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Effects of different meteorological variables on physiological parameters in black Bengal goat

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Abstract
Despite having well-developed mechanisms of thermoregulation, animal do not maintain strict homeothermy under extreme climatic condition. Harsh environments constitute stressful conditions to animals raised in extreme climatic areas, and as a result, animals develop various adaptive mechanisms that enable them to survive under conditions of extreme heat or extreme cold. The study entitled, "Effect of Meteorological variables on Physiological parameters in Black Bengal Goat" was conducted on twelve adult healthy Black Bengal Goats with the objective to determine the seasonal variations in different physiological responses. Twelve Black Bengal does were investigated for their physiological profiles during autumn (Oct to Nov) and winter (Dec to Jan) seasons. All Physiological parameters such as rectal temperature, respiration rate and heart rate measured daily at 6 A.M. and 3 P.M. throughout the study period. Meteorological parameters like dry bulb temperature and relative humidity were recorded daily for two times at 6 am and 3 pm for estimation of THI throughout the study period. In addition to that the meteorological data for last one year was also collected for estimation of THI. In the present study, the mean THI found during autumn and winter season was 70.45±0.60 and 57.58±0.91 respectively while the mean THI for last one year was 72.09±0.38 during autumn and 62.14±0.28 during winter season. During autumn season, the mean rectal temperature (^{0}F), respiration rate (breaths/min.) and heart rate (beats/min.) were 101.17±0.19, 25.50±0.43and 69.45±1.51 respectively. During winter season, the mean rectal temperature, respiration rate and heart rate were 98.67±0.29, 22.34±0.21and 67.55±0.88, respectively. Significant (P<0.05) differences were found in between day and season (autumn and winter) for all the physiological parameters during the experimental period. These physiological parameters were directly proportional to the THI.

Keywords: temperature humidity index, dry bulb temperature, wet bulb temperature

1. Introduction
The geographical distribution of Black Bengal Goat is found throughout north eastern India in the states of West Bengal, Jharkhand, Bihar and Orissa. Presently global warming, climate change, bioterrorism etc. are the most concerned challenges of the world. Among these challenges, the climate change is the most critical one that has an enormous impact on our planet's people, ecosystems, cities, and energy use. It is defined as the long-term imbalance of customary weather conditions such as temperature, radiation, wind and rainfall characteristics of a particular region.In tropical climate, both extreme hot and cold climatic conditions influence the animals' heat exchange process.

Goats (*Capra hircus*) are among the earliest animals domesticated by humans. The importance of goat in the rural economy is evidenced by its unparalleled economic traits, ability to get acclimatized under diversified agro-climatic condition, unfastidious type in choosing the available forage, high fertility and short generation interval. Economically goat is ideally suited for poor rural folk especially in low marginal and landless laborers due to low-cost maintenance, short-term return on capital with low risk on capital investment, no involvement of extraneous labour. Goats occupy a unique position since they are used as a multipurpose animal for production of milk, meat and fiber besides hides and skin. They are potential source of income in the villages and thrive upon minimum imputes through feeds and labour because of their small size, large surface area related body weight and limited subcutaneous fat cover. Goats adapt poorly to cold climates but make them relatively more adapted to areas of high temperatures (Shelton and spiller, 1977) [1]. Several researchers studied physiological adaptation mechanisms such as rectal temperature, pulse rate and respiration rate in small ruminants.

(Sevi *et al.*, 2001; Srikandakumar *et al.*, 2003; Maurya *et al.*, 2004; Marai *et al.*, 2007; Otoikhian *et al.*, 2009; Phulia *et al.*, 2010, Sharma *et al.*, 2013) [2-8].The seasons, and daily physical rhythms can have a profound effect on the physiology of the living organism. As demonstrated by several studies on serum and physiological parameters, a seasonal variation occurs in different animal species, and this is due to the hypothalamic suprachiasmatic nuclei activity. It is the principal generator of the rhythms which follow the life of an animal. The seasonal rythms reflect the endogenous adaptive mechanism to react in advance to the regular environmental changes associated with the seasons. Limited information is provided about the seasonal rythms of small ruminants. Goats adapted to a harsh environment, perform better than other domesticated ruminants (Shkolnik and Silanikove, 1981; King, 1983; Devendra, 1990) [9, 10, 11]. The range of thermo neutrality for goats is an environment having an air temperature of 13–27 ºC, relative humidity of 60-70 per cent (Mishra and Puneet, 2009) [12]. The temperature below and above this range makes animal stressful and reduces productivity. Goats have developed adaptive mechanisms that allow their survival at very high as well as very low temperatures (Al-Tamimi, 2007) [13].

