Effect of Housing on Physiological Responses and Energy Expenditure of Sheep in a Semi-arid Region of India

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ABSTRACT : An investigation was carried out to study the effect of two housing systems on physiological responses and energy expenditure of sheep in a semi-arid region of India. Two types of housing management were adopted. First was a shed- 6×3 m^2 structure with all the four sides of 1.8 m chain link fencing with a central height of 3 m. The roof was covered with asbestos sheets and with mud floorings. Second was an open corral- 6×3 m^2 open space with all the four sides covered with 1.8 m chain link fencing. Thirty-four (32 ewes and 2 rams) sheep of native Malpura breed aged about 18 months (body weight 28 kg ewes; 35 kg rams) were grazed together on a 35 ha plot of native range. All the sheep were grazed as a flock from 08.00 to 17.00 h during a yearlong study. The flock was divided into two groups (16 ewes+1 ram) in the evening and housed as per the systems (Shed and Open Corral). Dry and wet temperatures were recorded at 06.00 h and 21.00 h using a wet and dry bulb-thermometer both inside the shed and in the open corral and temperature humidity index (THI) was calculated. There was significant ($p<0.05$) difference in the THI between shed and open corral in all the seasons, indicating that shed was always warmer compared to open corral. Rectal temperature (RT) of both the groups of sheep was similar during morning as well as evening throughout the seasons. There were significant ($p<0.05$) differences in the skin temperature (ST) and respiration rate (RR) between the two groups at both the measurements in all the seasons. Highest energy expenditure (EE) was recorded inside the shed at 21.00 h (224 kJ/h) during monsoon and lowest at 6.00 h during winter (119 kJ/h). There was a significant ($p<0.05$) difference between the EE inside the shed and that in the open corral. It was concluded that housing had significant effects on the physiological responses and EE of sheep. Provision of housing at night was stressful during monsoon (with less rainfall) and summer, whereas it was protecting the sheep from acute cold during winter in a semi-arid region of India. ***(Asian-Aust. J. Anim. Sci. 2005. Vol 18, No. 8 : 1188-1193)***

Key Words : Housing, Physiological Responses, Energy Expenditure, Sheep, Semi-arid Region

INTRODUCTION

Semi-arid region of Rajasthan in India is characterized by minimum and maximum temperature of 8.0°C and 45.0°C with around 250 mm of annual precipitation. Most of the rainfall is received between June and September and some winter showers during January to March. Majority of the sheep in this region are kept either in open corrals or inside small thatched roof sheds. Animals are exposed to wide variety of environmental conditions during different seasons. However, in organized farms, sheep are housed in asbestos roofed sheds with open sides during monsoon and summer and covered sides during winter. Some housing and management practices can be a source of stress for sheep and domestic animals in general (Vandenheede and Bouissou, 1993). The relationship between behavioral and physiological indicators can be used to evaluate the adaptive capacity and consequently welfare (Broom and Johnson, 1993) of these animals in relation to different types of housing and management. Till now no systematic study has been conducted to evaluate the effect of housing system on the physiological responses and energy expenditure of sheep in the semi-arid conditions of India. The present study was therefore, designed to evaluate two typical housing systems on the physiological responses and energy expenditure of sheep in semi-arid region of India.

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MATERIALS AND METHODS

This study was carried out on a rangeland located at Central Sheep and Wool Research Institute, Avikanagar, India (75° 28' N latitude, 26° 17' E longitude and 320 m above m. s. l.). The climate is typically hot semi-arid with average annual rainfall of 275 mm. The rainfall is low, erratic and highly inconsistent. The region is characterized by a negative balance between annual rainfall and evapo-transpiration rate. The study was conducted from January 2002 to February 2003.

Three studies, one each in a defined season was carried out to determine the effect of housing on physiological responses and energy expenditure during different seasons. Season 1 (monsoon) from July to September was the main season of the vegetative growth with high rainfall (4.5 mm/day), temperature (30.4°C) and humidity (65%). Season 2 (winter) from November to February, was the moderate vegetative growth season with rain only in the form of little winter showers (0.3 mm/day), low

Table 1. Meteorological observations of the two housing systems during the experimental period

