Studies on Feed Intake and Nutrient Utilization of Sheep under Two Housing Systems 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 feed intake and nutrient utilization of sheep in a semi-arid region of India. Two types of housing managements were adopted. The first was a shed- 20'×10' structure with all the four sides of 6 'chain link fencing with central height of 10'. The roof was covered with asbestos sheets, with mud floorings. The second was an open corral- 20'×10' open space with all the four sides covered with 6' chain link fencing. Thirty-four (32 ewes and 2 rams) sheep 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 study. The flock was divided into two groups (16 ewes+1 ram) in the evening and housed according to two housing systems (Shed and Open Corral). Three digestion trials were conducted during three defined seasons of monsoon, winter and summer seasons to determine the effect of housing on nutrient intake and utilization. Blood samples were collected in three seasons for the estimation of hemoglobin and glucose. Dry and wet bulb temperatures were recorded at 06:00 A.M. and 09:00 P.M. using suitable thermometers 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 the shed was always warmer compared to open corral. The daily dry matter intake (DMI, g/d) was 965, 615 and 982 in sheep housed under shed and 971, 625 and 1,001 in those housed in open corral during monsoon, winter and summer season, respectively. These differences were however non-significant ($p>0.05$). The digestibility of DM was 45.92, 45.13 and 50.30 in sheep housed under shed and 43.64, 45.02 and 55.02 in sheep housed in open corral during monsoon, winter and summer seasons, respectively. There was no significant ($p>0.05$) difference in the digestibility of nutrients in sheep maintained under shed and in open corral. Blood Hb concentration was 13.97, 14.13 and 13.15 in sheep housed under shed and 15.27, 13.63 and 14.82 in those kept in open corral, whereas blood glucose concentration was 59.67, 59.70 and 52.33 in sheep under shed and 61.00, 61.00 and 57.83 in open corral, during monsoon, winter and summer, respectively. There was also no significant effect of housing on the body weight changes, wool yield and survivability in ewes. Although housing had no significant effect on nutrient intake, their utilization and blood parameters, there was significant effect on the physiological responses and energy expenditure of sheep maintained under the two housing systems (Bhatta et al., 2004). It can be concluded from this study that the housing systems didn't have any significant effect on the nutrient intake and utilization of native breed like Malpura, which were well adapted to the hot semi-arid conditions of India. However, while deciding provisions for housing of different breeds of sheep (both crossbred and native) parameters like physiological responses, energy expenditure, health conditions and overall economics of the systems should be taken into consideration. ***(Asian-Aust. J. Anim. Sci. 2004. Vol 17, No. 6 : 814-819)***

Key Words : Housing System, Sheep, Semi-arid Region, Nutrient Intake, Blood Composition

INTRODUCTION

The semi-arid region of Rajasthan in India is characterized by minimum and maximum temperature of 8.0 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 under small shed with thatched roofs. The animals are exposed to wide variety of environmental conditions during different seasons. However, in organized farms, sheep are housed in side open asbestos roofed sheds during monsoon and summer and covered sides during winter. Till now no systematic study has been conducted to evaluate the effect of different housing system on the feed intake and nutrient utilization in sheep in the semi-arid conditions of India. The present study was therefore, designed to evaluate two typical housing systems on the nutrient intake and their utilization of sheep in semi-arid region of India.

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 digestion trials, one each in a defined season was carried out to determine the effect of housing on nutrient intake and utilization during different seasons. Season 1

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(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 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 heterogenous 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 cordifolia* 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 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 period. They were supplemented with lopped foliage from the shrubs during the summer months. The animals were divided into two groups (16 ewes+1 ram) in the evening, and housed as per the two systems.

Shed : The 20×20'shed used for housing the sheep of the first group was made up of tubular structure with 10' central height, 6 '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 the animals.

Open corral : The open space of 20'×10' was covered on all the four sides with 6' chain link fencing to protect the animals from predation. In one corner of the corral an area of 5'×4' was covered up to a height of 5' 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 are hurdled inside the fenced area. Animals of both the groups were provided with drinking water, twice daily in the morning and evening.

Meteorological observations

Dry and wet bulb temperatures were recorded at 6:00 AM and 9:00 PM using suitable thermometers 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

Six ewes (1 year old) in each housing system weighing (25±0.5 kg) kg were used to collect representative samples of forage and faeces for estimation of forage intake and nutrient digestibility. The same animals were used in all the three seasons to avoid individual variation. Diet samples were collected daily by the operators by snatching 40-50 bites before swallowing from the mouth of each animal; samples with excessive salivary contamination were discarded immediately. Samples were collected throughout the grazing hours to avoid diurnal variation in dietary preference. The amount of faeces excreted was determined by using chromium oxide (Cr_2O_3) as an inert, undigested tracer (Harris, 1967). Each sheep was dosed for 10 days with 1 g chromic oxide in a paper capsule twice daily at 08:00 and 17:00 h, and at the same time faeces were sampled from rectum for the last 5 consecutive days (Sankhyan et al., 1999). Diet and faeces samples of individual animals were dried separately at 60°C. Individual animals were weighed using a spring balance in the morning hours, at fortnightly intervals throughout the year.

Blood collection

Blood was collected from the jugular vein from the individual animals with anticoagulant (EDTA).

Laboratory analyses

Forage, diet and faecal samples were ground to pass through a 1 mm sieve in a Wiley mill and stored in polythene bags for analyses. Nitrogen was determined by the Kjeldahl method (AOAC, 1999) and NDF, ADF and ADL by Van Soest et al. (1991) method. Nutrient digestibility was estimated by the lignin ratio technique (Wallace and Van Dyne, 1970). Metabolizable energy (ME) intake was calculated as MEI (Kcal/d)=OMI, g×19×0.82 (ARC, 1980). Blood was analyzed for haemoglobin (Varley et al., 1980) and glucose (Hultmann, 1959).

