wet season i.e., 26.33±0.65 and 43.75±3.16 per minute, in which case the air temperature was lowest. Similar trend was noticed in goats, wherein the corresponding values were 31.16 ±0.58 in the morning and 75.03±3.25 per minute in the evening hours, during hot and dry season and 26.39±0.58 and 45.51±3.25 per minute respectively, during cold and wet seasons. Highly significant ($P<0.01$) variations were noticed between all seasons.

Significant relationships (P<0.01) were observed between air temperature and respiration rate in both sheep and goats, during warm and wet and hot and dry seasons. The relative humidity showed highly significant (P<0.01) effect on respiration rate during warm and wet season. It was negatively significant at 5 per cent level during hot and dry season.

The regression analysis of seasonal variation in respiration rate on climatic variables are presented in Tables 26 and 27. Seasonal changes in respiration rate of sheep and goats and climatic variables are presented in Fig. 18 and 19.

4.6.2.3 HEART RATE

The seasonal variations on morning and evening heart rate of sheep and goats are presented in Table 23. Highly significant (P<0.01) difference was noticed between rainy and dry seasons as well as among cold and wet, warm and wet, warm and dry and hot and dry seasons. The highest heart rate was noticed in sheep and goats during hot and dry season. The lowest heart rates were observed during cold and wet season.

Highly significant (P<0.01) negative correlation was noticed between relative humidity and heart rate in both sheep and goats during warm and dry season. Regression analysis of heart rate on climatic variables are shown in Tables 26 and 27. The seasonal changes between heart rate of sheep and goats and climatic variables are presented in Fig. 20 and 21.

4.6.3 HAEMATOLOGICAL PARAMETERS

4.6.1 HAEMOGLOBIN

The seasonal changes in mean haemoglobin levels in sheep and goats are presented in Table 24. Highly significant seasonal differences ($P<0.01$) were observed in both sheep and goats. The lowest haemoglobin level in blood was observed during hot and dry seasons (9.77±0.16 g/100 ml blood in sheep 9.57±0.15 g/100 ml blood in goat), the highest during cold and wet season (12.53+0.16 g/100 ml in sheep and 11.23+0.15 g/100 ml blood in goat). Highly significant ($P<0.01$) negative correlation was observed between air temperature and haemoglobin during warm and wet season in sheep and goats and was no significant in other seasons. The relative humidity showed non-significant seasonal influence in both sheep and goats. Regression analysis of haemoglobin on climatic variables are presented in Table 26 and 27. The seasonal variations in haemoglobin of sheep and goats and climatic variables are represented in Fig. 22 and 23.

4.6.3.2 ERYTHROCYTE SEDIMENTATION RATE (ESR)

The seasonal variations in the mean ESR in sheep and goats are presented in Table 24. The ESR was comparatively higher during dry season when compared to rainy season in sheep. Highly significant ($P<0.01$) differences were observed between the seasons in them. But significant seasonal difference was evident in goats. In both sheep and goats highly significant ($P<0.01$) negative correlation's were observed between ambient temperature and ESR during the hot-dry season while such highly significant negative correlation between the variables existed only in the case of goats during the cold and wet season. In all other seasons the relationships were not significant at five per cent level.

Correlation analysis showed a highly significant ($P<0.01$) positive relationship between relative humidity and ESR during the cold -wet season in sheep and a significant ($P<0.05$) positive relationship in the goats. On the contrary a highly significant ($P<0.01$) negative correlation was observed between the two variables during the hot-dry season. In all other cases correlation coefficients were not significant ($P<0.05$).

The regression analysis of ESR on climatic variables are presented in Table 26 and 27 and the seasonal changes in ESR of sheep and goats and climatic variables are presented in Fig. 24 and 25.

4.6.3.3 SERUM POTASSIUM

The seasonal changes in mean serum potassium levels in sheep and goats are presented in Table 24. The serum potassium levels were lowest during hot dry season (5.99+0.14 mEq/l in sheep and 5.54+0.13 mEq/l in goats). The values were highest in cold and wet season (6.95+0.14 mEq/l in sheep and 7.08+0.13 mEq/l in goats). Highly significant difference ($P<0.01$) was noticed in sheep and goats between and among all the seasons.

Highly significant ($P<0.01$) negative correlation was observed between environmental temperature and serum potassium levels during warm and dry and cold and wet ($P<0.05$) seasons, in sheep. Whereas, in goat, the environmental temperature had a significant ($P<0.05$) difference only during warm and dry session. Correlation between relative humidity and serum potassium levels in goat during all the seasons were non-significant.

The results of regression analysis of serum potassium levels in sheep and goats are presented in Table 26 and 27. The seasonal changes in serum potassium levels in both sheep and goats and climatic variables are represented in Fig. 26 and 27.

4.6.4 BODY WEIGHT

Seasonal influence on body weight in sheep and goats are presented in Table 24. It showed no significant difference in sheep and goats between the seasons. Significant ($P<0.05$) correlation was noticed between body weight and air temperature only during cold and wet season in sheep. Highly significantly ($P<0.01$) negative correlation was observed between body weight and relative humidity during warm and wet, and hot and dry seasons and in others it was non-significant. In goat, highly significant ($P<0.01$) negative correlation was found between body weight and relative humidity during hot and dry season only.

The seasonal variations body weight in the both the species is presented graphically in Fig. 28 and 29.

Table 1 Climatic variables recorded outside the shed from August 1997 to July 1998

Variable	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Mean
1. Max.temp.(°C)	28.93± 0.29	30.58± 0.23	32.14± 0.19	31.63± 0.18	31.70± 0.18	32.99± 0.29	34.50± 0.18	36.18± 0.22	36.57± 0.24	34.19± 0.29	30.17± 0.42	29.16± 0.21	32.40± 0.71
2. Min.temp.(°C)	22.79± 0.17	23.35± 0.17	23.63± 019	23.24± 0.14	23.77± 0.16	23.59± 0.25	23.57± 0.25	23.58± 0.18	25.62± 0.25	25.19± 0.24	23.31± 0.19	23.61± 0.61	*23.77±* 0.22
Mean (°C)	25.86	26.97	27.89	27.43	27.74	28.29	29.04	29.88	31.10	29.69	26.74	26.39	
3. Rel.humidity 0800Hrs.(Rh.%)	95.16± 0.48	92.77± 0.60	87.77± 0.95	88.33± 1.12	82.84± 1.17	78.48± 1.50	83.04± 1.93	83.39± 2.82	86.20± 1.01	89.65± 0.86	93.57± 0.73	95.81± 0.28	88.08± 1.53
4. Rel.humidity1400Hrs.(Rh.%)	78.16± 1.50	71.57± 1.58	65.39± 1.98	67.37± 1.34	60.84± 1.35	48.87± 0.93	51.61± 1.59	47.03± 1.89	49.77± 1.77	62.94± 1.59	79.10± 1.89	80.35± 1.47	63.58± 3.38
Mean (%)	86.66	82.17	76.58	77.85	71.84	63.68	67.33	65.21	67.99	76.30	86.34	88.08	
5. Wind velocity (Km/h in 24h)	2.86± 0.21	2.57± 0.14	2.59± 0.24	3.02± 0.47	6.03± 1.05	6.63± 0.60	5.22± 0.67	3.41± 0.20	3.06± 0.13	2.54± 0.12	2.65± 0.20	2.76± 0.22	3.61± 0.41
6. Sunshine (hrs.)	4.08± 0.85	6.81± 0.54	7.31± 0.48	6.71± 0.52	7.54± 0.49	9.32± 0.28	9.62± 0.23	10.01± 0.14	8.98± 0.20	7.60± 0.52	3.44± 0.60	3.27± 0.49	7.06± 0.65
7. Rainfall (mm)	20.55± 5.40	5.47± 1.64	6.28± 2.27	7.04± 2.92	2.15± 1.56	--	--	0.36± 0.35	2.05± 1.15	6.55± 3.35	28.96± 4.91	24.26± 4.30	8.64± 2.80

Fig. 1 MONTHLY CHANGES IN AMBIENT TEMPERATURE AND RELATIVE HUMIDITY RECORDED OUTSIDE THE SHED

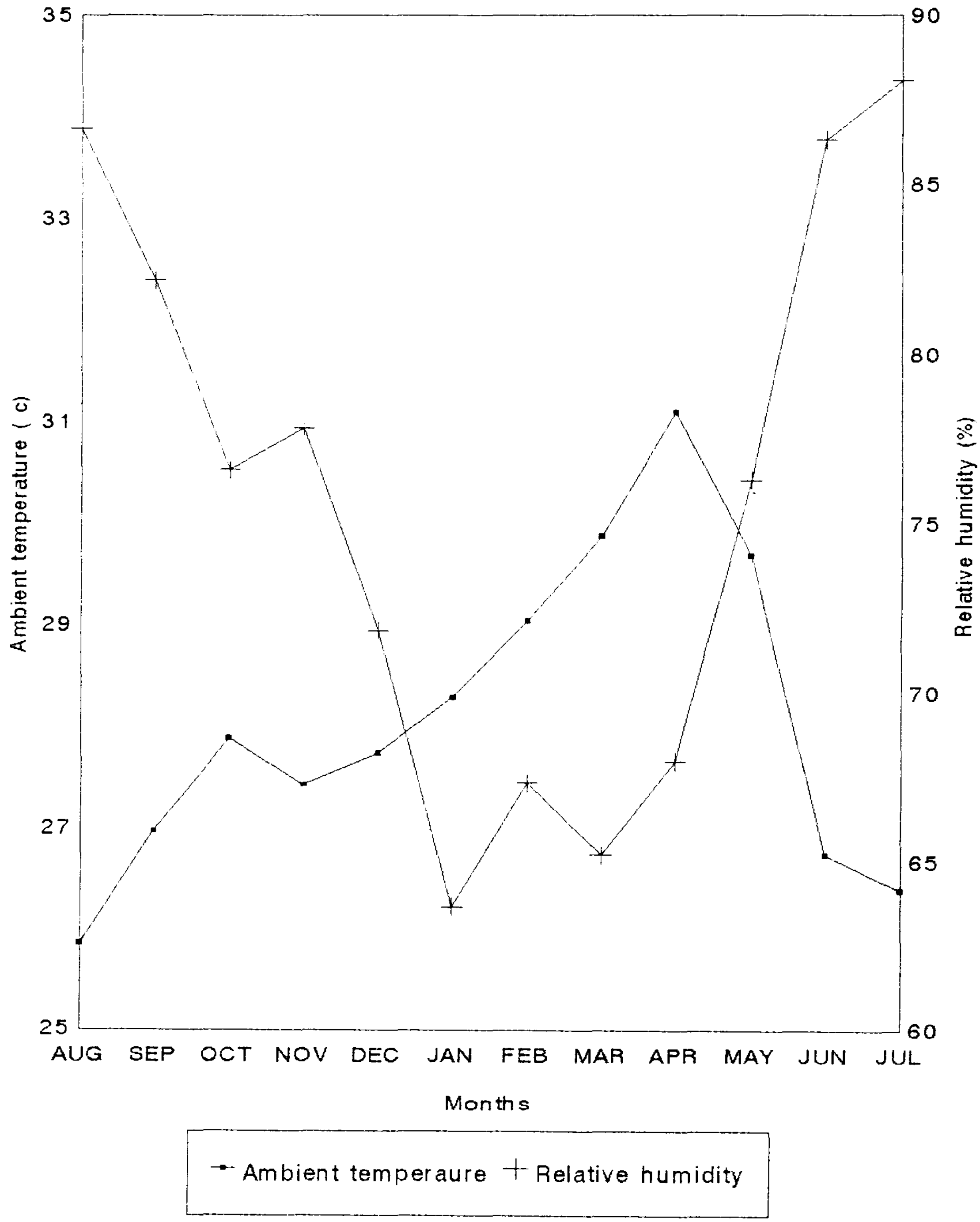

Table 2 Mean monthly morning and evening rectal temperature (°C) in sheep

Periods	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Mean
Morning	38.64± 0.05	38.74± 0.05	38.76± 0.03	38.75± 0.03	38.81± 0.04	38.84± 0.02	38.84± 0.05	38.88± 0.02	38.98± 0.01	38.82± 0.03	38.75± 0.03	38.54± 0.04	38.78± 0.03
Evening	39.45± 0.89	39.50± 0.03	39.54± 0.03	39.68± 0.06	39.65± 0.08	39.81± 0.05	39.74± 0.02	39.77± 0.04	39.86± 0.03	39.94± 0.02	39.86± 0.11	39.48± 0.03	39.69± 0.05
Monthly means	39.05	39.12	39.15	39.22	39.23	39.33	39.29	39.33	39.42	39.38	39.31	39.01	39.24

Table 3 Mean monthly morning and evening rectal temperature (°C) in goats

Periods	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Mean
Morning	38.53± 0.06	38.64± 0.10	38.53± 0.09	38.69± 0.04	38.75± 0.05	39.02± 0.20	39.01± 0.04	39.02± 0.04	38.99± 0.04	38.76± 0.07	38.50± 0.02	38.44± 0.03	38.74± 0.06
Evening	39.43± 0.06	39.53± 0.04	39.61± 0.08	39.72± 0.07	39.75± 0.06	39.83± 0.05	39.96± 0.06	40.09± 0.07	39.98± 0.08	39.73± 0.07	39.34± 0.04	39.32± 0.02	39.69± 0.07
Monthly means	38.98	39.09	39.07	39.21	39.25	39.43	39.48	39.56	39.49	39.25	38.92	38.88	39.22

Fig. 2 MONTHLY CHANGES IN AMBIENT TEMPERATURE AND RECTAL TEMPERATURE - SHEEP AND GOATS

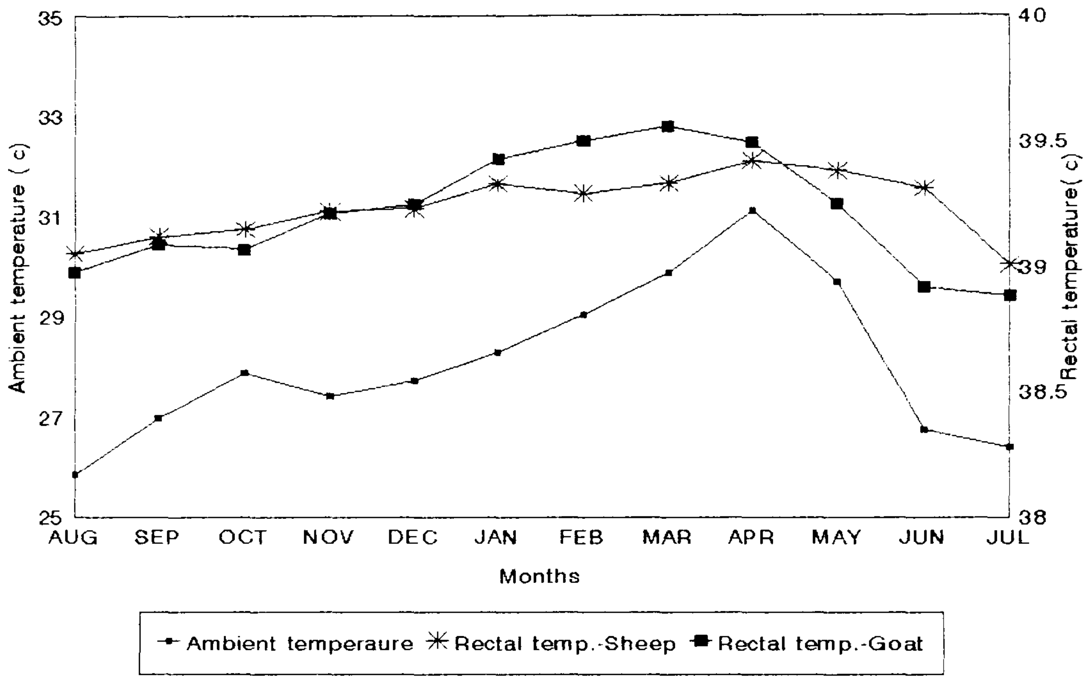

Fig. 3 MONTHLY CHANGES IN RELATIVE HUMIDITY AND RECTAL TEMPERATURE - SHEEP AND GOATS

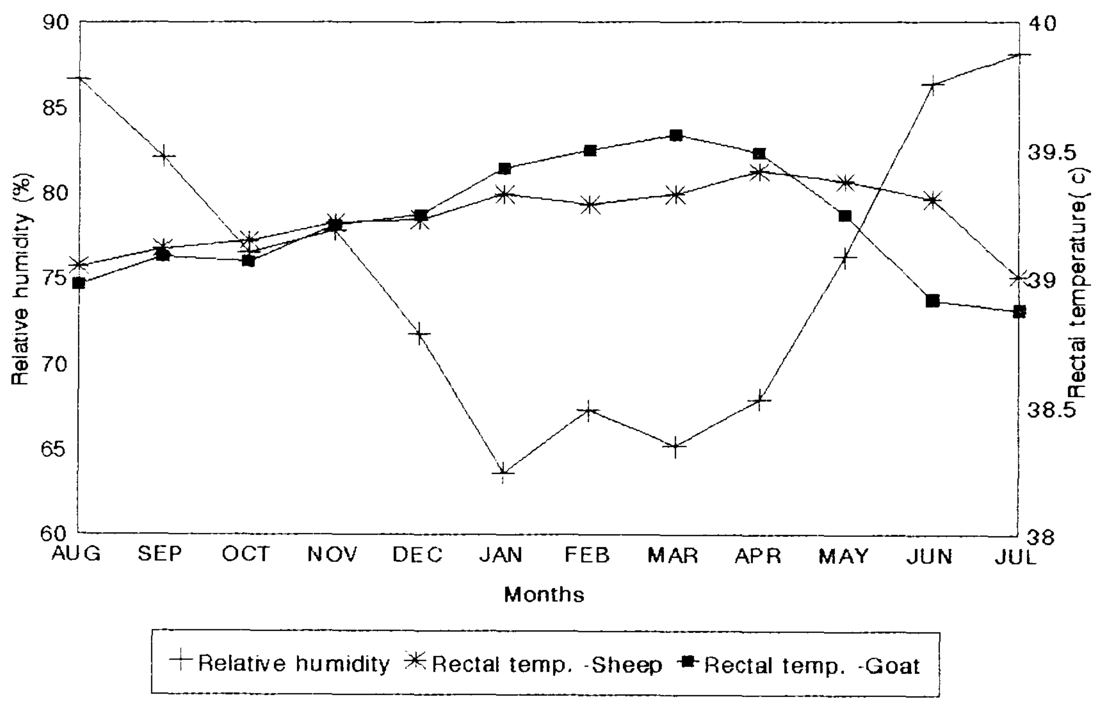

Table 4 Mean monthly morning and evening respiration rates (no./min) in sheep

Periods	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Mean
Morning	26.93± 0.62	24.21± 0.51	25.76± 0.31	26.20± 0.30	29.45± 0.45	28.41± 0.41	30.58± 0.86	30.42± 0.63	31.49± 0.65	32.36± 1.22	27.19± 0.53	24.71± 0.56	28.14± 0.75
Evening	34.25± 0.81	36.05± 0.26	36.59± 0.44	38.49± 0.40	44.05± 1.73	49.89± 2.47	56.32± 1.20	60.32± 0.34	66.17± 1.13	73.46± 1.60	58.36± 3.32	41.02± 1.16	49.59± 3.63
Monthly means	30.59	30.13	31.18	32.35	36.75	39.15	43.45	45.37	48.83	52.91	42.78	38.87	38.87

