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Seasonal variation of physiological response in ewes of farmers' flocks under semi-arid tropical environment

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This study was conducted to document the seasonal variation in physiological responses of sheep in farmers' flocks under extreme climatic conditions of semi-arid tropical regions. The study was carried out for one year (2012–2013). Forty-eight ewes of 2–4 year age were selected from three villages (two farmers from each village, eight ewes from each farmer). All the ewes were maintained by the farmers in their own management system. They used to take the animals for grazing morning (07:30 h) to evening (17:30 h). No extra mineral and concentrate supplementation were provided to the animals by the farmers. Farmers used to keep the animals in open areas within a surrounding during the night without any shelter above head. Respiration rate (RR), pulse rate (PR), and rectal temperature (RT) were recorded at morning (08:00 h), after noon (14:00 h), and evening (19:00 h) in summer (May–June), autumn (September–October) and winter (December–January) seasons three times at 15 days interval. The meteorological data in the farmers field were recorded twice daily at 8:00 h and 14:00 h for the entire study period. The study indicated significant ($p < 0.01$) variation in RR and PR with respect to season. Further, the time of the day also had significant ($p < 0.05$) effect on RR, PR, and RT in all season. Hence, it is pertinent to conclude from this study that seasonal variation had severe impact on physiological responses of sheep in field conditions.

Keywords: respiration rate; pulse rate; rectal temperature; semi-arid tropic; farmers flock; sheep

1. Introduction

Sheep are an important livestock species of arid and semi-arid tropical climate, especially in western India. Tropical regions characterized by high levels of solar radiation and temperature are known to adversely affect the animal production (McManus et al. 2009; Naqvi & Sejian 2010). The main problem in this region is the high ambient temperature which remains above thermo neutral zone for eight months. This high ambient temperature is the major constraint on animal productivity (Marai et al. 1995, 2007; Shelton 2000). Effect of high ambient temperature gets aggravated when heat stress is accompanied by high ambient humidity (Marai et al. 2007; Abdel-Hafez 2002). This type of climate negatively affects the sheep performance. Body temperature rise and increased respiration rate (RR) are the common signs of heat stress in sheep. The increase in body temperature is associated with marked reduction in feed intake, redistribution in blood flow, and changes in endocrine functions that will negatively affect the

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productive and reproductive performance of the sheep (Abouheif & Alsobayel 1982, 1983; Eltawill & Narendran 1990). The cardio respiratory system can also be influenced by season, day timings, ambient temperature, humidity, and exercise (Fahmy 1994; Marai et al. 2007). Daily variation of body temperature of endothermic animals is influenced by changes in physiological activity and metabolic changes (Stainer et al. 1984). In such adverse conditions, the physiological adjustments are essential to maintain the normal body temperature and to prevent hyperthermia (Bhattacharya & Uwayjan 1975; Al-Haidary 2000; Lowe et al. 2001).

In a semi-arid tropical climate, farmers rear their sheep mostly in an extensive production system, where the animal graze in the day time and remain under shelter only at the night. During noon in extreme heat, the animal remains protected under a tree shed. In this system of rearing, thousands of farmers in semi-arid tropical regions, especially western India, are earning their livelihood. But, no study has been conducted on the rhythmic changes in physiological responses of sheep to maintain thermo regulation during different seasons in farmers' flocks under field conditions. Most of the studies on this aspect were carried out in organized institutional farms under controlled conditions, where animals remained well protected from climatic variations. The information generated at farmer's flock will definitely be beneficial in formulating the strategies for better shelter management at farmer's level. Therefore, this study was carried out in farmers' flocks to document the seasonal variations in physiological responses of sheep under extreme climatic conditions of semi-arid tropical region.

2. Materials and methods

2.1. Location of the study

The experiment was carried out in farmers' flocks at three villages in the Tonk district of the Rajasthan State of India. These villages are located in the semi-arid region of the country almost at longitude 75°28′E and the latitude of 26°26′N and at altitude of 320 m above mean sea level. The average annual maximum and minimum ambient temperature ranges between 6 and 46 °C. The mean annual relative humidity (RH) ranges from 20 to 85% round the year. The annual rainfall in this area ranges from 200 to 400 mm with an erratic distribution throughout the year. The experiment was carried out in 2012–2013. The meteorological data at farmers' field condition were recorded twice daily at 8:00 and 14:00 h for the entire study period. The mean environmental temperatures, RH, temperature humidity index (THI), wind velocity (WV), and day length during the study period are depicted in Table 1. THI was calculated by the formula described by Marai et al. (2007).