		06.00 h		Sig.	21.00 h		Sig.
		Shed	Open		Shed	Open	
DBT	Monsoon	26.00±1.00	23.88±0.62	*	27.23±0.65	25.35±0.77	*
	Winter	7.00±0.87	5.50±1.30	*	16.13±0.54	14.50±0.43	*
	Summer	32.13±0.21	30.25±0.22	*	36.58±0.19	34.75±0.22	*
WBT	Monsoon	23.38±0.85	22.13±0.45	*	23.75±0.38	22.88±0.52	*
	Winter	5.88±0.76	4.00±0.87	*	11.75±0.65	10.75±0.65	*
	Summer	24.78±0.39	23.13±0.67	*	25.85±0.10	24.00±0.35	*
THI	Monsoon	76.15±1.52	73.72±0.88	*	77.30±0.85	75.32±1.04	*
	Winter	49.87±1.35	47.44±1.80	*	60.67±0.99	58.78±0.90	*
	Summer	81.57±0.48	79.03±0.65	*	85.55±0.23	82.90±0.45	*

* Significant, p<0.05.

DBT: Dry bulb temperature °C. WBT: Wet bulb temperature °C. THI: Temperature humidity index.

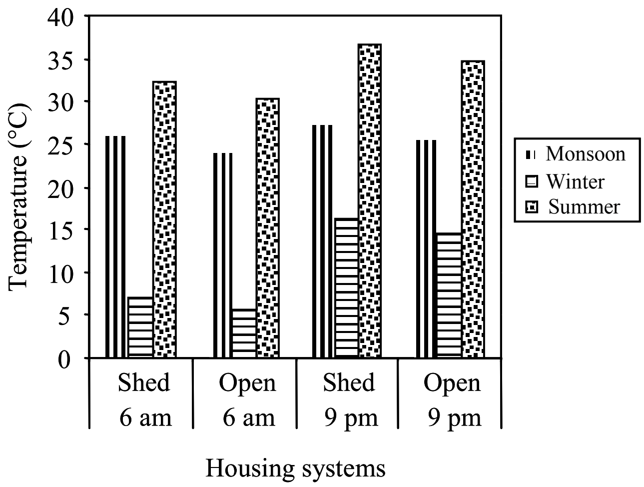

Figure 1. DBT of two housing systems during different seasons.

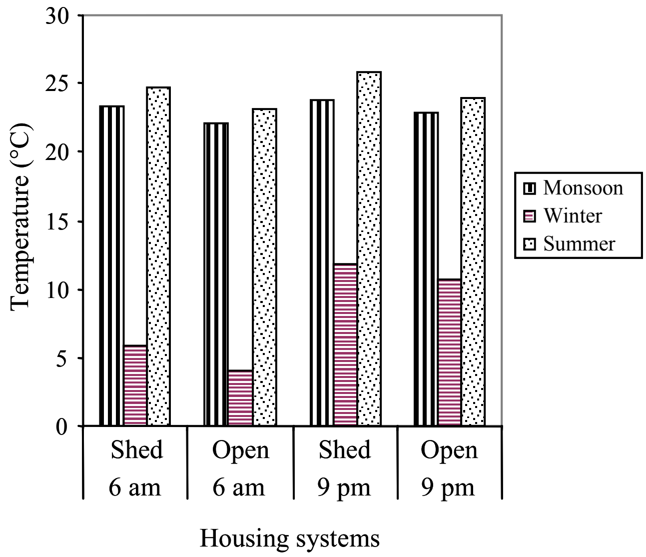

Figure 2. WBT of two housing systems during different seasons.

temperature (19.4°C) and moderate humidity (56%) and season 3 (Summer), from March to June, when the growth of vegetation stops, with very little rain (0.07 mm/day), moderate temperature (26.8°C) and low humidity (40%).

Rangeland

The native rangeland located at the institute is occupied by heterogeneous shrubs with annual herbaceous undercover. *Prosopis cineraria, Acacia senegal* and *Acacia tortalis* were the dominant shrub species and their foliage and pods offer potential source of protein during winter and summer months. The ground cover was occupied by *Melilotus indica, Tribulus terrestris, Crotolaria burhia, Celosia argentia* and *Indigofera cordfolia* grass and forb species. The foliage availability from deciduous trees and shrubs along with ground herbaceous vegetation formed an integral part of feed resource to sheep in different seasons.