Table 5 Mean monthly morning and evening respiration rate (no./min) in goats

Periods	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Mean
Morning	26.08± 1.01	25.05± 0.41	26.59± 0.18	27.21± 0.47	29.69± 1.21	29.48± 0.41	29.81± 0.66	31.59± 0.65	31.89± 0.47	31.52± 0.34	28.27± 0.18	24.67± 0.41	28.14± 0.71
Evening	35.84± 0.55	36.75± 0.58	36.36± 0.82	38.49± 0.40	43.69± 1.57	54.79± 3.12	67.29± 1.27	76.85± 1.72	79.76± 1.29	73.63± 1.69	60.64± 1.78	42.49± 1.02	53.88± 4.72
Monthly means	30.96	30.90	31.48	32.85	36.69	42.14	48.55	54.22	55.83	52.58	44.58	33.58	41.o1

Fig. 4 MONTHLY CHANGES IN AMBIENT TEMPERATURE AND RESPIRATION RATE - SHEEP AND GOATS

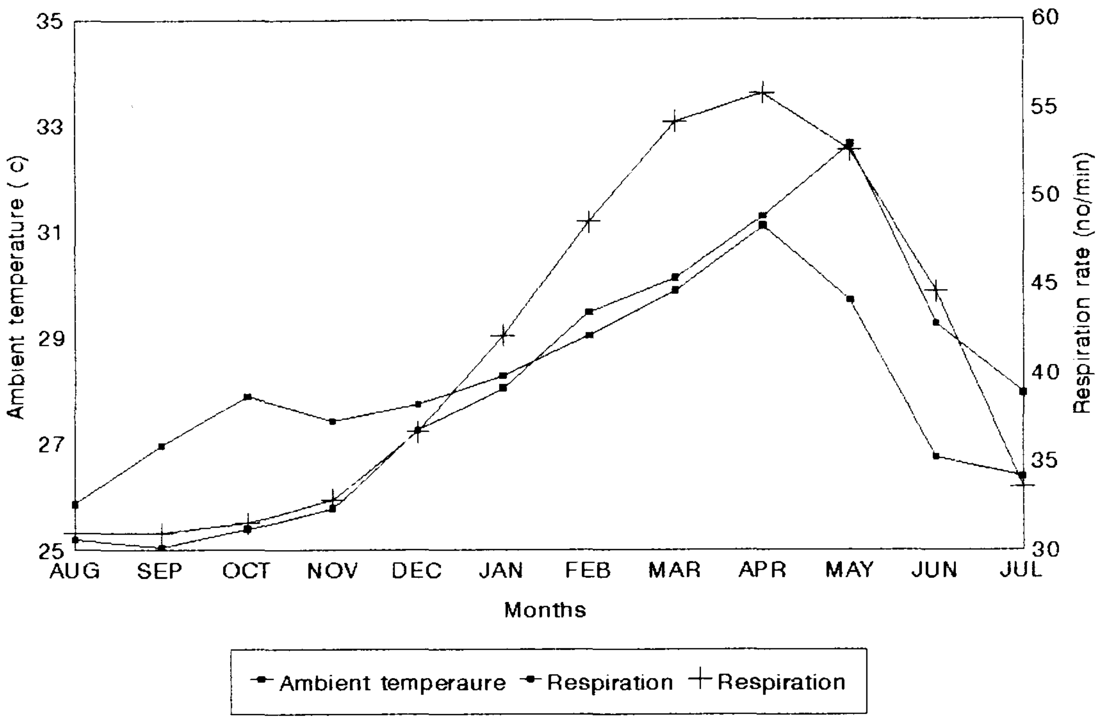

Fig. 5 MONTHLY CHANGES IN RELATIVE HUMIDITY AND RESPIRATION RATE - SHEEP AND GOATS

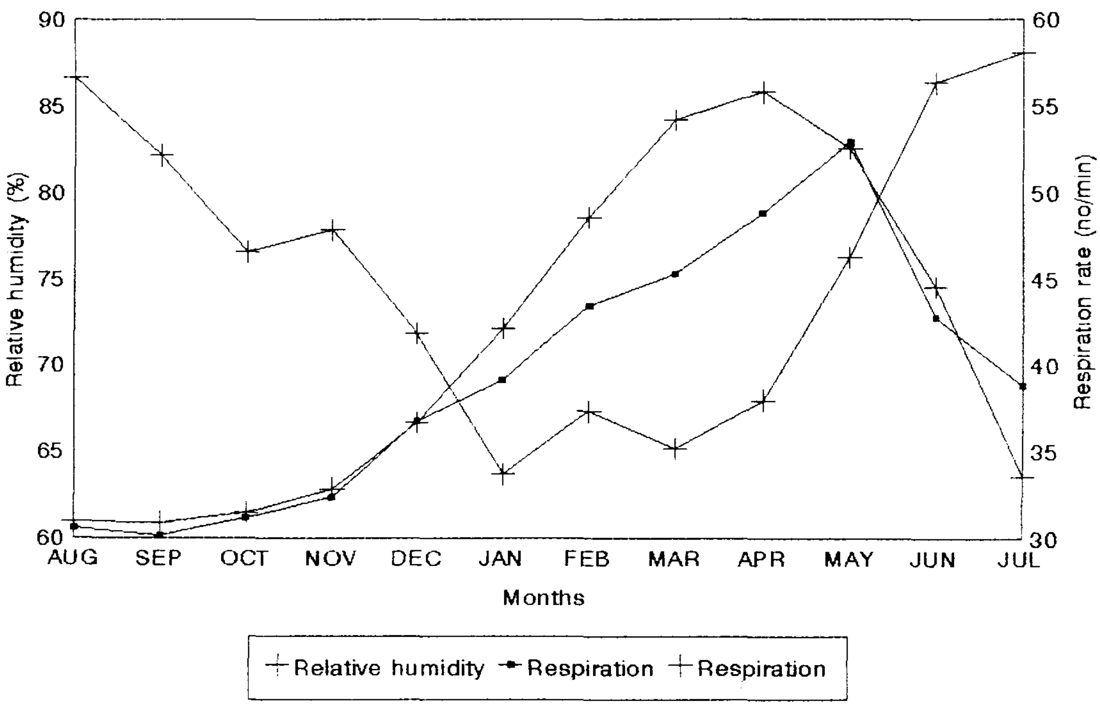

Table 6 Mean monthly morning and evening Hearts rate (beat / min) in sheep

Periods	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Mean
Morning	69.39± 0.89	64.79± 0.83	65.04± 0.82	64.51± 0.84	68.25± 0.70	66.16± 0.76	68.23± 0.52	67.75± 0.80	69.37± 1.23	67.68± 0.55	65.06± 0.62	62.19± 0.73	66.54± 0.62
Evening	84.15± 0.40	84.01± 0.74	83.74± 1.07	84.81± 0.93	87.71± 1.20	91.50± 1.37	93.73± 1.02	95.65± 1.32	96.20± 0.88	92.12± 1.44	80.95± 1.06	78.07± 0.48	87.72± 1.66
Monthly means	76.77	74.40	74.39	74.66	77.98	78.83	80.98	81.70	82.79	79.90	73.01	70.13	77.13

Table 7 Mean monthly morning and evening Heart rate (beat / min) in Goats

Periods	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Mean
Morning	69.27± 1.05	69.09± 1.95	74.04± 1.00	75.47± 1.19	76.61± 1.52	77.95± 0.75	79.61± 0.38	79.08± 0.82	77.80± 1.13	73.35± 1.42	67.40± 1.20	63.65± 0.43	73.61± 1.43
Evening	86.63± 0.90	87.87± 0.67	90.70± 0.48	96.59± 0.78	99.33± 1.18	101.72± 0.67	101.24± 1.27	103.25± 0.96	101.36± 1.67	95.79± 1.29	86.77± 1.93	81.64± 0.43	94.38± 2.03
Monthly means	77.95	78.48	82.37	86.03	87.79	89.84	90.43	91.17	89.58	84.57	81.60	72.65	84.00

Fig. 6 MONTHLY CHANGES IN AMBIENT TEMPERATURE AND HEART RATE - SHEEP AND GOATS

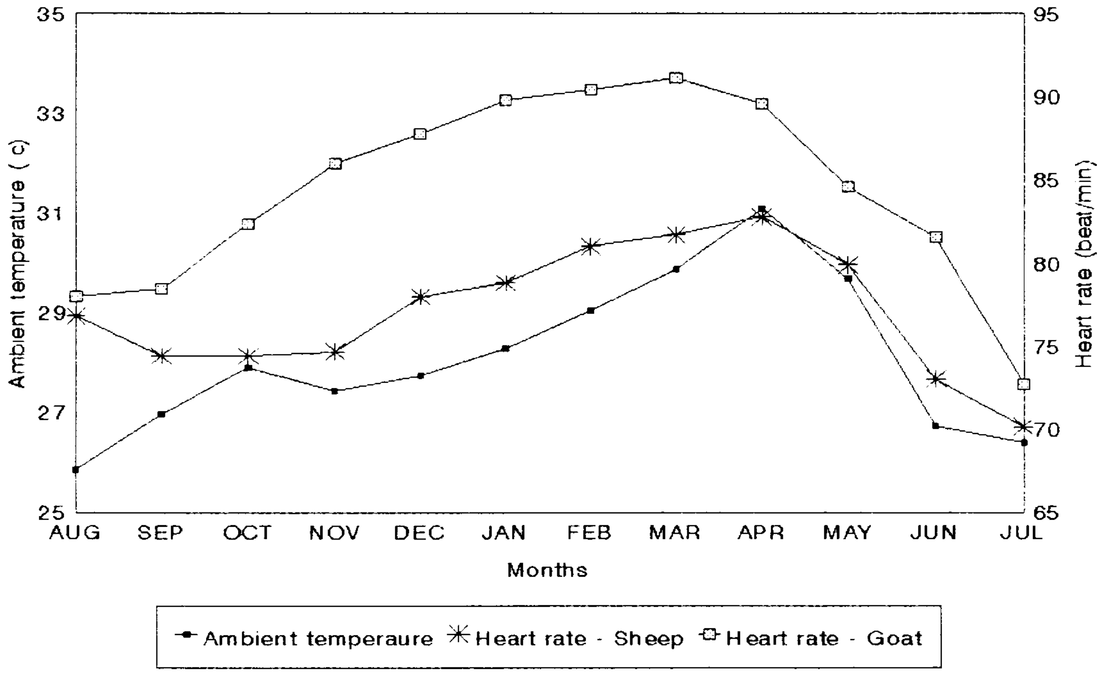

Fig. 7 MONTHLY CHANGES IN RELATIVE HUMIDITY AND HEART RATE - SHEEP AND GOATS

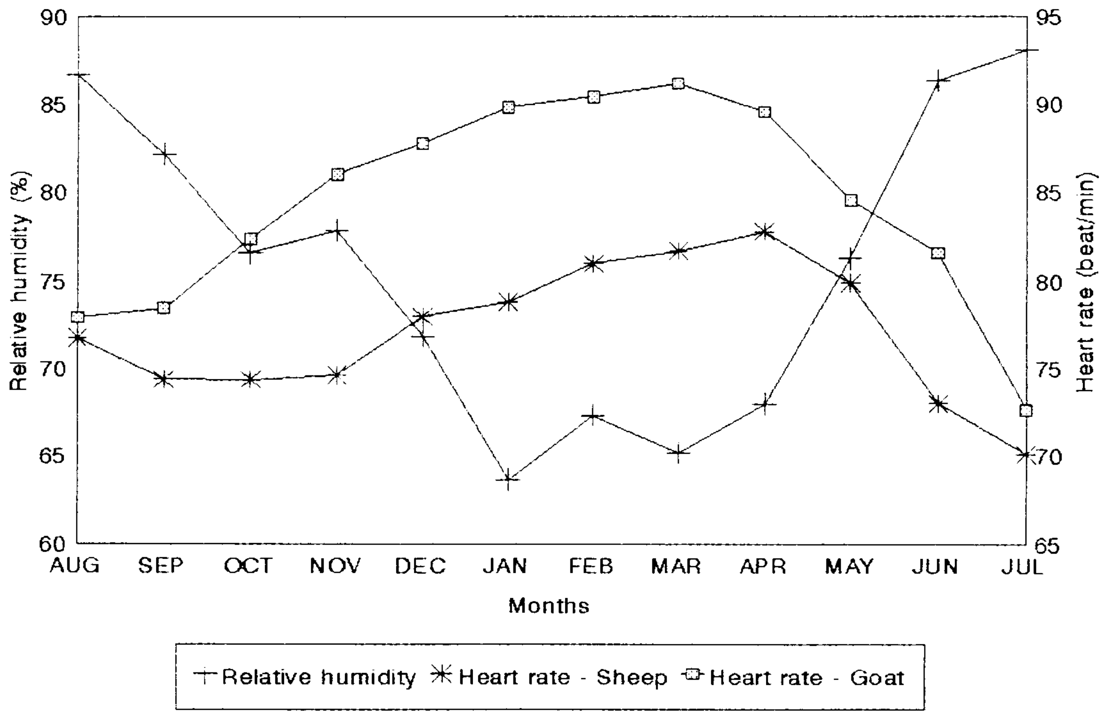

Table 8 Mean monthly haemoglobin values (g / 100 ml) of sheep and goats

Species	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Mean
Sheep	13.28± 0.23	11.63± 0.22	12.77± 0.24	13.59± 0.22	11.37± 0.26	9.99± 0.10	9.92± 0.09	9.53± 0.16	9.35± 0.12	10.35± 0.16	12.23± 0.17	12.09± 0.20	11.34± 0.41
Goats	11.03± 0.37	10.67± 0.28	10.67± 0.26	12.27± 0.29	10.23± 0.30	9.87± 0.14	9.60± 0.13	9.58± 0.16	9.52± 0.14	10.07± 0.12	11.07± 0.17	11.6± 0.20	10.52± 0.24

Table 9 Mean monthly Erythrocyte sedimentation rate (ESR) (mm/24h) of sheep and goats

Species	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Mean
Sheep	3.10± 0.08	3.09± 0.06	3.12± 0.06	3.25± 0.09	3.27± 0.07	3.39± 0.08	3.30± 0.05	3.26± 0.05	3.15± 0.07	3.10± 0.05	3.04± 0.04	3.17± 0.04	3.18± 0.03
Goats	2.29± 0.10	2.13± 0.07	2.19± 0.09	2.11± 0.07	2.21± 0.10	2.24± 0.09	2.29± 0.07	2.17± 0.05	2.27± 0.10	2.07± 0.09	2.07± 0.08	2.17± 0.05	2.17± 0.02