2.2. Animals

The Kheri breed was selected for this study. It is a hardy sheep breed of arid and semi-arid areas of Western tropical India and mainly reared for the purpose of mutton. Selected three villages were located surrounding the Central Sheep and Wool Research Institute, Avikanagar. Two farmers were selected from each village. Eight ewes were taken from each flock for the entire study. The selected ewes were of 2–4 years of age and weighing between 22 and 31 kg. The animals were kept within a fence/boundary only in the night without any protection over head in the back-yard of the farmers' house. The grazer used to take the animal into the grazing field in the morning (07:30 h) to the evening (17:30 h). The vegetation cover of the grazing land consisted of *Cynodon dactylon, Desmostachya*

Table 1. Mean (± SEM) of climatological data measured during the experimental period.

	THI morning	THI afternoon	THI evening	Max T (°C)	Min T (°C)	RH (%) morning	RH (%) afternoon	WV (m/s)	Day length (hrs)
Summer	26.51 ± 0.36	32.77 ± 0.49	31.14 ± 0.29	44.32 ± 1.61	30.75 ± 0.55	61.17 ± 4.19	41.83 ± 1.66	5.90 ± 0.30	10.28 ± 0.12
Winter	12.13 ± 0.81	18.92 ± 1.19	14.77 ± 1.10	26.07 ± 1.26	9.58 ± 1.95	79.83 ± 1.08	53.33 ± 2.14	1.85 ± 0.09	8.15 ± 0.22
Autumn	18.67 ± 0.65	28.45 ± 0.44	21.63 ± 0.56	36.72 ± 1.19	17.63 ± 0.68	83.67 ± 1.56	63.00 ± 4.07	1.89 ± 0.15	9.51 ± 0.11

Notes: THI temperature humidity index, Min T minimum temperature, Max T maximum temperature, RH relative humidity, WV wind velocity.
Morning reading was taken at 08:00 h, afternoon reading was taken at 14:00 h.

bipinnata, Celosia argentia, Cenchrus biflorus, Tephrosia purpuria, and *Kagler* grasses; *Zizyphus nummularia, Calotropis procera,* and *Capparis deciduas* shrubs; and *Zizyphus jujube, Acacia nilotica, Azadirachata indica,* and *Prosopis cineraria* fodder trees (Chaturvedi et al. 2012). No extra supplementation of concentrate or mineral mixture was provided to the ewes. In the extreme hot or during summer months in the noon time, the animals took shelter under the shade of large tree in the grazing field. The ewes drunk water from the nearby pond of the grazing area in the way of grazing in the morning, noon, and way to come back home from grazing. Prophylactic measures against sheep diseases like sheep pox, peste des petits ruminants, enterotoxaemia, and endo and ectoparasitic infestations were carried out as directed by the local health center of the village.

2.3. *Experimental procedure*

The study was conducted for one year in farmers' flocks under their own management practices. Physiological responses such as RR, pulse rate (PR), and rectal temperature (RT) were recorded thrice daily at morning (08:00 h), afternoon (14:00 h), and evening (19:00 h). The record was taken in three seasons viz. summer (May–June), winter (September–October), and autumn (December–January). In each season, physiological responses were recorded three times at 15 days interval.

2.4. *Data analysis*

Data were analyzed by GLM (SPSS 16.0, Chicago, IL, USA). The linear model was used for all the respondent variables using least squares analysis of variance. Comparison of means of the different seasons was made by Tukey's tests.

3. Results

3.1. *Respiration rate*

The effect of season on RR is depicted in Figure 1. Season had significant ($p < 0.01$) effect on RR. RR differed significantly ($p < 0.05$) between season in morning, afternoon,