Physiological equilibrium is maintained mainly by the blood in the body (Ahmed *et al.*,2003) [14]., but many physiological conditions may alter this equilibrium, namely: species, breed, sex, age, malnutrition, illness, reproductive status, season, nutrition and management systems etc. These can affect serum biochemistry of livestock animals (Swanson *et al.*,2004; Nazifi*et al.*,2003) [15, 16]. Goats appear to have superior adaptation to arid tropics because of its ability to conserve water,t ravel well, graze selectively and take willingly a wide Variety of vegetation (Meferlane and Howard, 1972; Maloity and Taylor 1971 and Merrill *et al.*,1965) [17, 18, 19]. Mountain areas with steep slopes cannot be used safely by cattle but may be used by goats (Haenlein,1978) [20].

Respiration rate, pulse rate and rectal temperature are the parameters which illustrate the mechanism of physiological adaptation. Goats adapted to a harsh environment, perform better than other domesticated ruminants (Shkolnik and Silanikove, 1981; King, 1983; Devendra, 1990) [9, 10, 11]. The range of thermo neutrality for goats is an environment having an air temperature of 13–27 ºC, relative humidity of 60-70 per cent (Mishra and Puneet, 2009) [12]. The temperature below and above this range makes animal stressful and reduces productivity. Goats have developed adaptive mechanisms that allow their survival at very high as well as very low temperatures (Al-Tamimi, 2007) [13]. Variation in physiological parameters in response to climatic variation has not been studied in Black Bengal Goats. So, the present study was conducted to observe the effect of climatic variation on various physiological parameters of Black Bengal Goats.

2. Materials and Methods

Healthy Black Bengal does n=12, having approximately average body weight of 8 to 14 kg and age 8-24 months, reared under uniform managemental husbandry practices were selected from, Instructional Farm of Small Ruminants (I.F.S.R.) College of Veterinary Science and A.H. Birsa Agricultural University, Kanke, Ranchi for the present experiment. Selected does were isolated from the herd at least fifteen days prior to start of the experiment.

2.1 Preparation of experimental animal

The does were provided green fodder, routine grazing (daily for four to six hours) with balanced ration. Animals were maintained on a standard ration (Maize 42.25%, Wheat bran 37%, GNC 18.5%, Mineral mixture2%, Common salt 0.25%, NRC 1980) at the rate of 250 gm/animal/day with green fodder and the water was provided *ad- libitum***.** The animals were dewormed with anthelmintic Fembendazole @ 10mg/kg of body weight 15 days prior to the start of experiment. The animals were kept in Instructional Farm of Small Ruminants, RVC. The experiments were conducted during two seasons i.e., autumn (Oct-Nov) and winter(Dec- Jan).The selected twelve animals were maintained at normal animal husbandry practices.

2.2 Meteorological Parameter

Climatic variables viz temperature, relative humidity was recorded. Temperature humidity index was calculated as per Johnson formula (1972)- THI = 0.72 (DBT+WBT) + 40.6. Where, THI is temperature humidity index, DBT is dry bulb temperature, WBT is wet bulb temperature

2.3 Physiological Parameter

Physiological parameters viz rectal temperature, respiration rate and heart rate of every animal were recorded at 6am and 3 pm daily from the start of experiment up to 120 days. The rectal temperature was measured by using a Clinical thermometer inserted into the rectum and left in position, there after the reading was taken. Respiration rate was recorded as the number of frequencies of flank movement per 20 second and later calculated as breaths per minute. Heart rate was recorded as beats per minute by placing the stethoscope on the chest of the goats to determine the rhythmic beats of the heart which was later calculated as beats per minute.

3. Results and Discussion

Climatic changes have range of impact on physical, mental & community health of animals. The present experiment was conducted to study the effect of meteorological variables on physiological parameters in Black Bengal Goat. Despite having well-developed mechanisms of thermoregulation, animal do not maintain strict homeothermy under extreme climatic condition. Harsh environments constitute stressful conditions to animals raised in extreme climatic areas, and as a result, animals develop various adaptive mechanisms that enable them to survive under conditions of extreme heat or extreme cold.