Fig. 8 MONTHLY CHANGES IN AMBIENT TEMPEARATURE AND HAEMOGLOBIN - SHEEP AND GOATS

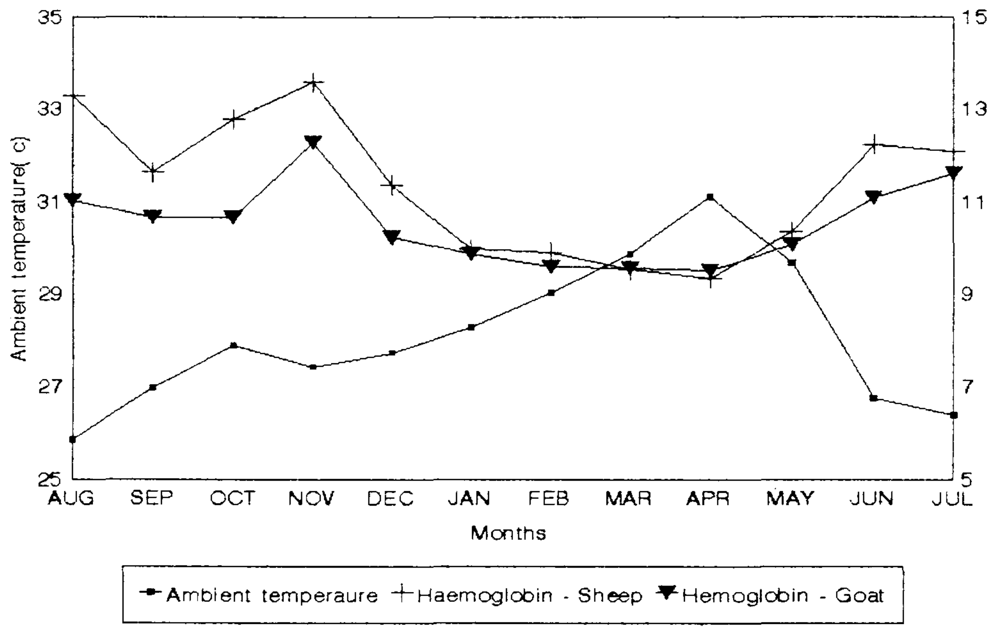

Fig. 9 MONTHLY CHANGES IN RELATIVE HUMIDITY AND HAEMOGLOBIN - SHEEP AND GOATS

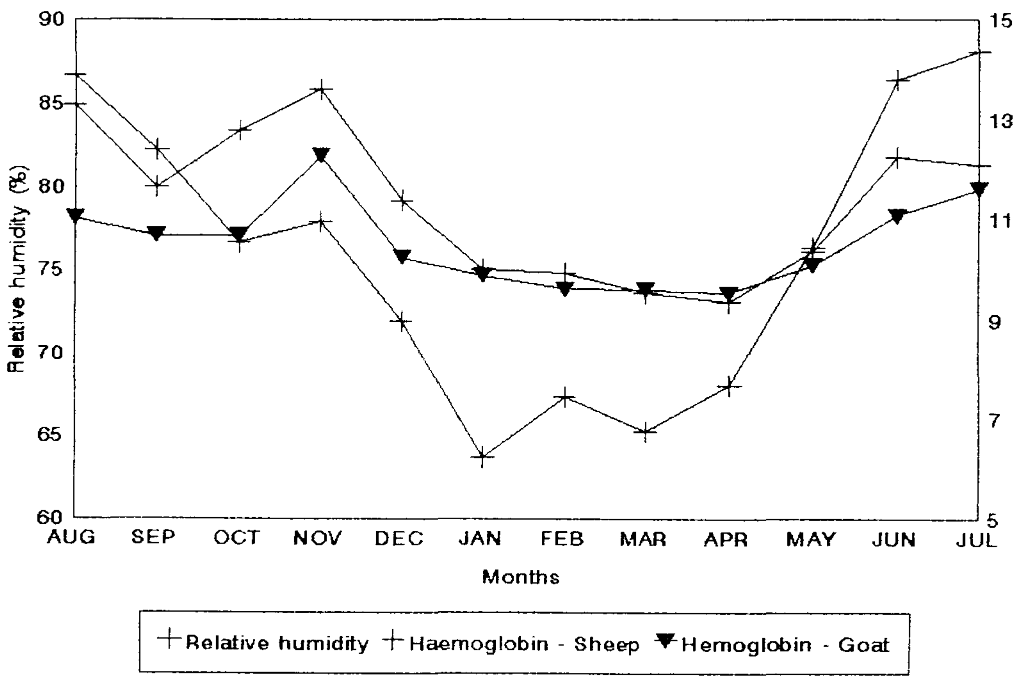

Fig. 10 MONTHLY CHANGES IN AMBIENT TEMPERATURE AND ERYTHROCYTE SEDIMENTATION RATE - SHEEP AND GOATS

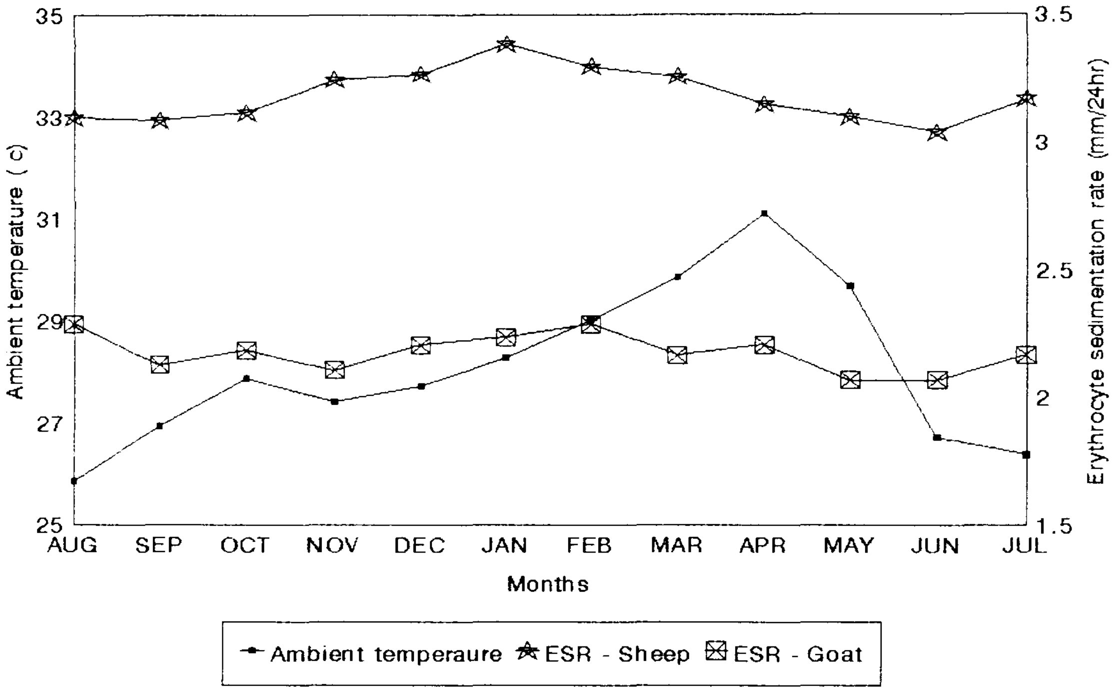

Fig. 11 MONTHLY CHANGES IN RELATIVE HUMIDITY AND ERYTHROCYTE SEDIMENTATION RATE - SHEEP AND GOATS

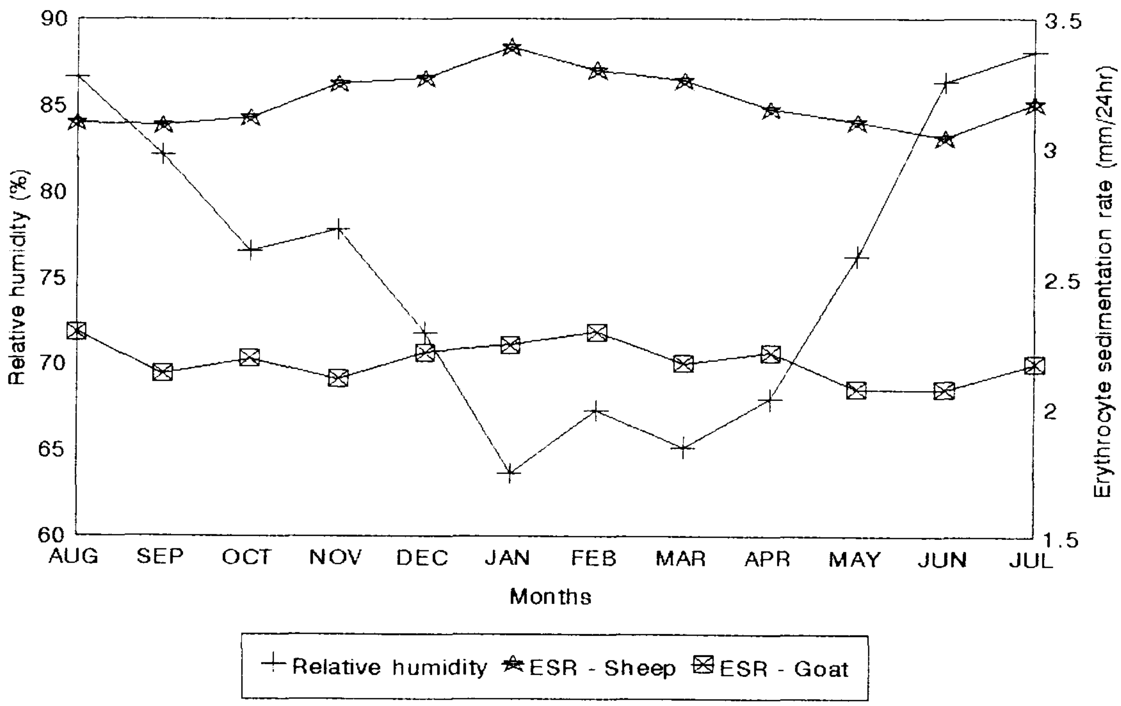

Table 10 Mean monthly serum pottassium levels (mEq/l) of sheep and goats

Species	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Mean
Sheep	6.95± 0.16	6.86± 0.31	7.24± 0.26	6.14± 0.16	6.74± 0.34	6.00± 0.17	6.36± 0.18	6.31± 0.16	5.31± 0.21	5.40± 0.14	6.67± 0.13	7.23± 0.13	6.43± 0.18
Goats	7.57± 0.23	6.54± 0.30	6.55± 0.27	6.11± 0.21	5.82± 0.14	5.61± 0.21	5.39± 0.26	5.51± 0.21	5.73± 0.23	6.25± 0.17	6.80± 0.19	6.74± 0.23	6.22± 0.18

Table 11 Mean monthly body weight (kg) of sheep and goats

Species	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Mean
Sheep	21.50± 0.91	21.68± 0.81	22.69± 0.68	23.37± 0.66	23.65± 0.79	23.37± 0.92	24.07± 0.90	24.10± 0.92	23.83± 0.87	24.11± 0.85	24.47± 0.82	24.73± 0.86	23.46± 0.28
Goats	24.68± 0.93	25.38± 0.72	25.57± 0.96	26.05 1.03	26.35± 0.90	26.05± 0.75	26.03± 0.72	26.05± 0.72	26.01± 0.71	26.31± 0.70	27.21± 0.67	27.22± 0.73	26.08± 0.19

ANOVA : Between months F - values = 3.883** Between species F - values = 112.053**