Animals and housing

Thirty-four (32 ewes and 2 rams) sheep of Malpura breed aged about 18 months (body weight 28 kg ewes; 35 kg rams) were grazed together on a 35 ha plot of native range. All the sheep were grazed as a flock from 08.00 to 17.00 h during the yearlong period. They were supplemented with lopped foliage from the shrubs during the summer months. Animals were divided into two groups (16 ewes+1 ram) in the evening, and housed as per the two systems.

Shed : A 6×3 m^2 shed used for housing the sheep from the first group was made up of tubular structure with 3 m central height, 1.8 m side walls of chain link fencing, asbestos sheets roofing at an angle of 45° and mud flooring. It was provided with single gate for in and out movement of sheep.

Open corral : An open space of 6×3 m^2 was covered on all the four sides with 1.8 m chain link fencing to protect the animals from predation. In one corner of the corral an area of 1.5×1.2 m^2 was covered up to a height of 1.5 m with a thatch made of locally available material, to provide shelter to the young ones during rainy season. During the night hours, sheep from the second group were hurdled inside the fenced area. Both the groups of sheep were

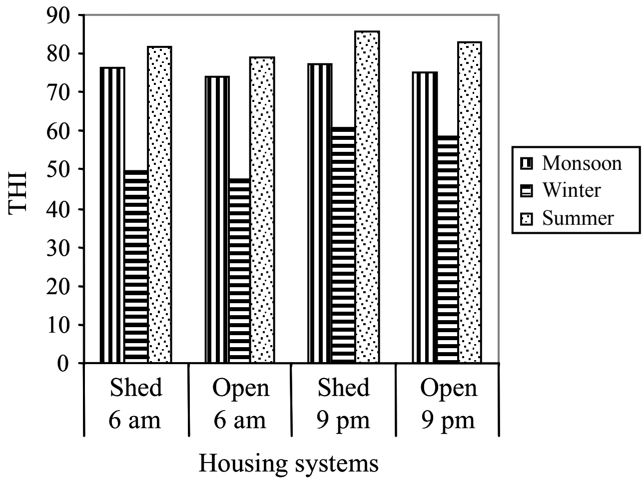

Figure 3. THI of two housing systems during different seasons.

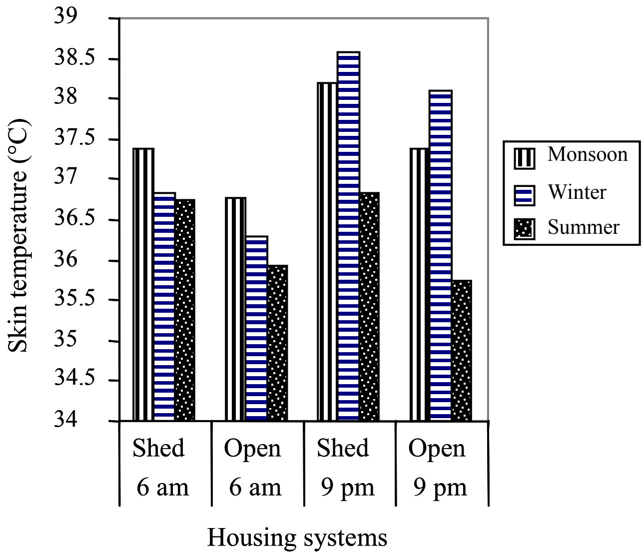

Figure 4. Skin temperature (°C) of sheep under two housing systems in different seasons.

provided with drinking water, twice daily in the morning and evening.

Meteorological observations

Dry and wet temperatures were recorded at 06.00 h and 21.00 h using a wet and dry bulb-thermometer both in the shed and in the open corral. The temperature humidity index (THI) was calculated using the formula of McDowell (1972)

$$THI = 0.72\ (DBT+WBT)+40.6$$

Where, DBT was dry bulb temperature; WBT was wet bulb temperature in °C.

Animal experimentation

Measurement of physiological responses and energy expenditure : Respiration rate (RR) was measured by counting thoracic and flank movements and heart rate (HR) by using a stethoscope placed on the ventro-lateral thorax. Rectal temperature (RT) and skin temperatures (ST) were measured using a multi-channel tele-thermometer (Engineering Corporation, India). Thermal contact was enhanced by shaving off the hair in the selected site, washing the skin with alcohol and applying a conducting jelly to the probe. The probe was held in place by adhesive tape.

Energy expenditure (EE) was calculated from the heart rate using the formula derived at the Institute from another experiment by Shinde et al. (1999).