3.1 Meteorological parameters

3.1.1Ambient temperature (ºC)

The following table-1 shows the ambient temperature of autumn & winter as recorded at 15th day interval at different period for the shades of experimental animals.

Table 1: Ambient temperature (ºC) of autumn and winter season at different periods (Mean ±SE).

Days	Autumn	Winter	t value (P critical)
15th day	17.27±0.40^{b}	6.91±0.62^{b}	7.00**
30th day	15.29±0.53^{b}	3.55±0.60^{a}	7.74**
45th day	16.43±1.07^{b}	3.89±0.40^{a}	3.00**
60th day	10.74±1.03^{a}	5.16±0.88^{ab}	0.009**
F value	12.79**	5.53**	

NS - $P \geq 0.05$; *$P<0.05$ - Significant; **$P<0.01$- Highly Significant.

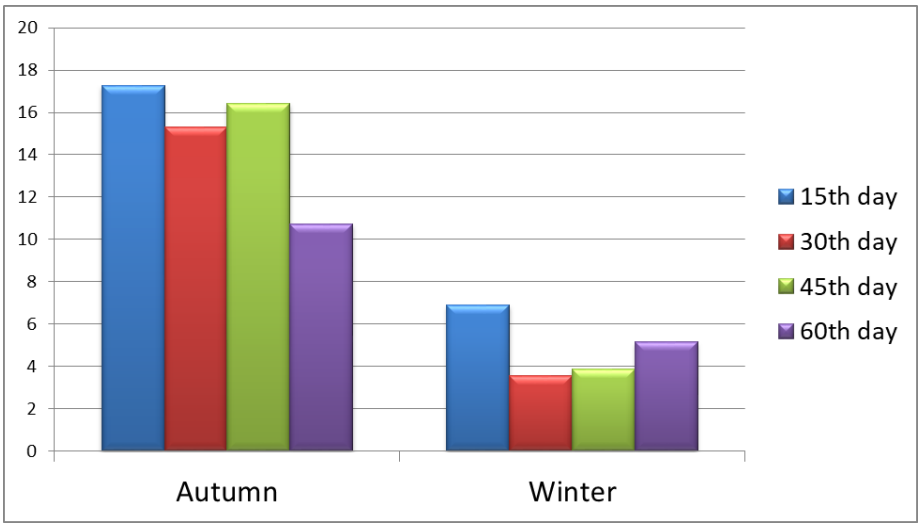

Fig 1: Bar diagram depicting the Ambient temperature (ºc) of autumn and winter season at different periods (Mean ±SE).

As observed from table no-1, mean ambient temperature in autumn recorded 15th day interval was 17.27±0.40, 15.29±0.53, 16.43±1.07 and 10.74±1.03 at 15th, 30th, 45th and 60th day respectively. The mean ambient temperature was found to be significantly lower (p<0.01) on day 60th during autumn. Similarly, during winter season, the mean ambient temperature recorded on 15th day was found to be significantly (p<0.01) higher as compared to that was on day 30th and 45th. The mean ambient temperature was found to be 6.91±0.62, 3.55±0.60, 3.89±0.40 and 5.16±0.88 on 15th day, 30th, 45th and 60th respectively. Significantly lower level of ambient temperature (p<0.01) was observed on day 60 as compared to day 15, 30 and 45 during autumn. The difference in ambient temperature between autumn and winter was found to be highly significant on each fortnight, it was higher during autumn whereas it was lower than the thermal comfort zone (12-24) during winter, and it was ≤ 5which creates cold stress in animals.

3.1.2 Relative humidity (%)

Table-2 suggests that the difference between relative humidity was non-significant between autumn and winter at all the fortnights except for that at day 15th. The t-value (p critical) in that case was 0.04 (p<0.05) and thus the relative humidity was significantly higher in autumn (69±0.33) than in winter (66.4±1.22).Relative humidity on 15th,30th,45th and 60th day in autumn was observed to be 69±0.33, 70.06±1.29, 66.4±2.43, and 65.26±1.76 respectively, while during winter, the relative humidity was found to be 66.4±1.22, 66.73±1.65, 67.8±0.50 and 67.53±0.74 on 15th, 30th, 45th and 60th day respectively.

Table 2: Relative humidity (%) of Autumn and Winter season at different periods (Mean±SE).