** Significant at one per cent level

Fig. 12 MONTHLY CHANGES IN AMBIENT TEMPERATURE AND SERUM POTASSIUM LEVEL - SHEEP AND GOATS

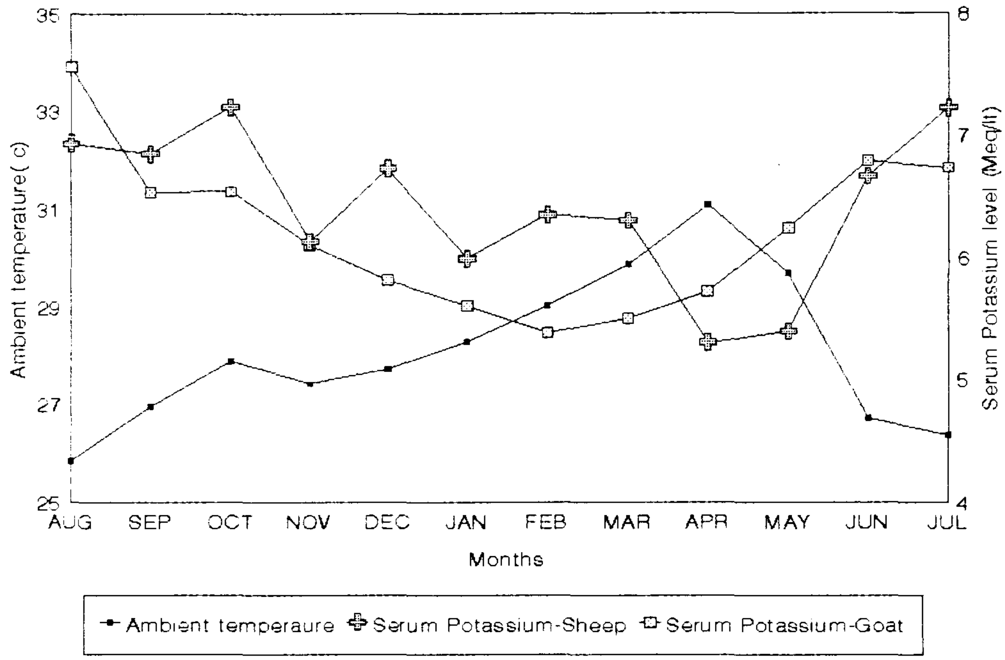

Fig. 13 MONTHLY CHANGES IN RELATIVE HUMIDITY AND SERUM POTASSIUM LEVEL - SHEEP AND GOATS

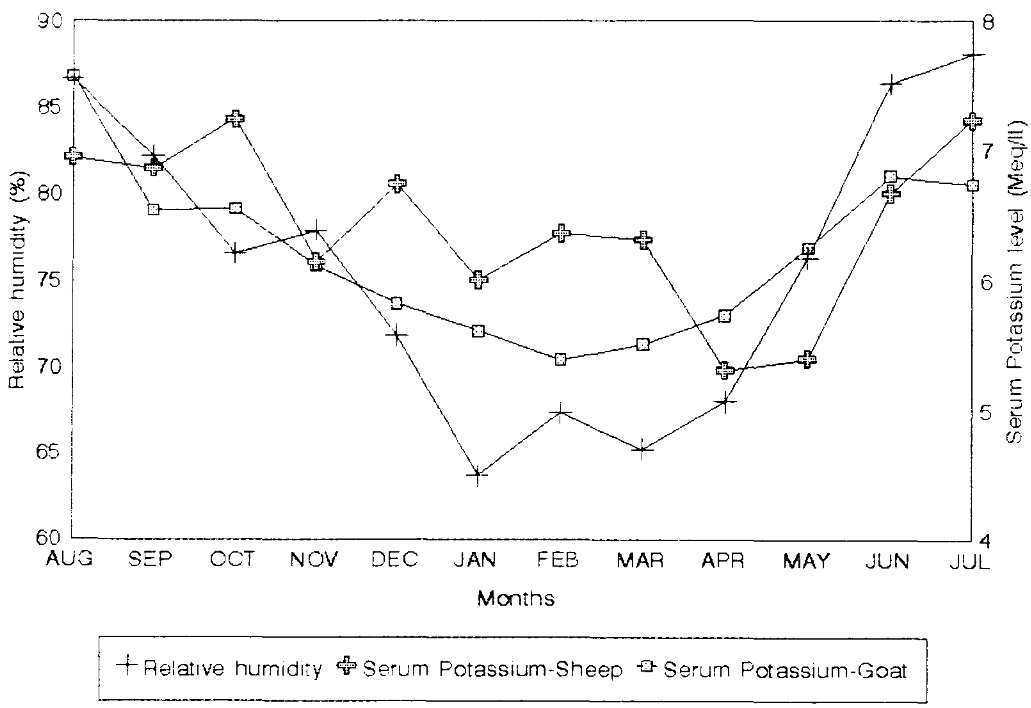

Fig. 14 MONTHLY CHANGES IN AMBIENT TEMPERATURE AND BODY WEIGHT - SHEEP AND GOATS

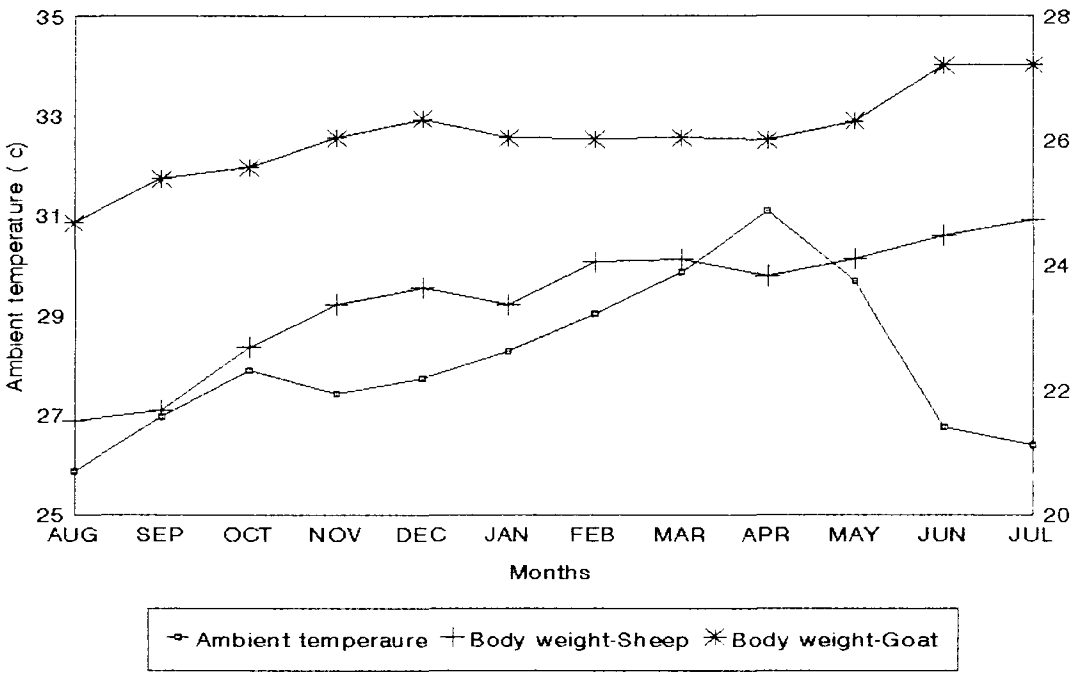

Fig. 15 MONTHLY CHANGES IN RELATIVE HUMIDITY AND BODY WEIGHT - SHEEP AND GOATS

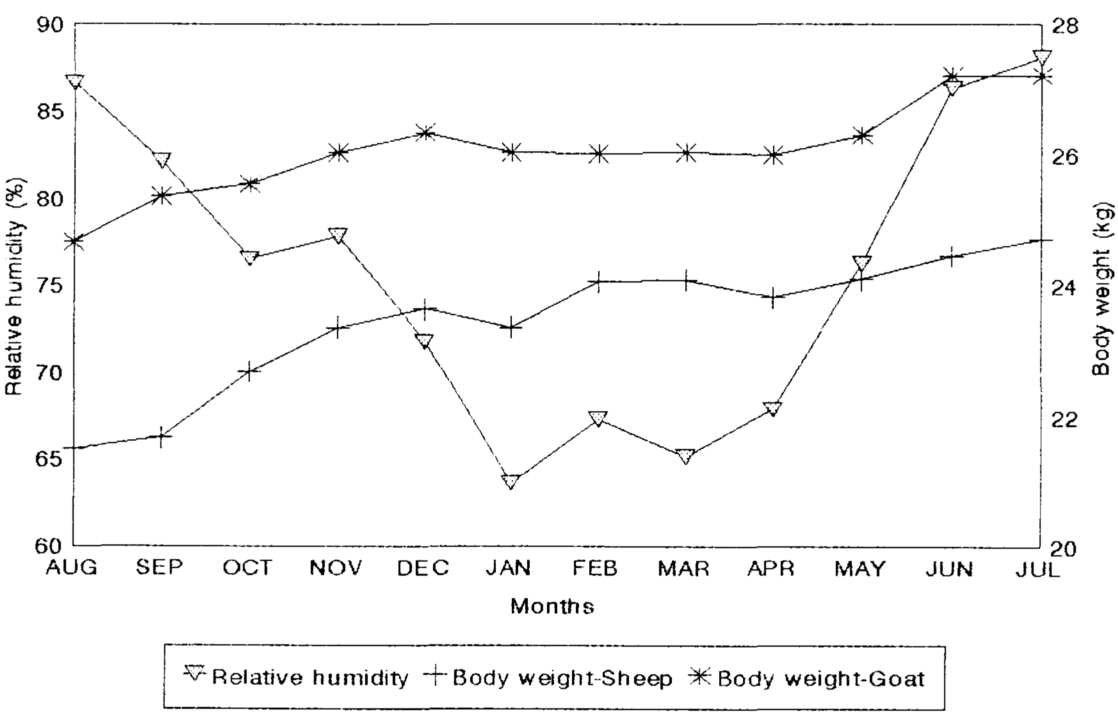

Table 12 Mean monthly body height (cm) of sheep and goats

Species	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Mean
Sheep	67.66± 0.71	68.09± 0.67	68.09± 0.67	68.51± 0.60	68.34± 0.68	68.96± 0.67	69.13± 0.64	69.45± 0.71	69.19± 0.67	69.37± 0.65	67.72± 0.67	70.13± 0.70	68.89± 0.21
Goats	63.77± 0.44	63.87± 0.45	64.31± 0.39	64.78± 0.35	64.75± 0.42	64.68± 0.46	65.25± 0.36	65.49± 0.43	66.12± 0.41	66.25± 0.37	66.92± 0.43	67.25± 0.36	65.29± 0.32

ANOVA : Between months F - values = 7.5382** Between species F - values = 327.037**
** Significant at one percent level ($P < 0.01$)

Table 13 Mean monthly body Girth (cm) of sheep and goats

Species	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Mean
Sheep	70.27± 0.81	69.72± 0.53	70.92± 0.51	70.03± 0.63	69.85± 0.58	70.37± 0.73	70.36± 0.61	69.59± 0.58	69.94± 0.58	70.25± 0.53	70.19± 0.51	70.63± 0.54	70.18± 0.11
Goats	66.43± 0.53	66.94± 0.42	66.77± 0.61	67.37± 0.65	67.80± 0.52	67.95± 0.29	67.84± 0.40	67.22± 0.43	67.68± 0.42	67.95± 0.44	68.45± 0.38	68.86± 0.57	67.61± 0.19

ANOVA : Between months F - values = 1.5879^{NS} Between species F - values = 180.971**

** Significant at one percent level (P < 0.01)

NS - Non-significant

Table 14 Mean monthly body length (cm) of sheep and goats

Species	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Mean
Sheep	60.70± 0.94	60.87± 0.91	60.88± 0.89	61.26± 0.85	61.64± 0.78	61.75± 0.83	61.88± 0.77	61.97± 0.86	62.00± 0.86	62.27± 0.79	62.59± 0.88	62.76± 0.85	61.72± 0.19
Goats	62.27± 0.79	62.24± 0.74	62.58± 0.65	63.05± 0.66	62.85± 0.73	62.70± 0.81	63.57± 0.88	64.58± 0.76	64.48± 0.67	64.27± 0.71	64.74± 0.68	64.77± 0.71	63.51± 0.28

ANOVA : Between months F - values = 4.368** Between species F - values = 61.178**

** Significant at one percent level (P < 0.01)

Table 15 Correlation between climatic variables and physiological norms of sheep and goats

Climatic variables	Species	Rectal temperature (oC)	Respiration rate (no./min)	Heart rate (beat/min)	Haemoglobin (91100 ml)	Erythrocyte Sedimentation rate (mm/24 hr)	Serum potassium level (Meq/L)	Body weight (Kg)
Ambient temperature (X_1)	Sheep	0.739**	0.794**	0.774**	-0.790**	0.170^{NS}	-0.726**	0.259^{NS}
	Goat	0.619**	0.749**	0.657**	-0.747**	-0.468**	-0.719**	+0.069^{NS}
Relative humidity (X_2)	Sheep	-0.703**	-0.956**	-0.822**	0.771**	-0.068^{NS}	0.570	-0.328
	Goat	-0.413**	-0.606**	-0.929**	0.766**	-0.744**	0.923**	-0.098^{NS}

* Significant at five per cent level ($P < 0.05$)

** Signficant at one per cent level ($P < 0.01$)

^{NS} Non-significant

Table 16 Average values of physiological norms of sheep and goats

Physiological norms	Periods	Mean Values		t-values
		Sheep	Goat	
Rectal temperature (°C)	Morning	38.82	38.78	2.2595*
	Evening	39.69	39.69	0.1238^{NS}
Respiration rates (no/min)	Morning	28.14	28.51	0.6591^{NS}
	Evening	49.35	53.83	1.5111^{NS}
Heart rates (beat/min)	Morning	66.61	73.70	8.3643**
	Evening	87.81	94.46	4.9589**
Haemoglobin (g/100 ml)	Monthly	11.38	10.51	5.9873
Erythrocyte sedimentation rate (mm/24hr)	Monthly	3.19	2.16	33.7137**
Serum potassium levels (mEq/l)	Monthly	6.434	6.23	1.9008^{NS}

* Significant at five per cent level (P < 0.01) ** Significant at one per cent level (P < 0.01). ^{NS} - Non-significant

Table 17 Comparative study of diurnal physiological norms of sheep and goats

Physiological norms	Species	Mean Values		t-values
		Morning	Evening	
Rectal temperature (°C)	Sheep	38.82	39.69	21.2412**
	Goat	38.72	39.69	19.4273**
Respiration rates (no/min)	Sheep	28.14	49.35	11.3824**
	Goat	28.51	53.83	10.6818**
Heart rates (beat/min)	Sheep	66.61	87.81	22.6314**
	Goat	73.70	94.46	16.2090**

* Significant at five per cent level (P < 0.01) ** Significant at one per cent level (P < 0.01). NS - Non-significant

Table 18 Comparative study of body weight and body measurements between sheep and goats

Parameters	Periods	Mean Values		t-values
		Sheep	Goat	
Body weight (Kgs)	Monthly	23.55	25.99	7.2417**
Body height (Cms)	Monthly	68.88	65.29	14.9466**
Body girth (Cms)	Monthly	70.18	67.58	11.8022**
Body length (Cms)	Monthly	61.71	63.51	5.4981**

* Significant at five per cent level ($P < 0.05$) ** Significant at one per cent level ($P < 0.01$). ^{NS} - Non-significant

Table 19 **Regression analysis of physiological norms (y) on ambient temperature (X_1) and relative humidity (X_2) - Sheep and goats**

	Rectal temperature (°C)				Respiration rate (no./min)				Heart rate (beat/min)			
	Sheep		Goat		Sheep		Goat		Sheep		Goat	
	X1	X2	X1	X2	X1	X2	X1	X2	X1	X2	X1	X2
Reg. Coefficients	0.0417	-0.005	0.035	-0.022	3.209	0.052	4.0320	-0.160	0.959	-0.245	0.044	-0.033
SE of Reg. Coef.	0.025	0.005	0.018	0.003	1.809	0.323	1.944	0.347	0.599	0.107	0.666	0.119
T- value	1.627NS	1.204	1.949	6.746	1.774	0.160	2.074	0.464	1.600	2.291	0.066	5.325
Intercept constant	38.495		39.867		55.207		-60.513		68.613		133.586	
R-value	0.781		0.969		0.621		0.756		0.864		0.929	
F-Value	7.02*		69.37**		2.82^{NS}		6.00**		13.29		28.38**	

** Significant at one per cent level (P < 0.01)
* Signficant at five per cent level (P < 0.05)
NS Non-significant

Table 20 Regression analysis of haemotological parameters (y) on ambient temperature (X_1) and relative humidity (X_2) - sheep and goats

	Haemoglobin (g/100ml)				Erythrocyte Sedimentation rate (mm/24hr)				Serum potassium (mE/l)			
	Sheep		Goat		Sheep		Goat		Sheep		Goat	
	X1	X2	X1	X2	X1	X2	X1	X2	X1	X2	X1	X2
Reg. Coefficients	-0.451	0.096	-0.228	0.047	-0.050	-0.016	-0.064	-0.009	-0.267	0.008	0.053	0.063
SE of Reg. coefficient	0.023	0.042	1.528	0.073	0.014	0.003	0.020	0.004	0.134	0.024	0.076	0.014
T-value	1.913^{NS}	1.655^{NS}	1.494	1.736^{NS}	3.628**	6.266**	3.283**	2.553	2.003^{NS}	0.326^{NS}	0.698	4.689**
Intercept constant	18.843*		13.375		5.762		4.656		13.400		2.928	
R-value	0.844		0.818		0.905		0.740		0.730		0.927	
F-Value	11.11**		9.11**		20.35**		5.43*		5.14*		27.02**	

** Significant at one per cent level ($P < 0.01$)

* Signficant at five per cent level ($P < 0.05$)

^{NS} Non-significant

Table 21 Regression analysis of body weight and body measurements (y) on ambient temperature (x1) and relative humidity (x2) - sheep and goats

	Body weight (Kg)				Height (cms)				Girth (cms)				Length (cms)			
	Sheep		Goat		Sheep		Goat		Sheep		Goat		Sheep		Goat	
	X1	X2	X1	X2	X1	X2	X1	X2	X1	X2	X1	X2	X1	X2	X1	X2
Reg. Coefficients	0.035	-0.034	-0.001	-0.008	0.138	0.012	0.274	0.054	-0.1190	-0.004	0.007	0.006	0.0887	0.009	0.376	0.046
SE of Reg. coefficient	0.298	0.053	0.201	0.036	0.226	0.040	0.334	0.060	0.105	0.019	0.213	0.038	0.204	0.036	0.290	0.052
T-value	0.117^{NS}	0.646^{NS}	0.003^{NS}	0.209^{NS}	0.612^{NS}	0.289^{NS}	0.818^{NS}	0.899^{NS}	1.141^{NS}	0.190^{NS}	0.034	0.154	0.435^{NS}	0.240^{NS}	1.298^{NS}	0.890^{NS}
Intercept constant	25.159		26.829		64.1019		53.497		73.819		66.927		58.544		49.412	
R-value	0.330		0.098		0.211		0.297		0.434		0.064		0.147		0.397	
F-Value	0.55^{NS}		0.04^{NS}		0.044^{NS}		0.44^{NS}		1.050^{NS}		0.02^{NS}		0.10^{NS}		0.84^{NS}	

** Significant at one percent level ($P < 0.01$)
* Signficant at five percent level ($P < 0.05$)
NS Non-significant

Table 22 Seasonal variation of climatological parameters

Climatological variables	Rainy Season		Dry Season	
	Cold and wet	Warm and wet	Warm and dry	Hot and dry
Ambient temperature (oC)	26.16 ± 0.24	27.86±0.28	28.03±0.26	30.08±0.35
Relative humidity (%)	86.86 ± 0.89	78.28 ± 1.02	67.61 ± 1.97	67.07 ± 1.33
Wind stroke (Km/hr)	2.79 ± 0.19	2.85 ± 0.30	6.34 ± 0.82	3.59 ± 0.32
Sunshine (Hrs.)	3.41 ± 0.54	6.97 ± 0.31	8.88 ± 0.36	9.50 ± 0.19
Rain fall (mm)	24.5 ± 3.49	6.65 ± 1.42	1.06 ± 1.06	0.85 ± 0.62

Table 23 Seasonal variation in physiological norms of sheep and goats.

Physiological norms	Species	Periods	Rainy season		Dry season		F-values	T-values
			cold & wet	warm & wet	warm & dry	Hot & dry		
Rectal temperature (°C)	Sheep	Morning	38.72±0.06	38.78±0.05	38.83±0.07	38.98±0.06	4.030*	2.8411**
		Evening	39.58±0.05	39.66±0.04	39.74±0.06	39.80±0.05	3.321*	3.0272**
	Goat	Morning	38.49±0.04	38.65±0.03	38.79±0.05	39.01±0.07	32.826**	7.3263**
		Evening	39.37±0.04	39.64±0.04	39.79±0.05	40.02±0.04	43.587**	2.3992**
Respiration rate (no / min)	Sheep	Morning	26.33±0.65	27.05±0.57	28.87±0.78	30.88±0.65	10.033**	5.2759**
		Evening	43.75±3.16	45.58±2.76	47.29±3.80	61.29±3.16	6.519**	3.4050**
	Goat	Morning	26.39±0.58	27.53±0.51	29.57±0.70	31.16±0.58	13.438**	5.7362**
		Evening	45.51±3.25	46.07±2.85	49.86±3.91	75.03±3.25	19.131**	4.7661**
Heart rate (beat/min)	Sheep	Morning	65.84±0.71	65.47±0.62	67.09±0.85	68.52±0.71	4.053*	3.2190**
		Evening	81.29±0.95	86.03±0.83	89.81±1.15	95.27±0.95	38.444**	7.6450**
	Goat	Morning	66.96±0.86	73.06±0.76	77.35±1.04	78.75±0.86	36.057**	7.8367**
		Evening	85.14±0.77	92.61±0.84	100.66±1.16	101.90±097	62.032**	10.4277**

* Significient as five per cent level (P<0.05)