06.00 h $Y = 0.13\pm0.50X$

21.00 h $Y = 1.70\pm0.55X$

where,

Y = EE (kcal/h)

X = heart rate (beats/min)

Statistical analysis

Data on RT, ST, HR, RR and energy expenditure were subjected to analysis of variance with time and housing as the independent variables using SPSS (version 10) package. Since the main treatment was housing, its effect on other parameters were determined, the interaction of time vs. housing was not calculated. Duncan's multiple range test (DMRT) was used to express the difference between treatment means (shed vs. open).

RESULTS AND DISCUSSION

Meteorological data of the shed and open corral during different seasons are depicted in Figure 1, 2 and 3. Maximum DBT and WBT were recorded in summer inside the shed at 21.00 h (36.6 and 25.9°C) and lowest in winter in open corral at 06.00 h (5.50°C and 4.00°C). Maximum THI was recorded in summer inside the shed at 21.00 h (85.6) and the lowest in winter in open corral at 06.00 h (47.44). There was significant ($p<0.05$) difference in DBT, WBT and THI between shed and open corral at 06.00 h and 21.00 h during three seasons. During monsoon, winter and summer seasons, THI was higher ($p<0.05$) both in the morning as well as in the evening hours indicating warmth inside the shed compared to that of open corral. Vandenheede and Bouissou (1993) have also reported that housing and management practices could be source of stress for sheep. Bhatta et al. (2002, 2002a) and Shinde et al. (2002) in earlier studies have reported monsoon and summer as the most stressful seasons in semi-arid regions.

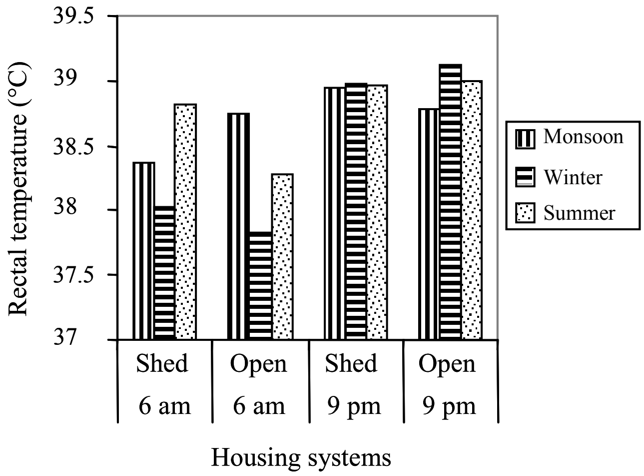

Figure 5. Rectal temperature (°C) of sheep under two housing systems in different seasons.

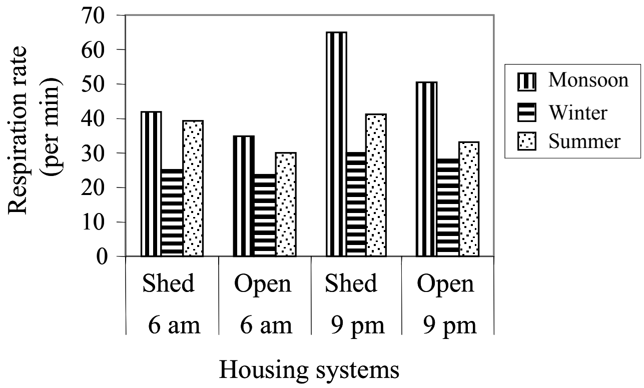

Figure 6. Respiration rate of sheep under two housing systems in different seasons.

There was significant difference in the skin temperature (ST) between the two groups at both the measurements in all the seasons (Figure 4). ST represents thermal state of the periphery and usually shows a diurnal variation with a minimum in the morning and maximum in the afternoon (Karim et al., 1985). Both heat gain and heat loss occurs through radiation, conduction and convection. During summer there is usually a net heat gain from radiation in the daytime and a net heat loss from radiation in the night with the animal radiating to the cooler sky. Summer facilities for animals should be planned to give maximum protection from direct solar radiation during the day, yet to permit maximum cooling by radiation at night. At normal summer temperature there is little heat gain or loss from either conduction or convection. At high ambient temperature during the day, most heat loss occurs through evaporative cooling (Yeck and Stewart, 1959). However in our study, radiation emanating from the roof at night hours during summer resulted in additional stress to sheep.