Days	Autumn	Winter	t value (P critical)
15th day	69±0.33	66.4±1.22	0.04*
30th day	70.06±1.29	66.73±1.65	0.12^{NS}
45th day	66.4±2.43	67.8±0.50	0.56^{NS}
60th day	65.26±1.76	67.53±0.74	0.28^{NS}
F value	1.83^{NS}	0.34^{NS}	

NS - P≥0.05; *P<0.05 - Significant; **P<0.01- Highly Significant.

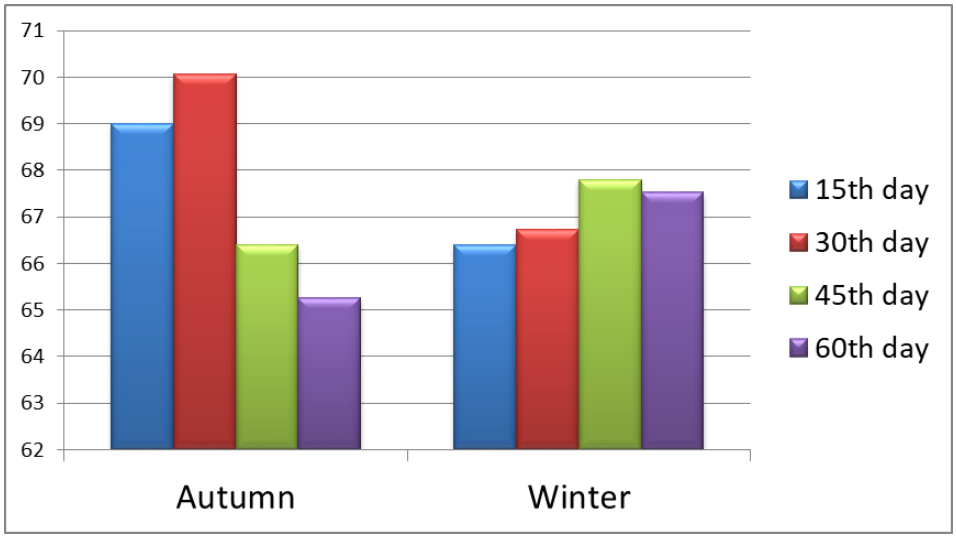

Fig 2: Bar diagram depicting relative humidity (%) of autumn and winter season at different periods (Mean±SE).

Statistically, non-significant differences were observed in average relative humidity (%) on different fortnights during autumn as well as during winter (Fig 2). There was a gradual fall in relative humidity during winter whereas a rise was observed on day 30 during autumn followed by a gradual fall on day 45 and 60. In our finding the average relative humidity during was higher than the findings of Rathwa*et al*. (2017) [21], may because of heavy rainfall in this region (tropical humid).

3.1.3 Temperature humidity index

The mean (Temperature humidity index) THI value have been found to be 72.48±0.45, 70.45±0.60, 72.73±1.23 and 66.64±0.97 for 15th, 30th, 45th and 60th day respectively. The F value of 10.54 (P<0.01) was highly significant indicating significant variation in THI value at periodical interval. The highest mean THI value was 63.87±0.56 as recorded at 15th day of winter followed by mean value of 57.58±0.91, 58.29±0.68 and 60.89±1.13 at 30th, 45th and 60th day respectively (Table 3, Fig 3).The difference between THI value of autumn and winter was found to be highly significant (P<0.01) at 15th, 30th, 45th day interval and significant (P<0.05) at 60th day interval. Although the THI value of autumn was higher than winter at all the four fortnightly intervals.

Table 3: Temperature humidity index of autumn and winter season at different periods (Mean±SE).

Days	Autumn	Winter	t value (P critical)
15th day	72.48±0.45^{b}	63.87±0.56^{c}	0.00**
30th day	70.45±0.60^{b}	57.58±0.91^{a}	0.00**
45th day	72.73±1.23^{b}	58.29±0.68^{a}	0.00**
60th day	66.64±0.97^{a}	60.89±1.13^{b}	0.01*
F value	10.54**	11.29**	

NS - P≥0.05; *P<0.05 - Significant; **P<0.01- Highly Significant.