** Significient at one per cent level (P<0.01)

Fig. 16. SEASONAL CHANGES IN AMBIENT TEMPERATURE AND RECTAL TEMPERATURE- SHEEP AND GOATS

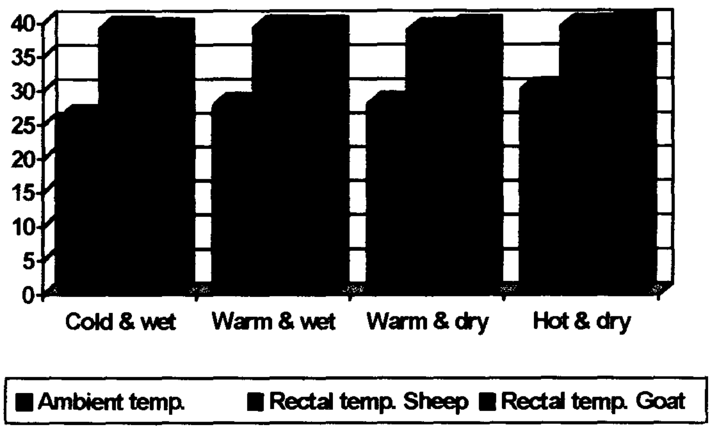

Fig. 17. SEASONAL CHANGES IN RELATIVE HUMIDITY AND RECTAL TEMPERATURE- SHEEP AND GOATS

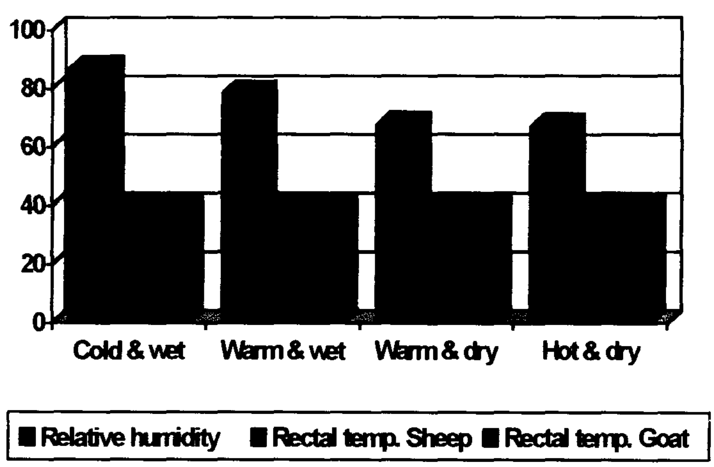

Fig. 18. SEASONAL CHANGES IN AMBIENT TEMPERATURE AND RESPIRATION RATE- SHEEP AND GOATS

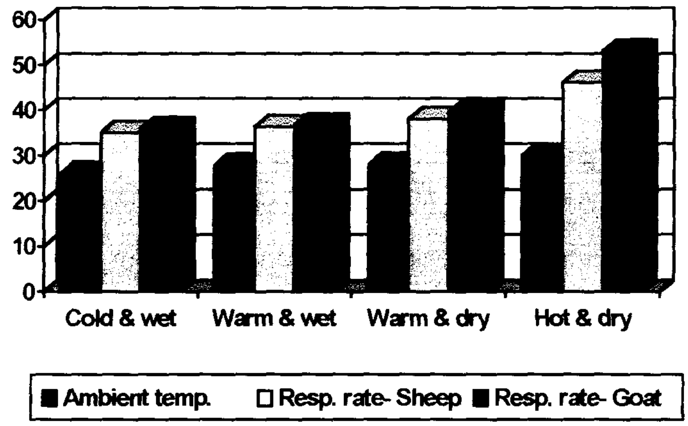

Fig. 19. SEASONAL CHANGES IN RELATIVE HUMIDITY AND RESPIRATION RATE- SHEEP AND GOATS

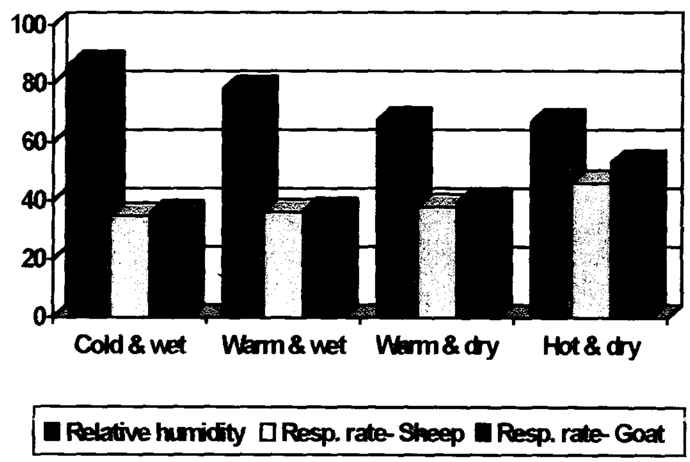

Fig. 20. SEASONAL CHANGES IN AMBIENT TEMPERATURE AND HEART RATE- SHEEP AND GOATS

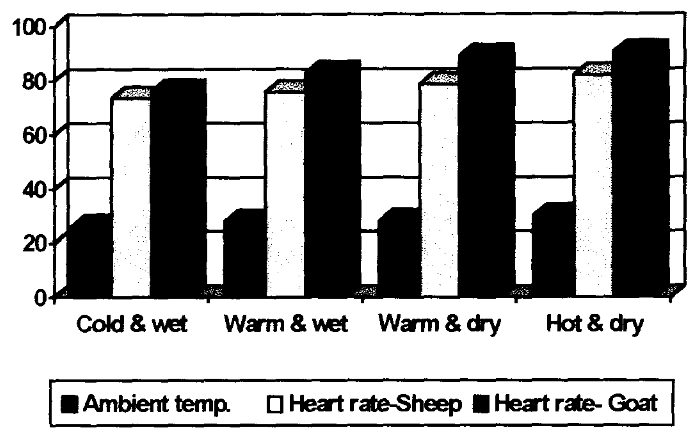

Fig. 21. SEASONAL CHANGES IN RELATIVE HUMIDITY AND HEART RATE- SHEEP AND GOATS

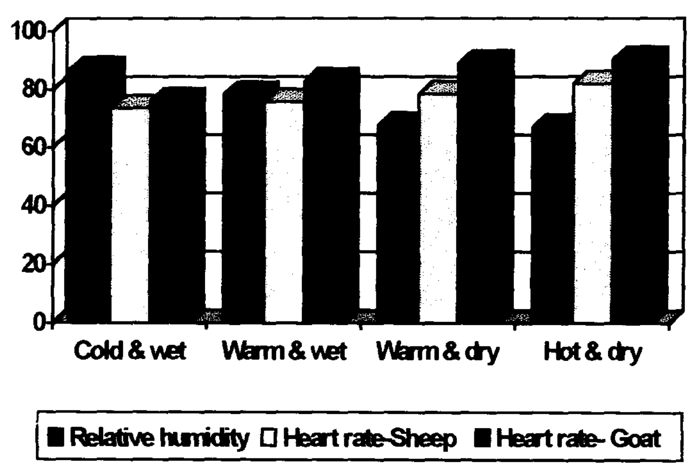

Table 24 Seasonal variation in Haematological parameters and body weights of sheep and goats.

Physiological norms	Species	Rainy season		Dry season		F-values	T-values
		cold & wet	warm & wet	warm & dry	Hot & dry		
Haemoglobin (g/100ml)	Sheep	12.53±0.16	12.08±0.14	10.68±1.20	9.71±0.16	63.034**	13.3531**
	Goat	11.23±0.15	10.91±0.13	10.05±0.18	9.57±0.18	26.746**	9.0763**
Erythrocyte sedimentation rate (ESR) (mm/24hr)	Sheep	3.10±0.04	3.14±0.03	3.33±0.04	3.24±0.04	6.449**	4.0221**
	Goat	2.18±0.05	2.13±0.04	2.23±0.06	2.14±0.05	0.781^{NS}	0.5604^{NS}
Serum Potassium levels (mEq/l)	Sheep	6.95±0.14	6.41±0.12	6.368±0.17	5.99±0.14	7.97**	3.4426**
	Goat	7.08±0.13	6.36±0.11	5.71±0.16	5.54±0.13	27.034**	7.6284**
Body Weight (kg)	Sheep	23.45±0.47	22.95±0.41	23.86±0.58	24.01±0.47	1.133^{NS}	1.6532^{NS}
	Goat	26.37±0.47	25.83±0.41	26.20±0.58	26.03±0.47	0.273^{NS}	0.0796^{NS}

* Significient as five per cent level ($P<0.05$)

** Significient at one per cent level ($P<0.01$)

^{NS} Non significat.

Fig. 22. SEASONAL CHANGES IN AMBIENT TEMPERATURE AND HAEMOGLOBIN- SHEEP AND GOATS

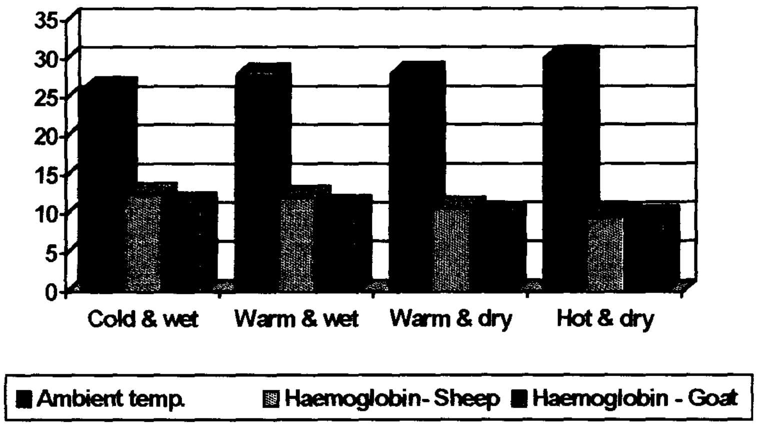

Fig. 23. SEASONAL CHANGES IN RELATIVE HUMIDITY AND HAEMOGLOBIN- SHEEP AND GOATS

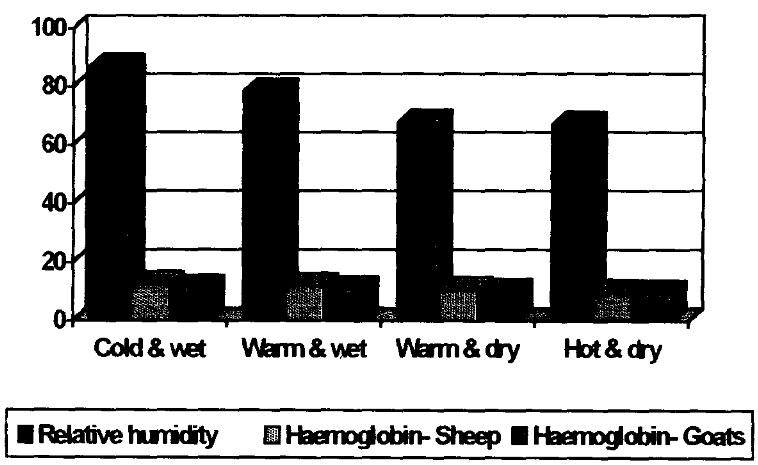

Fig. 24. SEASONAL CHANGES IN AMBIENT TEMPERATURE AND ERYTHROCYTE SEDIMENTATION RATE- SHEEP AND GOATS

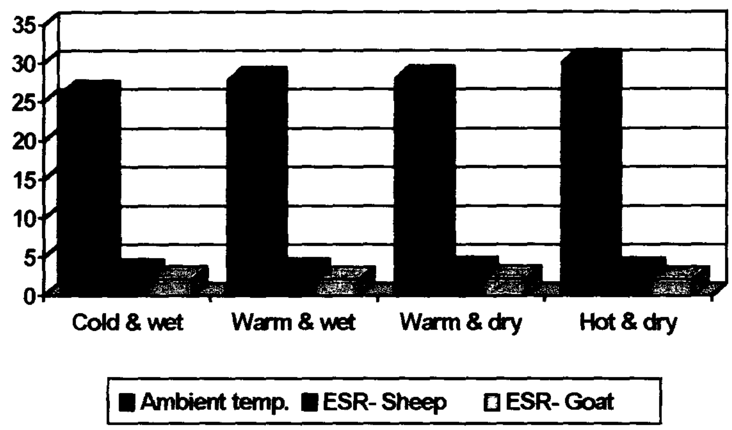

Fig. 25. SEASONAL CHANGES IN RELATIVE HUMIDITY AND ERYTHROCYTE SEDIMENTATION RATE - SHEEP AND GOATS

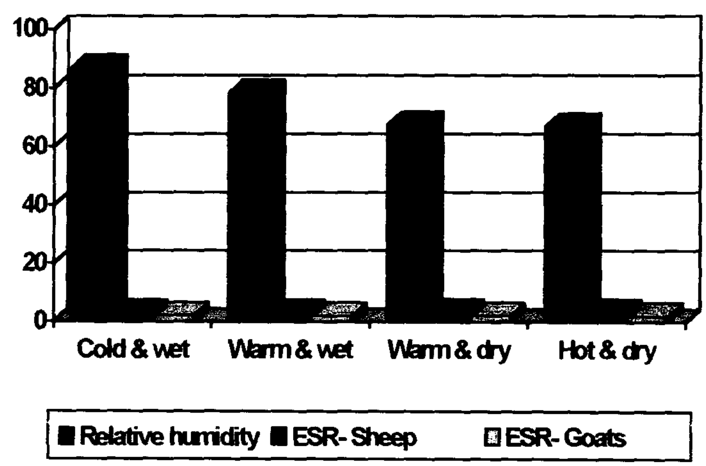

Fig. 26. SEASONAL CHANGES IN AMBIENT TEMPERATURE AND SERUM POTASSIUM LEVEL- SHEEP AND GOATS

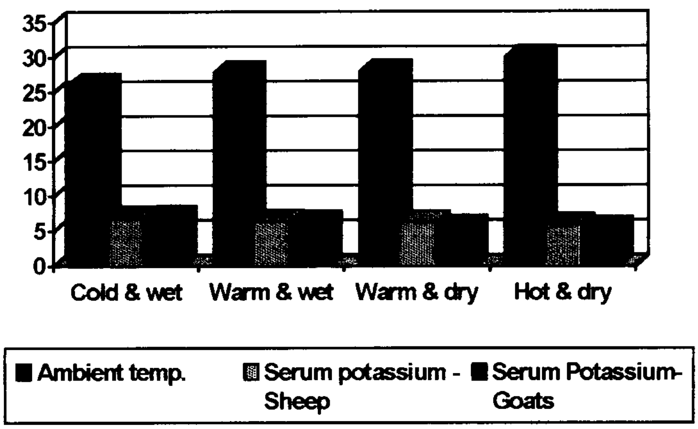

Fig. 27. SEASONAL CHANGES IN RELATIVE HUMIDITY AND SERUM POTASSIUM LEVELS - SHEEP AND GOATS

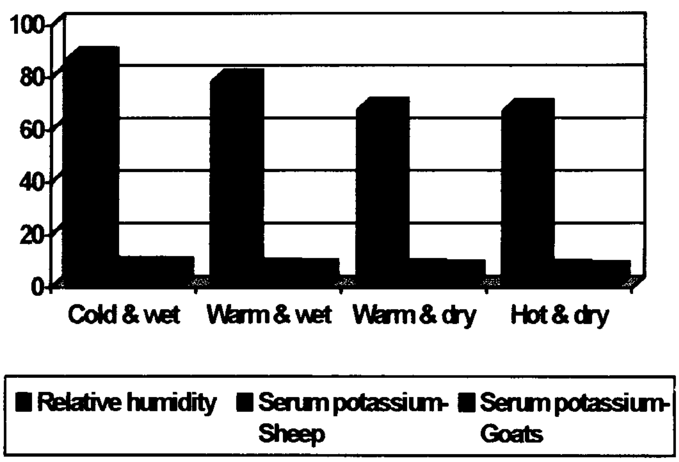

Fig. 28. SEASONAL CHANGES IN AMBIENT TEMPERATURE AND BODY WEIGHT- SHEEP AND GOATS

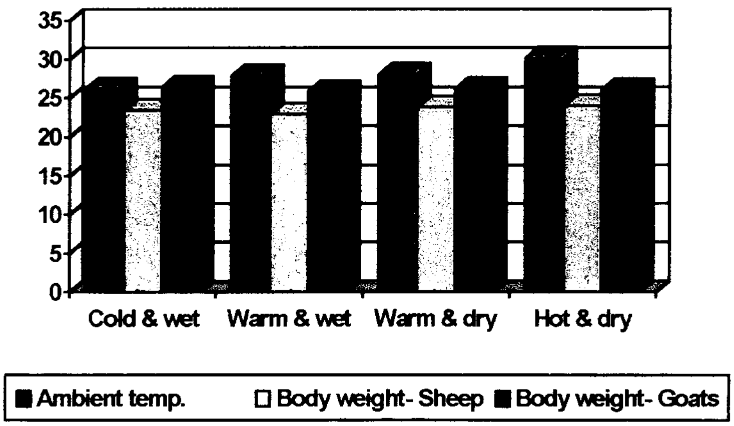

Fig. 29. SEASONAL CHANGES IN RELATIVE HUMIDITY AND BODY WEIGHT - SHEEP AND GOATS

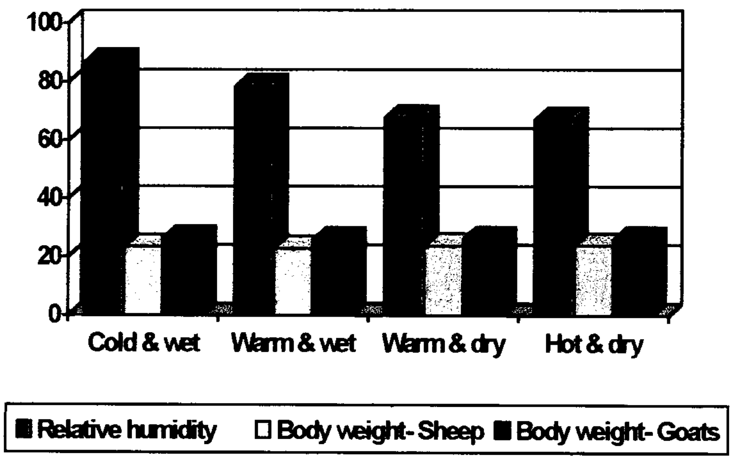

Table 25 Correlation between climatic variables and Animal responses.

Climatic variables	Seasons	Rectal temparature (°C)		Respiration rate (no/mm)		Heart rate (beat/min)		Haemoglobin (g/100ml)		ESR (mm/24hr)		Serum Potassium (mEq/l)		Body weight (kg)	
		Sheep	Goat	Sheep	Goat	Sheep	Goat	Sheep	Goat	Sheep	Goat	Sheep	Goat	Sheep	Goat
Ambient temperature (°C)	Cold & wet	0.558*	0.218^{NS}	0.469^{NS}	0.372^{NS}	-0.0300^{NS}	0.285^{NS}	-0.268^{NS}	-0.049^{NS}	-0.243^{NS}	-0.732**	-0.155^{NS}	-0.290^{NS}	0.495*	0.002^{NS}
	Warm&Wet	0.708**	0.326^{NS}	0.818**	0.819	0.756**	0.543**	-0.655**	-0.491*	0.672^{NS}	-0.118^{NS}	-0.640**	0.528^{NS}	-0.300^{NS}	0.190^{NS}
	Warm & dry	1.133^{NS}	0.717**	0.700**	0.289^{NS}	0.738**	0.507^{NS}	0.507^{NS}	0.300^{NS}	-0.418^{NS}	-0.462^{NS}	-0.380^{NS}	0.459^{NS}	0.513^{NS}	0.333^{NS}
	Hot & dry	-0.138^{NS}	-0.498^{NS}	0.683**	0.415^{NS}	0.207ns	-0.191^{NS}	-0.191^{NS}	-0.225^{NS}	-0.726**	-0.759**	-0.773**	0.251^{NS}	0.300^{NS}	-0.010^{NS}
Relative humidity (%)	Cold & wet	-0.531*	-0.656**	-0.135^{NS}	-0.037^{NS}	-0.057^{NS}	-0.395^{NS}	0.010^{NS}	-0.014^{NS}	0.688**	0.524*	0.559*	0.251^{NS}	0.300^{NS}	-0.010^{NS}
	Warm & wet	-0.204^{NS}	-0.634**	-0.221^{NS}	-0.231^{NS}	-0.209^{NS}	0.023	0.231^{NS}	-0.081^{NS}	-0.145	-0.052	0.190^{NS}	0.010^{NS}	0.544**	-0.137^{NS}
	Warm & dry	-0.510^{NS}	-0.708**	-0.650*	-0.631*	-0.855**	-0.563*	0.041^{NS}	0.160^{NS}	-0.856**	-0.173^{NS}	0.800**	0.411^{NS}	0.031^{NS}	0.463^{NS}
	Hot & dry	-0.498^{NS}	-0.247^{NS}	-0.509^{NS}	-0.113^{NS}	-0.263^{NS}	0.108^{NS}	0.389^{NS}	0.618^{NS}	0.080^{NS}	-0.102^{NS}	-0.361^{NS}	-0.385^{NS}	-0.715^{NS}	-0.700**

* Significient at five per cent level ($P<0.05$)
** Significient at one per cent level ($P<0.01$)
^{NS} Non significant.