Rectal temperature of both the groups of sheep was similar during morning as well as evening throughout the seasons (Figure 5). The immediate response of the sheep to sudden acute cold exposure was a sudden rise in RT followed by a gradual fall and this would suggest that in most cases summit metabolic rates were quickly attained. This characteristic rise in rectal temperature on initial cold

Table 2. Effect of two housing systems on physiological responses and energy expenditure of sheep

Parameters		06.00 h		Sig.	21.00 h		Sig.
		Shed	Open		Shed	Open	
RT (°C)	Monsoon	38.37	38.74	NS	38.94	38.78	NS
	Winter	38.02	37.83	NS	38.97	39.12	NS
	Summer	38.81	38.28	NS	38.96	38.99	NS
ST (°C)	Monsoon	37.36	36.78	*	38.19	37.36	*
	Winter	36.74	35.94	*	36.82	35.74	*
	Summer	36.82	36.30	*	38.57	38.10	*
Gradient (RT-ST)	Monsoon	1.01	1.96	*	0.75	1.42	*
	Winter	1.28	1.89	*	2.15	3.38	*
	Summer	1.39	1.98	*	0.39	0.89	*
HR (beat/min)	Monsoon	73.67	71.83	*	94.08	86.42	*
	Winter	56.58	61.17	*	69.83	70.08	*
	Summer	75.58	71.92	*	89.96	72.56	*
RR (per min)	Monsoon	42.17	35.25	*	64.83	50.58	*
	Winter	25.00	23.75	*	30.25	28.17	*
	Summer	39.33	30.25	*	41.25	33.04	*
EE (kcal/h)	Monsoon	36.88	36.05	*	53.58	49.64	*
	Winter	28.42	31.83	*	39.98	42.35	*
	Summer	37.92	36.08	*	51.17	43.66	*
EE (kJ/h)	Monsoon	154.31	150.83	*	224.18	207.69	*
	Winter	118.83	133.18	*	167.28	177.19	*
	Summer	158.66	150.96	*	214.10	182.67	*

* Significant $p<0.05$.

RT-rectal temperature; ST-skin temperature; HR-heart rate; RR-respiration rate; EE-energy expenditure.

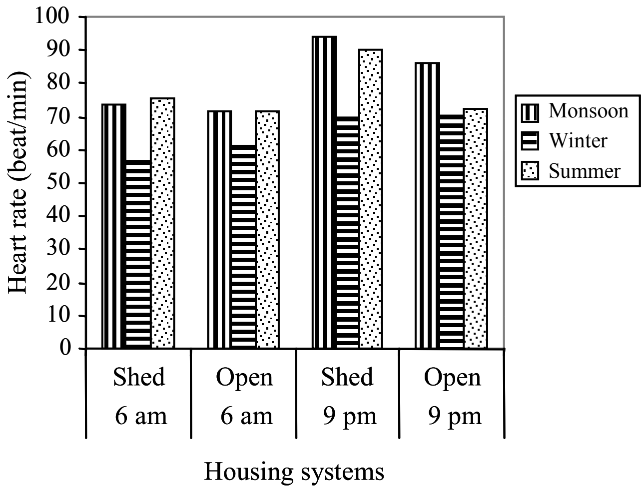

Figure 7. Heart rate of sheep under two housing systems in different seasons.

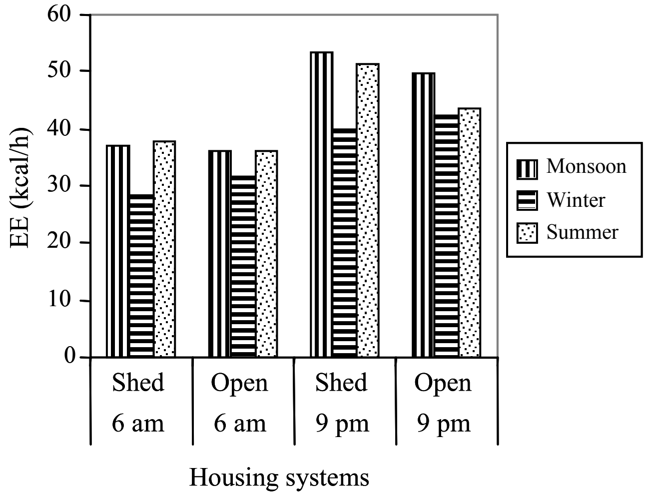

Figure 8. Energy expenditure of sheep under two housing systems in different seasons.