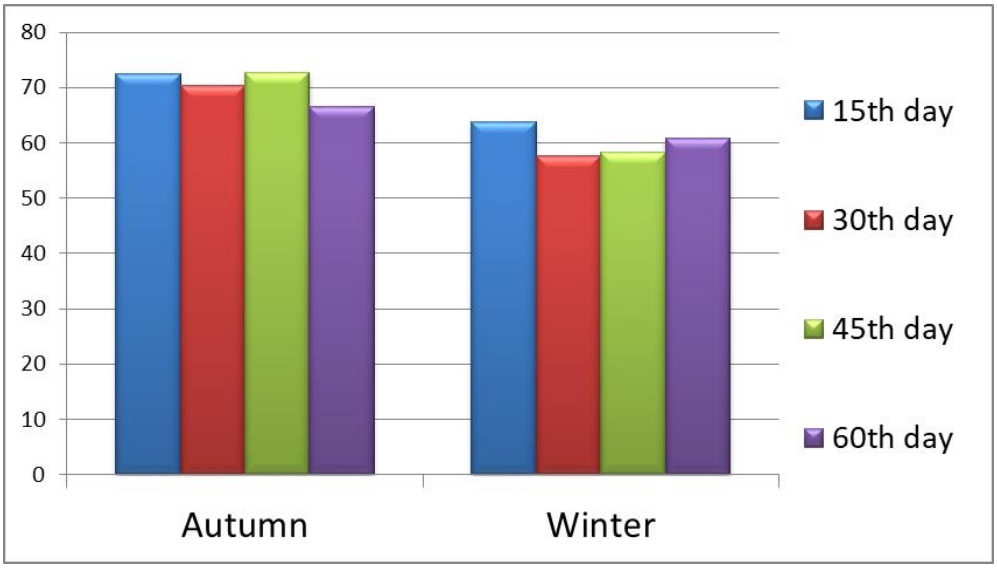

Fig 3: Bar diagram depicting Temperature humidity index of autumn and winter season at different periods (Mean±SE).

In the present study, significant differences were observed within season as well as between seasons.Significantly lower level of THI (p<0.01) was observed on day 60 during autumn whereas significantly lower level of THI (p<0.01) was observed on day 30 and 45 as compared to day 60 and 45. The THI was significantly higher during autumn as compared to winter is in consistent with the findings of Rathwa*et al.* (2017) [21] who also reporteda higher THI during summer.

3.2 Physiological parameters

To maintain body homeostasis, domestic animals respond to hot environments in various ways, such as changes in rectal temperature and respiration rate (Sano *et al.*, 1985). Physiological responses like rectal temperature, respiration rate and heart rate reflect the degree of stress imposed on animals (Ganaie*et al.*, 2013) [22].

3.2.1 Rectal temperature (ºF)

Rectal temperature recorded was 101.61±0.29, 102.10±0.20, 101.66±0.28 and 101.17±0.19 at 15th, 30th, 45th and 60th day respectively during autumn season. The difference between rectal temperature as recorded was found to be non-significant (P≥0.05). During Winter season, the F value of 20.37 (p<0.01) was found to be highly significant for variation between rectal temperature as recorded at 15th, 30th, 45th and 60th day (Table 4, Fig 4). The rectal temperature at 15th day during winter was found to be highest (100.51 ± 0.06ºC) and lowest at 30th day (98.67±0.29ºC).

Table 4: Rectal temperature (ºF) of Black Bengal Goats in autumn and winter season at different periods (Mean±SE).

Days	Autumn	Winter	t value (P critical)
15th day	101.61±0.29	100.51±0.06^{c}	0.002**
30th day	102.10±0.20	98.67±0.29^{a}	1.32**
45th day	101.66±0.26	99.09±0.14^{ab}	4.76**
60th day	101.17±0.19	99.38±0.12^{b}	1.63**
F value	2.57^{NS}	20.37**	

NS - P≥0.05; *P<0.05 - Significant; **P<0.01- Highly Significant.