Table 26 Regression analysis of animal responses to Ambient temperature

Animal responses	Species	Rainy season				Dry season			
		Cold & wet		warm & wet		warm & dry		Hot & dry	
		Reg.coeffi.	t-value	Reg.coeffi.	t-value	Reg.coeffi.	t-value	Reg.coeffi.	t-value
Rectal temperature	Sheep	0.2020	2.810*	0.1136	4.569**	-0.0239	0.82[NS]	0.0080	0.316[NS]
(°C)	Goat	0.0040	0.096[NS]	0.884	1.902*	0.0804	2.256*	0.0546	1.310[NS]
Respiration rate (no/min)	Sheep	5.2033	1.784[NS]	0.1030	8.445**	2.3729	2.219*	0.069	0.785[NS]
	Goat	5.4985	1.810[NS]	9.9513	8.188**	3.3049	2.063*	1.7736	1.397[NS]
Heart rate (beat/min)	Sheep	2.4862	1.947[NS]	2.9621	5.857**	1.4466	2.392*	0.3397	0.465[NS]
	Goat	-0.7679	0.608[NS]	0.7083	0.817[NS]	0.9635	1.070[NS]	0.4384	0.501[NS]
Haemoglobin (g/100ml)	Sheep	-0.4653	1.002[NS]	-1.2492	3.778**	-0.3831	0.766[NS]	-0.0356	0.416[NS]
	Goat	0.1230	0.323[NS]	-0.6980	2.369	0.3314	1.300[NS]	-0.0288	0.358[NS]
Erythrocyte sediment-	Sheep	0.0467	0.919[NS]	-0.0021	0.041[NS]	0.0563	1.401[NS]	-0.0732	2.582*
ation rate (mm/24hr)	Goat	-0.1383	1.867[NS]	-0.0334	0.494[NS]	-0.1367	1.211[NS]	-0.1302	3.226*
Serum potassium	Sheep	0.1542	0.814[NS]	-0.5923	2.360*	-0.2828	1.009[NS]	-0.4590	5.605**
levels (mEq/l)	Goat	-0.3547	1.217[NS]	-0.1411	1.038[NS]	0.4012	2.272*	0.1540	1.157[NS]
Body weight (kg)	Sheep	1.9341	1.427[NS]	0.3184	0.711[NS]	0.8107	0.770[NS]	0.0270	0.074[NS]
	Goat	2.0522	1.412[NS]	-0.1571	0.258[NS]	1.0521	0.834[NS]	0.2566	0.740[NS]

* Significient as five per cent level ($P<0.05$)
** Significient at one per cent level ($P<0.01$)
[NS] Non significat.

Table 27 Regression analysis of animal responses to Relative humidity

Animal responses	Species	Rainy season				Dry season			
		Cold & wet		warm & wet		warm & dry		Hot & dry	
		Reg.coeffi.	t-value	Reg.coeffi.	t-value	Reg.coeffi.	t-value	Reg.coeffi.	t-value
Rectal temperature (°C)	Sheep	+0.0270	1.534^{NS}	0.0143	2.047*	-0.0156	4.281**	-0.0042	0.801^{NS}
	Goat	-0.1147	1.938^{NS}	0.0173	1.322^{NS}	-0.0061	1.375^{NS}	5.0196	0.585^{NS}
Respiration rate (no/min)	Sheep	0.4926	0.691^{NS}	1.3627	3.967**	-0.2543	1.911^{NS}	-0.3213	1.772^{NS}
	Goat	0.8947	1.206^{NS}	1.2889	3.765**	-0.3493	1.753^{NS}	-0.0404	0.155^{NS}
Heart rate (beat/min)	Sheep	-0.9460	3.032**	0.3924	2.755*	-0.0829	1.109^{NS}	-0.2605	1.752^{NS}
	Goat	0.7991	2.591*	-0.4474	1.833^{NS}	-0.2399	2.160*	0.1300	0.723^{NS}
Haemoglobin (g/100ml)	Sheep	-0.0786	0.618^{NS}	-0.2402	2.267*	-0.2916	0.965^{NS}	0.0211	0.953^{NS}
	Goat	0.0687	0.658^{NS}	-0.1532	1.623^{NS}	0.0226	0.693^{NS}	0.0386	1.848^{NS}
Erythrocyte sedimentation rate (mm/24hr)	Sheep	0.0348	2.499*	-0.0055	0.338^{NS}	-0.0221	4.311**	-0.0015	0.198^{NS}
	Goat	0.0054	0.268^{NS}	-0.0088	0.404^{NS}	-0.3372	0.234	-0.0106	1.009^{NS}
Serum Porassium levels (mEq/l)	Sheep	0.0965	1.860^{NS}	-0.064	0.827^{NS}	0.1171	3.268**	-0.7182	3.368**
	Goat	-0.0184	0.231^{NS}	-0.0275	0.632^{NS}	0.0433	1.920^{NS}	-0.0311	0.897^{NS}
Body weight (kg)	Sheep	0.5927	1.596^{NS}	-1.4653	1.021^{NS}	0.2397	1.487^{NS}	-0.233	2.452**
	Goat	0.3501	0.879^{NS}	-0.0873	0.448^{NS}	0.0007	0.072^{NS}	-0.2116	2.347*

* Significient as five per cent level ($P<0.05$)
** Significient at one per cent level ($P<0.01$)
^{NS} Non significat.

4.6.5 ETHOGRAM

I. Gaits

Like other ruminants sheep and goats, walk, trot and run. The casual walking gait was a common feature for sheep and goats. But, more commonly observed in sheep, especially at the time of letting them out from the shed. This is a hurried walking gait.

1. Stepping in Place: These movements were more commonly seen when they were stationed inside the shed and also while grazing in the field. This was mainly to ward off flies and or mosquito from the legs :

II. Animal oriented movements

2. Approaching: Movements that reduce the distance between two animals beyond a certain distance is approach. These were more often observed in sheep than in goats. The movements were also resulting from walking, trotting or running exhibited in enclosure as well as in the field.

3. Low stretch : This was commonly seen in goats and occasionally in sheep. This was frequently found in animals during estrous. Here, the animals held their neck extended and head held low in more or less horizontal plane.

4. Departing : Employing a gait to move away from another animal. This was more pronounced , when the concentrate feeds were offered. The dominant animals rushed to the feed, whereas, the subordinates gave way and slowly departed from the dominant ones to nearby places.

5. Chasing : Observed frequently in both the species. This was mainly a playful behaviour especially in goats or at times agonistic in nature both in sheep and goats.

6. Threat swaggers : Noticed in animals engaged in parallel marching as well as by other individuals walking in the vicinity of other animals. Further, it was more of hierarchically oriented one. This was mainly exhibited by dominant ones. In this act, most of the facial expressions were pronounced.

III. Visual patterns

a). Animal oriented non-contact patterns :

7. Flehmen (Lip curl) : Observed in both sheep and goats. Frequently both in normal as well as estrous animals. This reaction was observed soon after licking of the ano-genital region of other animal (which were in oestrous or not) or by itself. During this reaction animals opened their mouth, raised upper lip and tilted head upward. This reaction ended soon after the individual licked its lips, after relaxing the muzzle.

8. Lip flipping : This was observed both in sheep and goats. The animals were attempting to avoid contact with other animals, wherein the rapid elevation of upper lip repeatedly was noticed. This was mainly accompanied by rapid biting motion. The head was held forward and low, as the animal turned away or quickly departed from the approaching individuals.

9. Yawning : Yawning was observed during rest hours, especially when they were housed inside the shed returning after grazing or feeding. The mouth parts assumed a yawn like position for a while before the cud was regurgitated. This was commonly seen in goats.

10. Pawing the ground : This act was observed in goats and rarely in sheep. More often this was done during fighting with the movement of muzzle and a strange look.

11. Ears back : This was noted in sheep in response to strange noise, inside the shed or during grazing hours where in animals retracted their ears backwards, and dorsally.

12. Arched tail : Observed only in goats. They assumed this posture especially during oestrus, defaecation and urination. The animal held the proximal part of their tail extended. But, in sheep this gesture was not seen, due to a bent down position of the tail.

b). Animal oriented contact patterns

13. Sniffing/Nasal contact : This was noticed in all the animals. One individual sniffed the anal region of the other individual. This was a common feature in sheep and goats, and was observed only when they were resting.

14. Licking : Observed often in goats than sheep, in this behaviour animals licked their own body and occasionally that of other individuals. It was observed as a companion's act or to relieve the irritation on their body.

15. Biting : This resulted from mosquito, insects or fly bites mainly to relieve the painful irritation that was inflicted. Bites were of brief duration and were more often observed in these species.

16. Fore leg kicking : This was a common feature. Goats, lift their leg and hoof was dropped on the body of the other individuals.

17. Head rubbing : It was observed very rarely in sheep but occasionally in goats. This is mainly seen in individuals during oestrous.

18. Head pressing : This feature was more often observed in goats than in sheep. Animals pressed their fore-head and crown together especially during agonistic interactions.

19. Head butting : This was noticed especially in goats during confrontations wherein two individuals held their heads pressed together. Immediately one individual or both bumped their head against each other. It was a rare feature in sheep.

20. Muzzle tossing : This was a common feature in both the species. Seen in individuals involved in confrontations, repeated movement (upward and downward) of muzzle was observed.

21. Rearing and kicking : This act was observed in goats, especially during agonistic interactions during which individuals stood up on their hind legs and stroke at each other with the fore legs with a peculiar head posture.

22. Chin resting : This was observed in both the species when they were housed inside the shed and when they slept side by side and also during oestrous.

23. Mounting : Commonly exhibited by individuals in oestrous. This was observed in some non-oestrous females also. This was common feature for sheep and goats, but was more frequent in goats.

24. Fighting : Commonly seen in goats was uncommon in sheep. During this act goats used their fore head, horns and fore legs. It was mainly an agonistic activity.

25. Standing-on : This pattern was exhibited by animals, as a playful behaviour wherein they kept their fore-feet on the companion's back. This was noticed more in goats than sheep.

IV. Object and Self oriented contact patterns.

a). Object oriented contact patterns :

26. Face and neck rubbing : Observed frequently in goats and occasionally in sheep during this act, animals wiped the side of the face and rubbed their throat region (to the manger walls provided inside the shed) and on the ground, when they were resting outside.

27. Head shaking : This pattern was exhibited commonly in goats. The head was rotated once or more times, probably to dislodge the materials from the head parts. This was also seen in both the species as a response to insects or flies getting lodged on the head region inflicting severe irritation.

b). Self oriented contact patterns :

28. Licking : This was more frequently exhibited by goats than sheep. The lower fore legs, flanks, mid back, belly, hind legs, rump, tail and ano-genital regions of the body were the common sites licked. During licking, the hind limbs were brought towards the head region. The udder region was licked by raising hind leg.

29. Scratching with horns : Goats used to scratch shoulders, back and flank regions of its body. This was observed only in goats mainly in response to an irritation on the body.

30. Muzzle to body touching : This behaviour pattern was observed frequently in both the species. The muzzle or the side of the face was occasionally used to touch, wipe or rub the fore leg, flank, or back. This was observed in response to flies and mosquitoes.

31. Tail swishing : Noted frequently in both the species, this was to avert the flies and mosquitoes on hind quarters especially when the animals were standing in a shed. Circular or semicircular tail movements were observed.

V. Vocal and Non-vocal patterns

a). Vocal patterns

32. Bleating/bellowing: This was more common in sheep and goats, and especially, more pronounced just before offering concentrate feed during morning hours.

b). Non-vocal auditory patterns.

33. Tooth grinding : This was observed both in sheep and goats mainly during rest period and while the animals are in a reclining position. Rhythmic grinding of cheek teeth was observed. The resulting sounds were of higher pitch and were of brief duration: It was observed during rumination also.

34. Rumination sounds : These sounds were clearly heard in both the species mainly, during group feeding and when concentrate feeds were given.

Feeding sounds were clear and distinguishable from other sounds and were also observed when they were grazing/browsing. Sounds of plucking grass and leaves were of typical nature.

VI. Stretching patterns

35. **Walk stretch :** This was a common feature exhibited by goats and sheep.

36. **Standing stretch :** This was noticed in both the species, mainly during stationary position and usually after rising from the reclining position. The animals strengthened their back and extended their neck forward and rarely downwards. The tail was held raised, in case of goats. The upper lip was curled, the eyes were closed and muzzle pointed backward.

VII. Stationary body positions and stances

37. **Curled lateral recumbancy :** This behavioural pattern was exhibited more often in sheep than goat. But in goats this pattern was of longer duration. Animals took rest initially on one side of their rib cage which was then supported by the flexed fore and hind legs. Head was held up. Some times they took rest in lateral recumbancy many on flank stretching legs across the ground : Ears were pointed backwards.

38. Extended lateral recumbancy : This was a common feature in goats and rarely observed in sheep. The animals, in their reclining position, extended their legs, whereas, flank and shoulders supported the body. The head was held extended and kept on the ground or some times held above the ground or placed on their back.

VIII. Feeding, digestive and elimination patterns

a). Feeding and digestive patterns :

39. Grazing and browsing : Goats preferred to browse. It was a common feature, in these species. But at times grazing was also observed. Sheep preferred grazing and they spent most of their time in grazing, but occasionally browsing was observed in sheep. During this act, plant parts were taken in the mouth and were cut by a brief forward and backward movement of head. Goats preferred mainly upper (top) portions of the plants, and invariably stem and root portions were dropped.

40. **Rumination :** There was not much difference in the rumination activity of both the species. The animals get separated individually from the group (common in goats) and lie down and ruminate. Rumination activity was more pronounced during dawn and dusk.

b). Elimination patterns

41. Defaecation patterns : The defaecation posture assumed by goats was such that they got least chances of getting soiled. But this posture was not much clear in sheep.

42. Urination : The posture assumed was similar to that of defaecation posture. Urination was observed commonly while standing. In sheep urination during reclining position was observed, but this was a rare scene in goats.

Table 28 The occurrence and probable functional categories of behaviour patterns in sheep and goats.

Serial no.	Behaviour pattern	Sheep	Goat	Function
1	Stepping in place	+++	+++	Protective
2	Approaching	++	+++	Variable, Social
3	Low stretching	++	+++	Variable, Social
4	Departing	+++	+++	Variable, social
5	Chasing	+++	+++	Play, Agonistic
6	Threat swaggers	++	+++	Agonistic
7	Flehmen	+++	+++	Sexual
8	Lip flipping	++	+++	Agonistic, Submissive
9	Yawning	++	+++	Comfort
10	Pawing the ground	+	+++	Agonistic
11	Ears back	+++	++	Agonistic, excitation
12	Arched tail	-	+++	Sexual, elimination
13	Nasal contact	+++	+++	Comfort, Variable
14	Licking	+++	+++	Comfort, Variable
15	Biting	+++	+++	Agonistic
16	Fore leg kicking	-	++	Agonistic
17	Head rubbing	+	+++	Contact promoting
18	Head butting	+	+++	Agonistic
19	Muzzle tossing	+++	+++	Agonistic, Sexual
20	Rearing and kicking	+	+++	Agonistic
21	Chin resting	++	+++	Play, Sexual, Contact promoting
22	Mounting	+++	+++	Play, Sexual, Contact promoting
23	Fighting	+	++	Agonistic
24	Standing-on	++	+++	Agonistic, Play
25	Face and neck rubbing	+	+++	Protective, Comfort
26	Head shaking	++	+++	Grooming
27	Scratching with the horns	-	+++	Grooming
28	Muzzle to body touching	++	+++	Grooming, Protective
29	Tail swishing	+++	+++	Protective
30	Bleating/Bellowing	+++	+++	Agonistic, Sexual, Discomfort
31	Tooth grinding	++	++	Agonistic, Sexual, Discomfort
32	Rumination sounds	+	+++	Nutritive
33	Feeding sounds	+++	+++	Nutritive, Contact
34	Walk stretch	++	+++	Comfort
35	Standing stretch	++	++	Comfort
36	Curled lateral recumbancy	++	+++	Rest, Sleep
37	Extended lateral recumbancy	++	++	Rest, Sleep
38	Grazing	+++	+	Nutritive
39	Browsing	+	+++	Nutritive
40	Rumination	++	+++	Nutritive
41	Defaecation	+++	+++	Elimination
42	Urination	++	+++	Elimination

Key : +++ Common occurrence

++ Rare occurrence

+ Occasional occurrence

- Has not been observed

Discussion

5. DISCUSSION

5.1 CLIMATOLOGICAL VARIABLES

Variations in environmental factors evoke a number of non-specific regulatory mechanisms resulting in general adaptation syndrome. The ambient temperature along with the relative humidity posed different biological alterations in different animals.

The climate of Mannuthy was classified (Somanathan, 1980) as rainy season extending from May to November with a cold and wet period during June, July, August; and warm and wet periods during May, October and November . The dry season extending from December to April also had two periods, *viz.,* warm and dry during December, January and hot and dry , during February, March, April months.

The rainy season as per the above report registered a monthly average of 200 mm and above. Though the relative humidity was high, sunshine and wind velocity showed lowest values. The dry season was characterized by high values of ambient temperature, hours of sunshine and wind velocity. Relative humidity and rainfall were the lowest during this season.