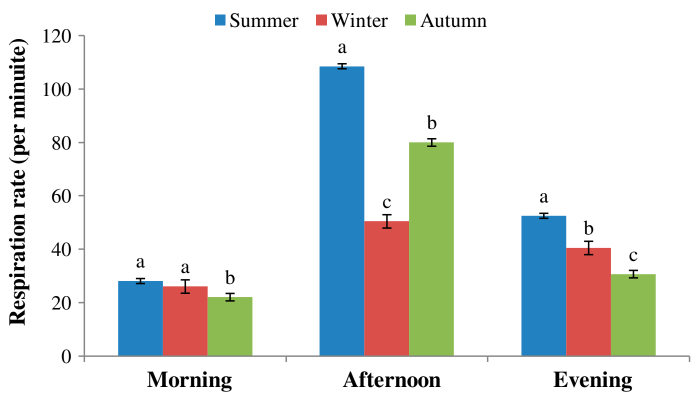

Figure 1. Effect of season on RR of ewes of farmers' flocks. RR in experimental animals were taken in the morning (08:00 h), afternoon (14:00 h), and evening (19:00 h) for 15 days interval during summer (May–June), autumn (September–October), and winter (December–January). RR of ewes varied significantly ($p < 0.01$) between the season. Similar superscripts bearing column within a group did not differ significantly ($p < 0.05$).

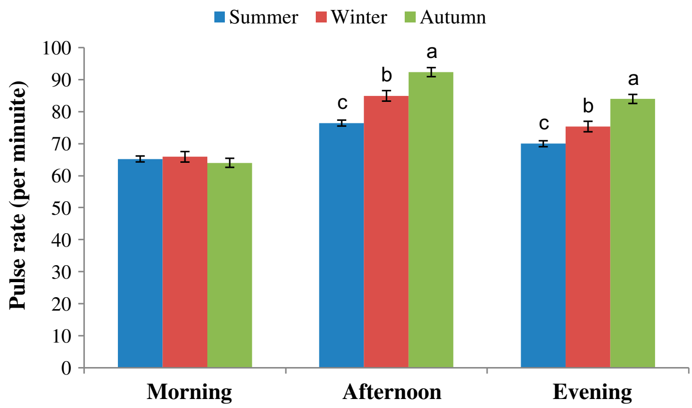

Figure 2. Effect of season on PR of ewes of farmers' flocks. PR in experimental animals were taken in morning (08:00 h), afternoon (14:00 h), and evening (19:00 h) for 15 days interval during summer (May–June), autumn (September–October), and winter (December–January). PR of ewes varied significantly ($p < 0.01$) between the season. Similar superscripts bearing column within a group did not differ significantly ($p < 0.05$).

and evening also. In all three seasons, RR increased significantly ($p < 0.05$) from morning to afternoon and again it reduced in the evening. Animal showed significantly ($p < 0.05$) higher RR in summer season. In all three times of the day (morning, afternoon, and evening) significantly ($p < 0.05$) higher RR was recorded in summer as compared to other season.

3.2. Pulse rate

The effect of season on PR is presented in Figure 2. It was found that PR differed significantly ($p < 0.01$) with changes of season. The PR remained significantly higher

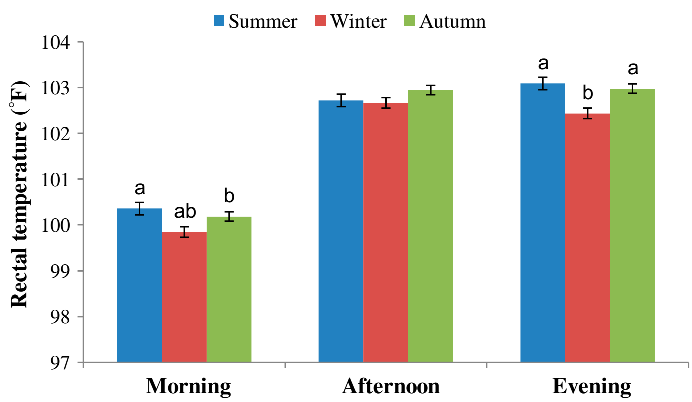

Figure 3. Effect of season on RT of ewes of farmers' flocks. RT in experimental animals were taken in morning (08:00 h), afternoon (14:00 h), and evening (19:00 h) for 15 days interval during summer (May–June), autumn (September–October), and winter (December–January). RT of ewes did not differ significantly ($p < 0.01$) between the season. Similar superscripts bearing column within a group did not differ significantly ($p < 0.05$).

($p < 0.05$) in afternoon than morning and evening in all the seasons. There was significantly ($p < 0.05$) higher PR in autumn followed by winter and summer. Afternoon and evening PR of autumn was significantly ($p < 0.05$) higher than other seasons.

3.3. Rectal temperature

Figure 3 describes the effect of season on RT of sheep in farmers' flocks. Season had no significant effect on overall RT. But it remained significantly ($p < 0.05$) higher in morning in summer season than in winter. In evening also it was significantly ($p < 0.05$) higher in summer than the winter. Except winter maximum RT was recorded in evening.