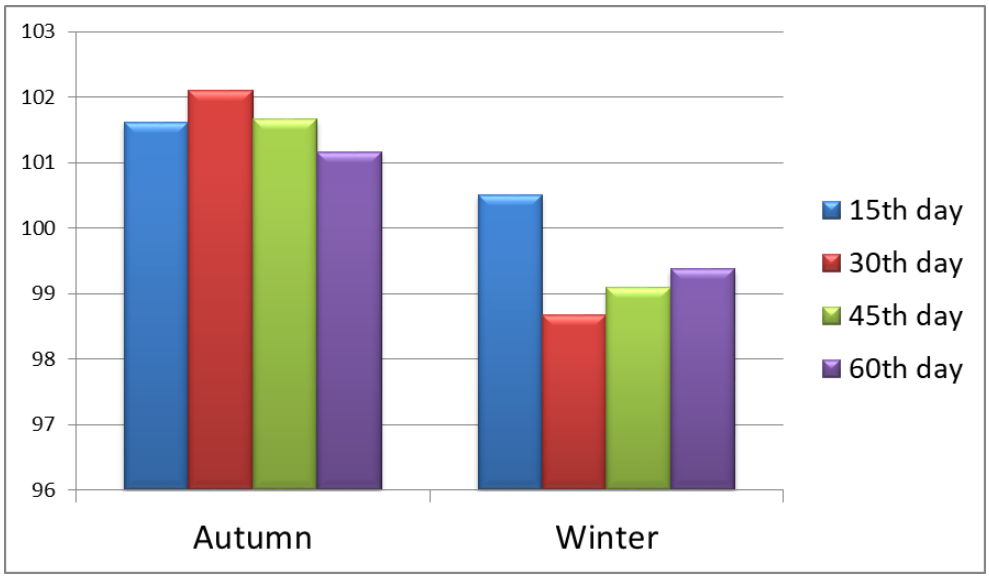

Fig 4: Bar diagram depicting Rectal temperature (˚F) of Black Bengal Goats in autumn and winter season at different periods (Mean±SE)

In the present study, significantly higher rectal temperature was observed on each fortnight during autumn as compare to winter.This reduction in mean value of rectal temperature is also an indication of decreased skin temperature caused by decreased peripheral blood flow. Significant differences in rectal temperature were recorded on different days during winter is associated with similar pattern of variation in ambient temperature. The range of rectal temperature during winter in our findings is in close proximity to the findings of Rathwa*et al*. (2017) [21] who reported a mean rectal temperature of (99.96 ºF) but the ambient temperature was higher they reported compared to present study, which indicates the animals were not adversely affected by cold exposure during winter or they were adapted to cold climate. The average rectal temperature recorded were below normal range as described by Melvin and William, 1996 [23], may because of fall in ambient temperature below 5ºCduring winter

3.2.2 Respiration rate (breaths/min)

A comparison of the mean value of this physiological parameter revealed significant variation ($P<0.05$) in the mean respiration rate with respect to the effect of season at 15th, 30th and 45th day while the effect was highly significant ($P<0.01$) at 60th day (Table 5, Fig 5). The mean respiration rate during autumn was found out to be greater than that of winter for all the periodical intervals. Greatest mean respiration rate was highest at 15th day, the value being 25.50±0.43 while it was highest at 60th day during winter (22.34±021 breaths/ minute). And the lowest mean respiration rate is 23.08±0.16 breaths/min at 60th day during autumn and 21.00±0.26 breaths/ min at 15th day during winter.

Table 5: Respiration rate (breaths/min) of Black Bengal Goats in autumn and winter season at different periods (Mean±SE).

Days	Autumn	Winter	t value (Pcritical)
15th day	25.50±0.43^{c}	21.00±0.26^{a}	1.25*
30th day	25.37±0.35^{c}	21.39±0.40^{a}	5.31*
45th day	24.45±0.21^{b}	21.81±0.29^{ab}	1.14*
60th day	23.08±0.16^{a}	22.34±0.21^{b}	0.008**
F value	13.48**	3.71*	

NS - $P\geq0.05$; *$P<0.05$ - Significant; **$P<0.01$- Highly Significant.

In the present study, significant differences in average respiration rate were recorded on different days during autumn ($p<0.01$) as well as during winter ($p<0.05$). There was a gradual decrease in respiration rate during autumn whereas the trend was rising during winter.Significantly lower level of respiration rate was observed during winter as compared to autumn could be to reduce evaporative heat loss through respiration known as physical regulation (Melvin and William, 1996) [23].