In the present observations the maximum temperature was recorded during April and the minimum during August. This categorizes April as hot and dry and August as cold and wet, as per the previous classification. But the maximum temperature from January to May and October was above 32° C . This difference may be due to the fact that the present observation is only a seasonal recording whereas, the previous report is a climatological recording. The major variations as depicted in the results show that the cold and wet period had a mean ambient temperature of 26.16±0.24° C and relative humidity 86.86±0.89% as against that of Somanathan's classification, the rainfall was only 24.5±3.49 mm. The warm and wet season had an ambient temperature less than 30° C, *i.e.,* 27.86±0.28° C and relative humidity 78.28±1.02 %, and the rainfall was less than 500 mm . The warm and dry period registered similar ambient temperature and relative humidity as to that of the previous classification. The hot and dry period differed in the ambient temperature value. It was 30.08±0.35° C as against the value given in the previous classification.

5.2 PHYSIOLOGICAL VARIABLES

5.2.1 RECTAL TEMPERATURE

Diurnal variations in the rectal temperature of sheep and goats could be discerned in the present finding. The means of rectal temperature of sheep during morning and evening were 38.78±0.03° C and 39.62±0.05° C respectively. In goats, the mean figures were 38.74±0.06° C during morning and 39.69±0.07° C in the evening. Highly significant diurnal variations of rectal temperature of sheep and goats were observed. The present finding in akin to that of Misra, *et al.* (1985), Jadhav *et al.* (1989), Dollah *et al.* (1992), De-Silva and Minomo (1995), Acharya *et al.* (1995) and Hassanin *et al.* (1996).

Ambient temperature and relative humidity showed a highly significant influence on rectal temperature of sheep and goats. Vihan and Sahni, (1981) observed, increase in rectal temperature with the rise in air temperature. Similar findings were reported by Singh *et al.* (1992), Kornel and Kumar (1990), Gupta and Acharya (1993), Abisaab and Sleiman (1995) and Guney, *et al.* (1992). Under high environmental temperatures and with slight alterations in relative humidity the temperature of both sheep and goats were significantlyaffected. This was in agreement with the reports of Vihan and Sahni, (1981), Jadhav *et al.* (1989), Guney *et al.* (1992).

Coefficient of correlation between rectal temperature and ambient temperature as well as relative humidity were highly significant in both the species. This finding is akin to the reports of Jindal (1980), Sanyal and Sarkar (1990) and Guney *et al.* (1992). Comparing the rectal temperature of sheep and goats during morning, significant differences were noted. This finding agrees with findings of Ghosh and pan (1994). The differences during evening recordings were non-significant. Singh *et al.* (1980) reported that there were no significant differences in rectal temperature between sheep and goats.

Williams (1997) reported that the body temperature of homeotherms were influenced by age, sex, season, time of day, environmental temperature, exercise, eating, digestion and drinking of water. Ghosh and Pan (1994) and Degen (1977) also reported similar results.

Significant diurnal differences were observed in the rectal temperature of sheep, among cold and wet, warm and wet, warm and dry, and hot and dry seasons. It showed highly significant differences between rainy and dry seasons. In goats, highly significant differences were found in their rectal temperature between rainy and dry season, as well as among all the seasons. Kaushish *et al.* (1989), Nazki and Rattan (1990) and Williams (1997) reported similar, alterations in body temperature in different seasons.

The rectal temperature in sheep was highest during hot and dry season, followed by warm and dry, warm and wet and cold and wet seasons. Similar, trend was also observed in goats. Ghosh and Pan (1994) reported higher rectal temperature in *Black Bengal* goats and *Sahabadi* sheep, during hot-humid season and it was lower during cold-humid season. The body temperatures of ewes recorded during summer was significantly higher than those recorded in other seasons (Nazki and Rattan, 1990), Similarly De-Silva and Minomo (1995) and Abdel-Baki *et al.* (1995) reported higher values of rectal temperature during summer compared to other seasons. The animal's primary efforts to withstand the heat stress is reflected in compensations like skin vasodilatation, evaporative cooling and when these fail increase in rectal temperature. The present observation is also pointing to this fact. Alnaimy *et al.* (1992) stated that increase in rectal temperature occurs in animals when the heat production exceeds heat dissipation due to reasons like failure in response eliciting by peripheral receptors, nervous system, endocrine glands and enzymes, showing that increase in body temperature is a way of thermoregulation. This view holds true in the present context also. Increased body temperature provides a higher gradient against environmental temperature which enables thermolysis through physical means. These seasonal adjustments in body temperature should be related to other physiological reactions and productive responses before pronouncing them as "stress" or a mere "physiological adjustment"

5.2.2 RESPIRATION RATE

The diurnal response imposed on this physiological norm is similar to different research reports from different climatic profiles. Sheep showed 28.14±0.75 breathings per minute in the dawn and it increased to 49.59±3.63 breathings per minute in the dusk. In goats it was 28.49±0.71 breathings per minute in the morning and 53.88±4.72 breathings per minute in the evening.

This finding concur with the reports of Srivastava *et al.* (1980), Kumar and Singh (1992), Acharya *et al.* (1995) and Hassanin *et al.* (1996).

Highly significant differences between respiration rates of sheep and goats and climatic variables were observed. This is in agreement with the reports of Vihan and Sahni (1980), Singh *et al.* (1980), Valls and Folch (1982), Abdul (1986), Guney *et al.* (1992) and Sleiman and Abisaab (1995). All the above reports it is made explicit that respiration rate increased with increase in environmental temperature. Increased respiration rate is one of the first reaction of animals to the increased environmental temperature stress. Further, the elevation of respiration rate due to heat stress enables the animal to dissipate the excess body heat by vaporizing more moisture through expired air (Alnaimy *et al.* 1992). Guney, *et al.* (1992) reported that all goats belonging to different genotypic groups were affected by rise in ambient temperature and relative humidity. These findings are similar to the present observation.

The diurnal variation in respiration rate between sheep and goats were similar. They utilize increased respiration rate as a means to dissipate heat load. Ghosh and Pan (1994) reported an increase in morning respiration rate in sheep over goats.

Vihan and Sahni (1981) reported highly significant variations in respiration rate recorded in sheep under different seasons. Breeds, sex and time of recordings also influenced these values. Similarly, Ghosh and Pan (1994) after a study in sheep and goats reported that respiration rate, varied significantly, between species, seasons and times of recording. Highly significant differences were observed in the respiration rate of sheep and goat during morning and evening recordings, between rainy and dry seasons as well as among cold and wet, warm and wet, warm and dry, and hot and dry seasons. Nazki and Rattan (1990) reported that average respiration rate recorded during rainy and summer times were significantly higher than those recorded during winter and spring seasons. Marai *et al.* (1992) measured higher rates of respiration during summer than winter months. Similar, observations were made by Singh *et al.* (1982), Jager (1986), Esmail (1986) and Silanikove (1987).

The respiration rates in sheep and goats were higher during hot and dry and warm and dry seasons when compared to cold and wet and warm and wet seasons. One of the reasons for this may be the higher environmental temperature and relative humidity. The animal dissipates the excess body heat by evaporative cooling (Alnaimy *et al.,* 1992). The higher respiration rate observed during dry season (hot and dry and warm and dry seasons) may help in heat dissipation and lower respiration rate during rainy season (warm and wet and cold and wet) may aid in conservation of heat in animals' body. Many workers have a similar repots about this (Hooda and Nagvi, 1992 ; Singh, *et al.,* 1992 ; Abdul-Baki, *et al.,* 1993 ; Sleiman and Abisaab, 1995).

5.2.3 HEART RATE

Highly significant diurnal difference was noted in the heart rate of sheep and goats. Also highly significant difference was observed in heart rate between sheep and goats, in their morning as well as evening recordings. Acharya *et al.* (1996) recorded higher values of pulse rate in the afternoon ; this is in agreement with the present study. Ghosh and Pan (1994) reported that pulse rate was significantly influenced by season and the time of recordings. They also reported that during evening hours the pulse rate increased and that goats showed a higher pulse rate than sheep. The present finding is in agreement with this. Due to the feed given in the afternoon and the increase in ambient temperature, these animals might have shown an elevated heart rate. Vihan and Sahni, (1981) reported that higher metabolic rate increases heart rate.

Correlation coefficient of heart rate of sheep and goats with climatic variables were highly significant. Nazki and Rattan (1990) reported that environmental conditions had a direct influence on thermo-regulatory and respiratory mechanisms of animals. Increase in pulse rate was noticed, when the animals were exposed to high environmental temperature (Alnaimy *et al.*, 1992). Many workers have similar reports about this (Salem, 1980; Aboul-Naga, 1987; Hooda and Nagvi, 1992; Abdel-Baki *et al.*, 1993; Singh *et al.*, 1992 and Sleiman and Abisaab, 1995).

Significant seasonal differences were noticed in the morning heart rate of sheep. Highly significant difference was observed between rainy and dry seasons. Significantly higher differences were recorded in heart rate of sheep in their evening recordings between rainy and dry season as well as among all the four sub-seasons. Similarly diurnal difference varied significantly from season to season in goats. The present finding concur with the reports of Srivastava *et al.* (1980), Jager (1986), Kaushish *et al.* (1990), Nazki and Rattan (1990), Ghosh and Pan (1994), Abdel-Baki *et al.* (1995), Sleiman and Abisaab (1995) and Abisaab and Sleiman (1995).

The heart rate recorded during different seasons showed higher rates in hot and dry season followed by warm and dry, warm and wet and cold and wet seasons in both sheep and goats. Ghosh and Pan (1994) reported increase in pulse rate in goats and sheep to 70.45 and 67.94 per cent in hot-humid season and 81.55 and 80.55 per cent in cold-humid season, respectively. Significantly lower pulse rates were observed during winter (85.4 beats per minute) over summer months in sheep (96.0 beats per minute) (Nazki and Rattan, 1990). Abdel-Baki *et al.* (1995) recorded higher values of pulse rate during summer (41.0 beats per minute). In winter, it was 69.0 beats per minute, in Egyptian sheep. This seasonal variation in heart rate is in agreement with the present study.

The animals were increasing their heart rate to bring more blood to the surface capillaries to augment heat exchange and evaporation. However, many physiological mechanisms often working in different directions may give varied results in the case of heart rate. In most of the climatic chamber studies on cattle there is generally a decrease in pulse rate (Nauheimer-Thoniek, *et al.*, 1988) under high ambient temperature. This may be the result of lower metabolic rate (Alnaimy, *et al.*, 1992) and increase in blood volume (Thomas, 1969). However in some field studies in hot-dry regions in cattle there was an increase in pulse rate during summer (). The same workers also observed a reduction in the blood volume during summer and were of the opinion that the difference between climatic chamber studies and field observations on heart rate was due to overriding effect of change in blood volume.

The observation of Maria *et al.* (1991) in calves that pulse rate does not change appreciable under high environmental temperature may be also explained as due to the effect of similar conflicting forces.

5.3 HEMATOLOGICAL PARAMETERS

5.3.1 HEMOGLOBIN

The mean hemoglobin levels in the blood of sheep and goats respectively were 11.34+0.41 and 10.52+0.24 g per cent respectively.

In sheep and goats, climatic variables influenced the hemoglobin value. The hemoglobin concentration decreased with an increase in ambient temperature. This may be due to the depression of haematopoiesis and due to haemodilution. Blood volume and total body water (Habeeb, 1987) increased with the increased evaporative process under heat stress (Shebaita and Kamal, 1975). Decrease in haemoglobin concentration with increase in air temperature were also reported by Silva *et al.* (1992), Baumgartner and Pernthaner (1994), Alnaimy *et al.* (1992) and Dutta *et al.* (1996).

Pernthaner *et al.* (1993) reported significant differences between breeds, age and seasons. There were highly significant differences between cold and wet, warm and wet, warm and dry and hot and dry seasons. It was highest during cold and wet season and lowest during hot and dry season, in both the species. Baumgartner and Pernthaner (1994) reported that haemoglobin values were significantly different in sheep during summer and winter. Hemoglobin level was 7.51 g/100 ml and 7.3 g/100 ml during autumn and spring seasons respectively (Baranow *et al.* 1994). Chahal and Rattan (1981) reported that hemoglobin levels varied significantly between animals and also between seasons. Similar seasonal influence on hemoglobin level was reported by Musinov (1979), Jelinek *et al.* (1986) and Pospisil *et al.* (1987).

As against the present findings Santra *et al.* (1996) found no significant difference in hemoglobin level between seasons in *Jamnapari* goats. Kataria *et al.*

(1990) and Kataria *et al.* (1992) also made a similar observation. Thomas (1969) reviewed the seasonal effect on blood volume and haemoglobin concentration in blood of Sahiwal and cross-bred calves. Haematopoesis and haemodilution are two mechanisms influencing the haemoglobin level in blood. Some times when these two mechanisms act in opposite direction the haemoglobin level remain unchanged. Thomas and Razdan (1974) observed haemoconcentration during hot-dry season in calves probably because of the fact that the rate shift of the water moiety from the extracellular space to the vascular space did not keep up with the rate of evaporation from the skin surface and respiratory tract put together.

5.3.2 ERYTHROCYTE SEDIMENTATION RATE (ESR)

The average ESR was 3.18+0.03 mm/24hr in sheep and 2.17+0.02 mm/24hr in goats. Benjamin (1985) reported the normal ESR values in sheep and goats, as 3.0 to 8.25 mm/24hr and 2.0 to 2.5 mm/24hr respectively. Schalm *et al.* (1975) also reported similar values. These values are akin to the present observation. The differences between sheep and goats were highly significant ($P<0.01$).

This finding is in line with the reports from Bunce (1954), and Hathout (1957). In sheep the higher values may be due to presence of erythrocyte rouleaux formation which increases the sedimentation rate, whereas absence of this or only a minor rouleaux formation degree in the thicker areas of blood film in goats may be the reason for species difference (Schalm *et al.,* 1975).

Ambient temperature showed a non-significant influence on ESR of both sheep and goats. Xavier (1981) observed that the climatic variables showed a non-significant influence on ESR in buffaloes and this is in agreement with present findings in sheep and goat.

Seasonal variations in ESR values of goats were also not significant ($P<0.05$). Xavier (1981) noted similar result in buffaloes. On the contrary highly significant seasonal differences in ESR values were observed in sheep. It was highest during dry season and lowest during rainy season. This may be due to haemodilution of blood occurring during heat stress (Shebaita and Kamal, 1975) which might have hastened the ESR in sheep.

5.3.3 SERUM POTASSIUM LEVELS

The average serum potassium levels recorded in sheep and goats in the present study were 6.43±0.18 mEq/l and 6.22±0.18 mEq/l respectively. The normal levels of serum plasma potassium level reported was 3.5 to 5 mEq/l. (Williams, 1995 ; Vasudevan and Sreekumari, 1995). Studies on sheep and goat serum potassium levels are meager and literature scanty.

Air temperature as well as relative humidity variations influenced serum potassium levels. Potassium levels in serum showed a negative trend with increase in air temperature. Kamal *et al.* (1989) observed significantly lower serum mineral values (Na, K, Ca and Zn) in lactating Friesian cows at elevated ambient temperature . Aboul-Naga (1987) also found similar result in Friesian calves at 36° C, Srivastava and Gupta (1996) observed decrease in serum potassium levels with higher air temperature. They reported that variations between seasons were evident. The present study is in agreement with these findings. Thermal stress induce alterations in electrolyte levels and a negative mineral balance. High environmental temperatures (32 to 39° C) induced significant decreases in retention of minerals (K, Ca, Na, P and Zn) in animals (Kamal and Johnson, 1977; Aboul-Naga , 1983). High environmental temperatures induces decreases in the intake of most minerals (Aboul-Naga, 1987).

Seasonal variations in serum potassium was much evident in the present study. Highly significant differences were noticed between the seasons. Cold and wet season recorded highest value (6.95+0.14 mEq/l) and hot and dry season recorded lowest (5.99+0.14 mEq/l).The serum potassium levels in sheep were higher during Winter, followed by Autumn, Spring and Summer seasons (Srivastava and Gupta , 1996). Mostaghni (1990) also observed similar seasonal variations in this values in sheep. Siebert and Macfarland (1971) observed in serum potassium and sodium levels in a desert living camel, that during dehydration potassium was excreted while sodium was tended to be retained in the extra cellular fluid and was used later to restore fluid volume. This might be true for sheep and goats, as a similar trend of change was observed in present study.

Bhattacharyya *et al.* (1995) reported higher values of serum potassium level during summer season in goats. The level of serum potassium was 5.52+0.13 mEq/l in summer and (5.06+0.14 mEq/l) during winter. Possibly due to consumption of forages rich in mineral, in summer higher levels of Na and K in serum were observed. Further, this increase may also be due to increase in haemoconcentration during summer. Similar results were also observed by Mc Dowell (1985).

5.4 BODY WEIGHT

The average body weights recorded during the experiment was 23.46+0.25 kg in sheep and 26.08+0.19 in goats.

The correlation coefficient between body weight and climatic variables were non-significant in both sheep and goats. Further, there was no significant differences between seasons noticed, in goats and sheep. Nagpal and Chawla

(1985) reported that the influence of season was more pronounced at an early age in various crossbred goats, but it gradually reduced with the advancement of age. Lupton *et al.* (1996) observed no seasonal difference. These reports are akin to the present findings. Wilson (1987) also found the similar results in sheep.

There was highly significant difference between months in sheep and goats. The body weights were higher during cooler months of the year. Highest body weight was recorded during July in sheep (24.73+0.86 kg) and in goats (27.22+0.73 kg). Sanchez *et al.* (1984) observed the body weight of one year old female goats to be higher in May - July and February to April periods than the rest. This may possibly be due to the availability of good quality of *ad libitum* feeds during cooler months.