exposure has been observed in adult sheep by Joyce and Blaxter (1962) and Slee (1966) and in lambs by Alexander (1961). As suggested by Slee (1966) it is probably the results of an overcompensating rise of metabolic rate, coupled possibly with insulative vasomotor changes. Some sheep also showed small periodic fluctuations in RT during subsequent stages of cold exposure. Acclimatized sheep in comparison to non-acclimatized sheep exhibited good overall cold resistance with slow terminal rates of fall in body temperature. Webster (1976) calculated the lower critical temperature (LCT) for confined sheep with full fleece and fed near maintenance was estimated to be -15°C. However, in this study, ambient temperature was much higher than LCT in both the groups explains the reason for the absence of any housing effect on rectal temperature.

The gradient at 21.00 h was much higher in winter, while it was lower in monsoon and summer (Table 2) probably due to the combined effect of high temperature coupled with humidity and high temperature respectively, which has made evaporative cooling very inefficient (Monty et al., 1991). This was because of the lower sweating rate in monsoon compared to that of summer. Shinde et al. (1998) also made similar observations in sheep grazing on a semi-arid pasture.

Lowest respiration rate was recorded in the open at 06.00 h in winter (23.75 per min) and the highest was in shed (64.83 per min) at 21.00 h during monsoon (Figure 6). The recorded differences in RR in sheep between shed and open corral was statistically significant ($p<0.05$). These values probably reflect ambient temperature and humidity. Shinde et al. (1998) also reported similar findings in sheep grazing on a semi-arid pasture.

It was reported that linear relationship, within limits, exists between the heart rate and oxygen consumption thus the energy expenditure (EE) of the animals. Highest and lowest EE were recorded at 21.00 h during monsoon (224.2 kJ/h) and at 06.00 h during winter (118.8 kJ/h) inside the shed, respectively (Figure 8). During monsoon and summer seasons, EE were higher inside the shed compared to open and also EE in monsoon (224.2 kJ/h) was more than summer season (214.1 kJ/h) inside the shed at 21.00 h. Although the temperature in monsoon was less than summer, higher humidity has resulted in greater heat stress. This gives a clear indication that in semi-arid region, provision of shed especially at night during monsoon (when there is very less rainfall) and summer would add to the stress because of the radiation emanating from the roof. At dry bulb temperature (DBT) below the critical temperature sheep maintained minimum EE by non-evaporative heat loss. At higher DBT, EE increased with increase in the cost of thermoregulation. At higher DBT, sheep used respiration to increase evaporative heat loss resulting in higher EE. Shinde et al. (2002) measured the energy expenditure of sheep under grazing condition and reported that monsoon and summer were the most stressful seasons in semi-arid region. However, during winter season, ambient conditions inside the shed appears to be favoring sheep. EE of sheep inside the shed (118.8 kJ/h at 6.00 h; 167.3 kJ at 21.00 h) was significantly less compared to open corral (133.2 kJ/h and 177.2 kJ/h). Higher EE during winter was due to the rise in HR. Higher HR of sheep in the open corral during winter facilitated increased need for energy (Sleiman and Saab, 1995) and in summer contributed to an increased blood flow to the skin to encourage evaporative cooling (Hales, 1974).

Summer and monsoon seasons are very harsh in semiarid regions of Rajasthan due to hot and humid conditions and sheep and goats spend a lot of energy in thermoregulation. Different housing systems are in practice in organized and un-organized sheep farms. Although housing had no significant effect on nutrient intake, their utilization and blood parameters (Bhatta et al., 2004) there was significant effect on the physiological responses and energy expenditure of sheep maintained under the two housing systems. In reviewing heat stress effects on animal production, one must consider the entire scope of factors affecting thermoregulation in the animal. The goal is to help the animal maintain those increments of metabolic heat associated with growth, lactation and gestation. This could be accomplished to some degree through modified diets and modified environments.

CONCLUSIONS

It can be concluded that housing had significant effect on the physiological responses and energy expenditure of sheep in a semi-arid region of India. Provision of housing was stressful during monsoon (with less rainfall) and summer, whereas it was protecting the animals from severe cold during winter season. While deciding housing for different breeds of sheep (both crossbred and native) parameters like physiological responses, energy expenditure, health conditions and economic aspects should be taken into consideration.

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