4. Discussion

Season cycle of physiological functions to cope with seasonal fluctuations in climate and food availability is common in most of the species (Patkowski et al. 2006; Duarte et al. 2010). These seasonal rhythms reflect the endogenous adaptive mechanism to react in advance to the regular environmental changes associated with the seasons (Piccione et al. 2009). The present study also establishes the variation of physiological response of sheep in farmers' flocks under semi-arid tropic region in respect to different seasons.

RR is an indicator of heat stress (Habeeb et al. 1992). The present study showed significantly higher RR in the summer season. Fahmy (1994) and Marai et al. (1997) also described that, during summer, the RR is higher than in winter for sheep. Shalaby (1985), Yousef (1985), and Marai et al. (1997) observed the trend in RR in Egyptian Rahmani, Ossimi, and Ossimi × Suffolk crossbred ewes, they found that RR was markedly lower at 8:00 than at 12:00 and 16:00, and the trend is similar in winter as well, which is in agreement with our present study where we found maximum RR in afternoon (14:00 h) and was significantly lower in the morning (08:00 h) in all seasons. Sejian et al. (2012) also found higher RR in the afternoon than morning in Malpura sheep of this region. In natural thermo-neutral conditions, CO_2 is eliminated from the tissues of the body and provide O_2 through respiration (Marai et al. 2007). Thompson (1985) reported that sheep loose approximately 20% of total body heat via respiratory moisture in a neutral environmental temperature (12 °C) but environmental temperature increased in the summer and during afternoon (14:00 h), which causes increased heat load of animal as well as higher RR to dissipate heat load from the body.

The PR reflects primarily the homeostasis of circulation along with the general metabolic status. The rate increases on exposure to high environmental temperature (Aboul-Naga 1987). But our result indicated that significantly higher PR in autumn which is contradictory to previous observations. It is well documented that seasonal variation in heart rate is expected because basal metabolic rate (Blaxter & Boyne 1982) and the amount of food consumed per day (Gordon 1964; Milne et al. 1978; Kay 1979) varied with season. Here in this Western Indian semi-arid tropical region, feed availability for the grazing is increased during autumn along with that environmental temperature also reduced somewhat than summer. In this period, grazers do not allow the animal to take rest under the tree shade in the noon and go for continuous grazing. So this increased walking for grazing and higher feed intake altogether increased the metabolic rate of the animal, which may be the possible reason of increased PR in the autumn in our study. Mittal and Gosh (1979), and Singh et al. (1980) reported that the PR was significantly lower in the morning (8:00) than during the afternoon (15:00) in Corriedale, Marwari and Magra sheep which is similar to our findings. In a recent study, Sejian et al. (2013)

also reported higher PR in afternoon than morning in Malpura ewes. This was expected because metabolic rate is known to show the same pattern, and changes in metabolic rate are likely to be reflected in changes in heart rate (Baldock et al 1988).

Sheep are homoeothermic animals; they can maintain near constant body temperature under a wide range of environmental conditions. Under thermoneutral conditions, they can keep their body temperature in a normal range utilizing sensible heat loss (convection, conduction, and radiation) to dissipate body heat to the surrounding environment. The RT is often used as a representative measurement of animal core temperature, for practical purposes (Nieslon 1997). During exposure to heat stress, the hyperthermia is the result of decreased thermal gradient between animal and the surrounding environment, and as a result, sensible heat loss becomes less effective. Under these conditions, animals must rely on evaporative cooling mechanisms from the skin and the respiratory tract (Al-Haidary 2004). Our study also showed no significant effect of season on RT but significantly ($p < 0.05$) higher RR during summer season.

Exposure to heat stress is registered by the temperature–humidity index that includes both ambient temperature and RH (LPHSI 1990; Marai et al. 2001). In winter nights, animals remain exposed to extreme cold without any shed, so in the winter THI decreased and animals were unable to maintain their core body temperature and their RT decreased. In the summer season, the THI prevails higher during the evening as well, that may cause significantly higher RT in the evening in summer as compared to other seasons.

5. Conclusions

The present study clearly indicates that seasonal variation has severe impact on physiological responses to maintain thermo regulations. This is evident from the significant variation in physiological responses. Rhythmic changes in physiological response with the season definitely reflects that, although the local breed is well adapted to the semi-arid tropical climate; still they need protection during the afternoon (14:00 h) in summer and autumn, along with that they should be provided with shelter in nights during the winter season to maintain their body temperature and hence production.

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