Nasholm (1990) observed that body weight in ewes, aged 6 months to 6 years, were significantly influenced by age, season, flock size and breed. Similar, studies were also done by Schoeman (1990), Ruvuna *et al.* (1991), Kulkarni and Deshpande (1991) and Brown and Jackson (1995). Das and Bisht (1997) observed that body weight gain was significantly higher during winter season than hot-dry and hot-humid seasons. Increase in weight gain during cooler seasons and decrease during hot months may be due to availability of quality food, especially grass, during cooler seasons, leading to the seasonal variations in these values. Direct effect of the heat stress on the growth process also cannot be ruled out.

5.5 BODY MEASUREMENTS

5.5.1 HEIGHT

The average body height at withers was 68.89+0.21 cm in sheep and 65.29+0.32 cm in goats, during the study. Patnaik and Mishra (1985) recorded body height at withers in Bengal goats (55.23 cm)and in crossbred goats. and (74.11 cm).

Significant differences were noted, between months in sheep and goats. Singh *et al.* (1990) reported changes in body dimensions with increase in age. This is natural and was observed in the present study also. Ifut *et al.* (1991) reported that body measurements appeared to approach mature dimensions by 22 months of age in female goats. Sex had no significant influence on height in female *Segurena* sheep (Blanco *et al.,* 1990).

5.5.2 GIRTH

The mean girth measurements of animals at the end of experimental period was 70.18+0.11 cm and 67.61+0.19 cm in sheep and goats respectively. Pattabiraman (1955) recoeded the girth of Tellichery and Jamnapari adult does', as 71.10 and 76.10 cm respectively, whereas, it was 73.8 cm in Malabari goats (Misra, 1985). Ifut *et al.* (1991) measured girth of *Nigerian* goats aged 20 to 36 months. It was 59.58 cm. The girth measurements were recorded for ewes of three types, aged three years. It was 72.0+1.19, 77.0+1.5 and 73.0+2.4 cm for the three groups. Achary (1992) observed the heart girth of adult female Jamnapari and Malabari goats. The values were 63.20 and 67.40 cm respectively.

There was no significant difference between months as well as between species. Further, climate also had a non-significant influence on girth measurement in both sheep and goats. Physical dimensions of body approached mature dimension by 22-moths of age in goats (Ifut *et al.,* 1991).

5.5.3 LENGTH

The mean body length in sheep and goats averaged 61.72+0.19 cm and 63.51+0.28 cm respectively. The average body length measured in *Tellichery* and *Jamnapari* adult females were 66 and 127 cm respectively (Pattabiraman, 1955), whereas, Misra (1985) measured body length in *Malabari* goats as, 70.20 cm. Body length in *West African* dwarf goats, showed 80.3 cm in males and 83.5 cm in females. (Seifert and Waschko, 1991). Pavon (1986) measured body length in three types of ewes aged three years. They were 69.0+1.33, 71.0+0.8 and 67.0+1.4 cm in the three groups. Acharya (1992) reported body length in *Jamnapari* does as, 75.20 cm and *Malabari* does 63.20 cm.

Highly significant differences were noticed in sheep and goats in their body length, over months. It showed an increase with months. This finding is in agreement with the Singh *et al.* (1990). Body length had significant correlation with body height in age groups in *Black Bengal* goats (Mohapatra and Nayak, 1996).

In general the direction of changes and difference in body measurements were similar to that of body weight.

5.6 ETHOGRAM

Normal occurrence of behavior patterns of adult female sheep and goat are presented in Table 28. It also presents the classification of each patterns into one or more functional categories.

Sheep exhibited 39 of 42 patterns, of which nine patterns were commonly observed, 15 were often and 10 were occasionally noticed. In goats 36 patterns of 42 were frequently exhibited, six were observed often and one pattern was occasionally exhibited.

Ten out 42 patterns can be classified as those having primarily comfort, grooming or protective functions and seven patterns were of feeding and elimination, in sheep and goats. Three patterns were of social type. Eighteen patterns can be classified as agonistic, sexual, excitation, discomfort and play behaviour. Seven patterns were exclusively of agonistic nature exhibited more commonly by goats and rarely by sheep. Three of them were sexual, three patterns were both sexual and agonistic, two patterns in each were excitation, discomfort and playful acts and one pattern was agonistic or submissive ; observed more frequently in goats than in sheep. Two behavioural patterns were concerning rest or sleep in sheep and goats. Three behavioural patterns were not observed in sheep, *viz.*, arched tail, fore leg kicking and scratching with the horns.

When these animals were housed inside the shed, sheep and goats were less active and exhibited mainly rumination, sleep and defaecation. Grooming and rumination were the most common behaviour patterns exhibited by these species under confinement. Investigative behavior such as sniffing urine and faeces, licking objects and biting were less commonly observed in these places. No earlier reports on ethogram of sheep and goats of Kerala is existing. MacNamara and Eldrigde (1990) observed similar patterns in captive *Pudu* and *Red Brocket.* Biting, fore leg kicking, head rubbing, head pressing, muzzle tossing, rearing and kicking and fighting were also more commonly observed during rest period when they were in groups in an enclosed area. Further these behaviors were more commonly found and explicit in goats rather than in sheep. Low stretch and yawning were a typical patterns observed more frequently during rest period. Flehmen, tongue flipping and mounting were exhibited mainly during oestrous period.

Object and self oriented contact patterns were mainly observed as to dislodge adhering material on the body. *e. g.,* Head shaking , tail swishing, face and neck rubbing, licking, muzzle to body touching, scratching with the horns in case of goats were observed Probably while trying to get rid of the irritation on the body parts or for grooming the body.

Bleating/Bellowing was the commonly noticed behaviour pattern when they were taken for grazing, possibly due to the fear of being missed from the group. (Das *et al.,* 1990) observed similar vocalization in sheep and goats during grazing . Pawing the ground was seen commonly in goats and rarely in sheep. Walther, (1984) reported that pawing the ground is a common behaviour in artiodactyles. Cervids generally paw and scrape the ground before wallowing or when smelling a concespecific's urine or faeces (MacNamara and Eldrigde, 1990). This may be related to territorial activity (Fraser and Broom, 1990)

Tooth grinding was mainly observed in goats and rarely in sheep. This may be due to species differences and feeding habit differences. Rumination sounds and feeding sounds were also more audible in goats than in sheep. This may be due to the anatomical difference between sheep and goats with the latter having a bifid cleft.

Walk stretch was a common feature for goats than sheep. Stand stretch was noted in both the species. These were commonly observed soon after rising from the reclining position. Curled lateral recumbency was a common position and postures observed during rest and sleep. Wemmer *et al.* (1983) observed similar kind of patterns in male and female deer.

Feeding and digestive patterns were more evident in both the species. Grazing was a common feature in sheep and it was uncommon in goats whereas, browsing was more specific in goats and non-specific in sheep and it was only occasional. Goats spent their major time for browsing and sheep on grazing. Malechek and Provenza (1983) reported that goats differ fundamentally from sheep and other livestock in their sensory and morphological traits that appear to render them well adapted to utilization of leaves, buds and fruiting bodies of woody plants. Further, they were highly flexible in their feeding habits. Goats select more browse than sheep. Valerius, (1971) observed that goats were apparently phlegmatic climber, and showed rather wide variations in food habits. Das *et al.* (1990) and Anonymous, (1996) also reported similar observations.

Defaecation and urination were observed during foraging/feeding in ranges as well as at rest. Das *et al.* (1990) observed that both sheep and goats exhibited investigative and eliminative behavior during feeding in ranges.

In the present study it was found that maximum number of behavior patterns were exhibited by goats than in to sheep. Further, these patterns were more evident and clearly noticeable in goats when compared to sheep. These differences may be due to varied anatomy, feeding habits and social structures of these species. Gangyi *et al.* (1992) reported that most of the activities get expressed during the day-time except rumination and sleep.

Boval *et al.* (1992) observed that goats were highly active during day time when compared to sheep. Thus, the ethogram of sheep and goats observed in the hot-humid Kerala belonging to the south-western coastal regions of India have imilar facets and features as that reported from other parts of the world.

Summary

6. SUMMARY

The study was conducted for a period of one complete year during 1997-1998 to assess the comparative performance of *Malabari* goats and *Ramnad white* sheep and also to find out the adaptability of these animals to the to the environment prevailing in Mannuthy area of Kerala state in the western coastal strip of peninsular India. Effect of environmental factors on physiological norms, haematological parameters and body weight and body measurements were evaluated

Fifteen adult female *Ramnad white* sheep and fifteen adult female *Malabari* crossbred goats were selected for the study. These animals were housed together in an identical conventional type of goat shed. The roof was of asbestos sheet and the shed was well ventillated. The experimental animals were group-fed with a scientifically planned standard ration and were taken out for two hours grazing during the morning. Clean, fresh water was provided *ad libitum.*

The observations on physiological norms were taken for consecutively three days a week and daily observation of climatological variables were made. Heamatological parameters as well as morphometric observations were made once in a month for twelve months.

The mean maximum temperature during the study ranged from 28.93° C in the August to 36.57° C in the April and the minimum from 22.79° C to 25.62° C in the respective months. The relative humidity in the morning ranged from 78.48 per cent in January to 95.81 per cent in July. This range was 47.03 per cent in March to 80.35 per cent in August, during the afternoons. The hot and dry season recorded highest ambient temprature of 30.08° C and lowest during cold and wet season (26.16° C). The relative humidity was highest during cold and wet season (86.86 per cent) and it was lowest during hot and dry season (67.07 per cent).

The physiological norms *viz.*, rectal temperature, respiration rate and heart rate, recorded during the experiment, showed significant differences due to climatic variables, and the seasonal variations were evident in both sheep and goats. The mean rectal temperature recorded was 39.24°C in sheep and 39.22°C in goats. The differences in rectal temperature between sheep and goats during morning was significant ($P<0.05$), but it was non-significant in the evening hours. The hot and dry season recorded the highest values of rectal temperature and cold and wet season recorded the lowest in both sheep and goats.

The mean respiration rate was 38.86 and 41.19 per minute in sheep and goats respectively. Diurnal differences in respiration rates of sheep and goats showed a significant variation ($P<0.01$). These variations were similar in sheep and goats. Further, the seasonal variations in respiration rates were highly significant in both the species. The hot and dry season recorded the highest respiration rates and cold and wet season the lowest values.

The average heart rate per minute was 77.13 in sheep and 84.01 in goats. Significant differences due to species and climatic variability were observed. The diurnal differences in heart rate of both the species was highly significant. Also highly significant differences were found between sheep and goats in the diurnal recordings.

Among the haematological parameters, haemoglobin and serum potassium levels showed significant differences due to climatic variables. The ESR did not show a similar difference. The average haemoglobin levels of 11.34 g/100 ml of blood in sheep and 10.52 g/100 ml of blood in goats were observed during the experiment. The cold and wet season recorded highest haemoglobin values (12.53 g/100 ml in sheep and 11.23 g/100 ml of blood in goats). Highly significant species and seasonal differences ($P<0.01$) were evident.

Erythrocyte sedimention rate showed no-significant relationship with the ambient temperature in both sheep and goats. But it showed significant variations among the seasons in sheep. Highly significant difference in ESR was obsrved between sheep and goats. The average ESR values were 3.18 mm/24hr and 2.17 mm/24hr in sheep and goats respectively.

Highly significant relationship ($P<0.01$) between serum potassium levels and climatic variables were observed, in both sheep and goats. The seasonal variation in serum potassium levels was also significant. The average serum potassium levels recorded were 6.43 mEq/l in sheep and 6.22 mEq/l in goats. The differences between sheep and goats in the serum potassium levels were non-significant .

The analysis of variance of body weight revealed significant differences ($P<0.01$) between sheep and goats and also between months. The average body weight in sheep and goats recorded during the study was 23.46 kg and 26.08 kg respectively. The correlations between body weight and climatic variables were not significant in both the species.

The morphometric observations *viz.,* the height , girth, and length were recorded. The average height at withers, girth and length recorded during the study were 68.89, 70.18 and 61.72 cms respectively in sheep and 65.29, 67.61 and 63.51 cms in goats. The analysis of variance in all body measurements recorded during the experiment showed highly significant differences between sheep and goats. But, only the differences in the height at withers and body length in both the species, was significant ($P<0.01$) between months. It was non-significant in case of chest girth between sheep and goats.

ETHOGRAM

The observations of all basic behavioural patterns of both sheep and goats were made and an ethogram was prepared for sheep and goats under farm conditions.

Totally forty two behaviour patterns were observed during experiment in both sheep and goats. These patterns were classed under eight main behavioural categories *viz.*, gaits, animal oriented locomotion, visual patterns, object and self oriented patterns, vocal and non-vocal patterns, stretching patterns, stationary body positions and stances, and feeding, digestive and elimination patterns. During the experimental period the observation of basic behavioural patterns revealed that the maximum number of these patterns were exhibited by goats when compared to sheep. They were more evident and clearly noticeable in goats, while they were subdued and of less intensity in sheep.

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BIO-CLIMATOLOGICAL INFLUENCE ON PHYSIOLOGICAL NORMS OF SHEEP AND GOATS

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ABSTRACT OF A THESIS

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ABSTRACT

An experiment was conducted to compare the influence of climatic elements on the physiological norms of *Ramnad white* sheep (*Ovis aries*) and *Malabari* crossbred goats (*Capra hircus*) maintained at the goat and sheep farm of College of Veterinary and Animal Sciences, Mannuthy. The preparation of an ethogram for these animals maintained in the same shed under same managemental conditons were also made.

Fifteen adult females each of *Ramnad white* sheep *Malabari* crossbred goats were randomly selected for the study. The animals were maintained under a standard ration and housed together in a conventional type of goat shed. Animals were offerred clean fresh water *ad libitum* during the experiment.

The experiment was conducted for a period of one year during 1997-'98. The climatological observations such as ambient temperature, relative humidity, windstroke, sunshine and rainfall were recorded daily. Again the experimental period was classified as two seasons, *viz.,* rainy (includes, cold and wet; warm and wet) and dry (includes, warm and dry ; hot and dry) season, based on the climatological observations made during the experimental period.

Physiological norms, *viz.*, rectal temperature , respiration rate and heart rate were observed, and these showed significant higher rates during hotter months when compared to cooler months. The ambient temperature showed a positive correlation with physiological norms. On the other hand, the relative humidity showed negative correlation with the same, in both the species. The average rectal temperature recorded during the experimental period was 38.78°C in the morning and 39.69°C in the evening hours in sheep . The corresponding values in goats were 38.74°C and 39.69°C. The average respiration rates in sheep were 28.14 and 49.59 breathings per minute in the morning and evening. The respective figures in goats were 28.14 and 53.88 per minute. The corresponding heart rates during morning and evening were 66.54 and 87.72 in sheep and 73.61 and 94.38 beats per minute in goats. The hot and dry season recorded highest values for all these norms and cold and wet season the lowest.

Highly significant to significant diurnal variation ($P<0.01$) were observed in these norms in both sheep and goats. It was non-significant with respiration rates and showed a highly significant difference ($P<0.01$) in their heart rates, between sheep and goats. Further, the seasonal variations among all physiological norms were also significant.

Highly significant relationships were observed between climatic variables and haemoglobin percentage of blood and serum potassium in both the species. No such relationships were discernible in the case of ESR. The average values of heamoglobin, ESR and serum potassium were 11.34 g/100 ml, 3.18 mm/24hr and 6.43 mEq/l in sheep respectively. The corresponding values in goats were 10.52 g/100 ml of blood, 2.17 mm/24hr and 6.22 mEq/l respectively.

Ambient temperature and heamoglobin levels in both sheep and goats were negatively correlated and this showed a positve correlation with the relative humidity. The difference between the species was significant in their heamoglobin levels. The season also had a significant influence on heamoglobin levels of both sheep and goats. The ESR did not show significant relationship with the climatic variables in both the species. But the difference between the species was highly significant ($P<0.01$). The effect of seasons showed significant differences in sheep and was non-significant in goats. Highly significant negative correlation ($P<0.01$) was recorded between serum potassium levels of sheep and goats and ambient temperature. Relative humidity had a positive correlation with the serum potassium levels in both the species. Further, the differences between the species was non-significant. The season had a significant influence ($P<0.01$) on serum potassium levels in both sheep and goats

.

The average body weight recorded during the experiment was 23.46 kg in sheep and 26.08 kg in goats. Analysis of variance revealed significant differences in body weight between months and also between species. Climatic as well as seasonal influences were non-significant on body weights in both sheep and goats. Measurements of physical dimensions of the body were taken at monthly intervals for twelve months. The average values in sheep were 68.89 cm, height at withers ; 70.18 cm, chest girth and 61.72 cm, body length. The respective values in goats were 65.29 cm, height ; 67.61 cm, girth and 63.51 cm body length.

ETHOGRAM

The experimental animals were observed for their basic behavioural patterns for six hours in a day for a period of 700 hr during the study. Based on these observations the ethogram was constructed and compared between sheep and goats, under farm conditions.

Eight main behavioural categories consisting of forty two different behavioural patterns, grouped under different headings were used for the study. The behavioural categories included, gaits ; animal oriented locomotion ; visual patterns ; object and self oriented patterns ; vocal and non-vocal patterns ; stretching patterns ; stationary body positions and stances and feeding, digestive and elimination patterns. The results revealed that, the goats exhibited more number of behavioural patterns during the study period than sheep. The patterns observed in these species were stronger and more evident in goats than sheep. Further, goats preferred browsing over grazing and spent most of the alloted time for the same. Sheep utilised the maximum time for grazing activity, with occasional browsing on plants, trees, etc. Defaecation and urination were the common patterns exhibited along with the feeding activities.