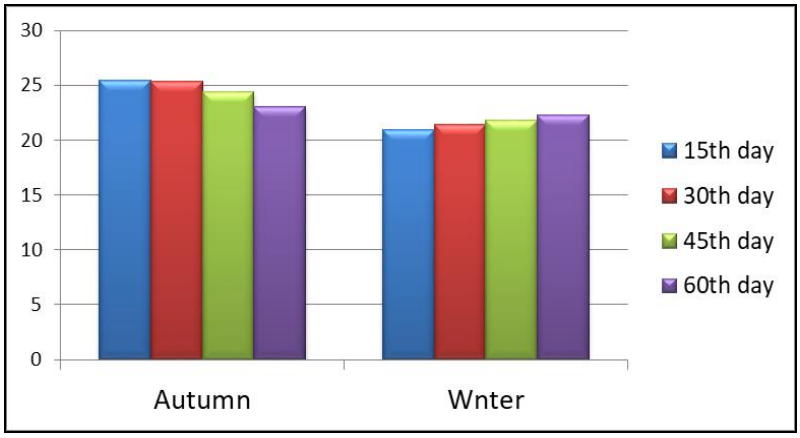

Fig 5: Respiration rate (breaths/min) of Black Bengal Goats in autumn and winter season at different periods (Mean±SE)

3.2.3 Heart rate (beats/min)

The mean heart rate of 67.85±1.35, 69.14±1.39, 69.45±1.51 and 68.87±1.13 beats/ min was recorded at 15th, 30th, 45th and 60th day respectively and the difference between mean heart rate was non-significant (p<0.01). Further during winter, the mean value of heart rate was 67.55±0.88, 67.07±0.85, 67.13±0.94 and 67.04±0.88beats/min for 15th, 30th, 45th and 60th day respectively (Table 6, Fig 6).Although mean heart rate was greater in autumn than in winter at all the intervals, the difference was highly significant (p<0.01) at 60th day, significant (p<0.05) at 30th and 45th day.Significant differences were observed in average heart rate between autumn and winter on day 30 to 60, comparatively higher during summer may be due to vasodilatation of skin capillary bed and consequently increase in blood flow to body surface areas to facilitate heat dissipation.The average heart rate recorded in our finding was lower than those reported by Rathwa*et al*. (2017) [21] could be because of higher ambient temperature they found.

Table 6: Heart rate (beats/min) of Black Bengal Goats in autumn and winter season at different periods (Mean±SE).

Days	Autumn	Winter	t value (P critical)
15th day	67.85±1.35	67.55±0.88	0.741^{NS}
30th day	69.14±1.39	67.07±0.85	0.015*
45th day	69.45±1.51	67.13±0.94	0.014*
60th day	68.87±1.13	67.04±0.88	0.008**
F value	0.26^{NS}	0.07^{NS}	

NS - P≥0.05; *P<0.05 - Significant; **P<0.01- Highly Significant.

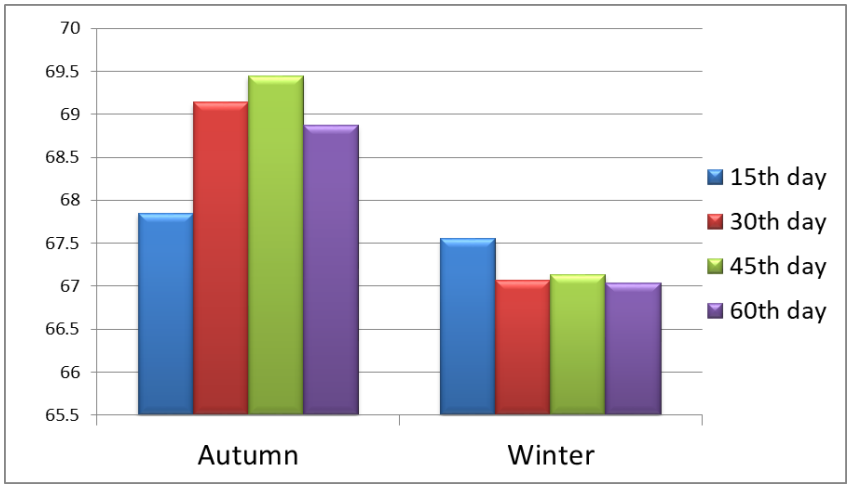

Fig 6: Bar diagram depicting Heart rate (beats/min) of Black Bengal Goats in autumn and winter season at different periods (Mean±SE).

4. Conclusion

The present study reports the effect of climatic parameters on physiological parameters during the period of autumn and winter in Black Bengal Goats. Significant variation observed in basic parameters like rectal temperature, respiration rate, heart beat during both the period which was in accordance with the reports observed for other breed of goats. The study will be helpful in investing the health status of animal in relation to various deseases in different climatic aspect.

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