Statistical analysis

Data on chemical composition of the range and diet and nutrient intake and digestibility of nutrients were subjected to analysis of variance using SPSS package. Duncan's multiple range test (DMRT) was used to express the differences among the means.

RESULTS AND DISCUSSION

Meteorological observations

The meteorological data of the shed and open corral

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

		6.00 AM		Significance	9.00 PM		Significance
		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	*

* $p<0.05$. DBT: dry bulb temperature °C. WBT: wet bulb temperature °C. THI: temperature humidity index.

Table 2. Nutrient composition of the diet of sheep and range (% DM) during different seasons

	Monsoon		Winter		Summer	
	Diet	Range	Diet	Range	Diet	Range
Dry matter	41.9	32.7	85.8	92.3	91.8	95.4
Organic matter	87.1	86.4	82.0	76.0	75.0	60.0
Crude protein	13.4	11.5	9.8	8.0	14.8	7.0
NDF	64.1	62.8	70.1	75.6	60.6	76.1
ADF	37.6	35.3	48.2	56.2	47.0	60.6
Cellulose	23.5	24.8	36.0	35.2	26.5	35.3
ADL	10.9	8.8	8.8	9.4	15.5	8.5

during different seasons are presented in Table 1. There was significant ($p<0.05$) difference in the THI between shed and open corral during the three seasons. During the monsoon, winter and summer seasons THI was higher ($p<0.05$) both during the morning as well as in the evening hours indicating that the shed was always warmer as compared to the open corral.

Forage yield of the range

The mean herbage yield of the range was 1,720 kg DM/ha during monsoon. It attained a peak yield of 2,182 kg in winter and subsequently declined to 1,260 kg DM/ha in summer. This seasonal variation in DM yield was due to the combined effect of continuous grazing by the sheep as well as the growth cycle of the grasses and forbs. Similar observations were also made by Shinde et al. (1998), Bhatta et al. (2002, 2002a, 2004) and Chaturvedi et al. (2003). The contribution of fodder tree leaves to the total biomass was not accounted here as these were lopped and fed to sheep only during the summer season.

Nutrient composition of the diet and the range

Nutrient composition of the diet and the range is presented in Table 2. Since all the sheep were grazed as a single flock, the differences recorded in the nutrient composition of the range are solely due to the seasonal variation in the growth pattern of the grasses and shrubs in semi-arid region. The crude protein content of the range vegetation declined from monsoon to summer through winter with concomitant increase in NDF and ADF values. Selective grazing behaviour of the sheep was responsible for the seasonal changes in nutrient composition of the diet. Similar observations were also made by Jung and Sahlu (1986) and Ramirez et al. (1995). Consumption of lopped foliage and pods of *Prosopis cineraria*, *Acacia senegal* and *Acacia tortalis* resulted in higher CP and ADL contents of the diet during the summer season. A higher proportion of browse in the diet coincided with the maximum level of dietary ADL, since the browse species contain higher lignin than the grass species (Norton and Poppi, 1995).

Nutrient intake and digestibility

The daily dry matter intake (DMI) of sheep housed under shed was 965, 615 and 982 and in sheep housed in open corral was 971, 625 and 1,001g/h/d during monsoon, winter and summer seasons, respectively. When expressed as per cent of the body weight, the mean DMI was 3.11 in sheep under shed and 3.25 in open corral irrespective of the seasons. There was no significant ($p<0.05$) difference in the DMI of sheep housed under the two systems. There are reports that when lambs were offered similar amounts of forage in insulated (+10°C) and non-insulated enclosures (-10°C), there was no significant difference in roughage intake due to housing condition (Boe et al., 1991). Similarly, in a study with crossbred cows, Thiagarajan and Thomas (1991) have also reported that feed intake was not much affected in the unsheltered condition. They concluded that the crossbred cows could be maintained without much housing in tropical conditions. Further, the provision of shelter apparently had a negative influence on feed intake in a study conducted at humid tropics (Thomas, 1969). Unsheltered cows consumed more DM and TDN than the sheltered ones. However, crossbred calves reared in thatched house consumed more ($p<0.05$) DM, CP and TDN than those in loose house in humid tropical region of India (Yazdani and Gupta, 2000). Whereas in temperate region, animals exposed to cold stress (-7°C) increased their food intake (Christopherson and Kennedy, 1983). In the present study, since there was no difference in DMI between the

Table 3. Effect of two housing systems on blood composition of sheep during three seasons

Parameters	Season	Housing		Significance
		Shed	Open	
Blood Hb (g/dl)	Monsoon	13.97	15.27	NS
	Winter	14.13	13.63	NS
	Summer	13.15	14.82	NS
Blood glucose (mg/dl)	Monsoon	59.67	61.00	NS
	Winter	59.70	61.00	NS
	Summer	52.33	57.83	NS

NS: Non significant ($p<0.05$).

two treatments, it is imperative that the extent and duration of exposure to cold during winter season in open corral might have been of minor importance.

The digestibility of DM was 45.9, 45.1 and 50.3 in sheep housed under shed and 43.6, 45.0 and 55.0 under open corral during monsoon, winter and summer seasons, respectively. However, there was no significant ($p<0.05$) difference in the digestibility of the nutrients maintained under shed and in open corral. Studies in sheep exposed to natural winter conditions or subjected to prolonged exposure in climatic chambers (-7°C to -10°C) indicated an average depression of apparent DM digestibility of about 0.2 units per degree centigrade (Young and Christopherson, 1974). Furthermore, the changes in digestive function are independent of feed intake and appear to be associated with an increased gut motility and increased rate of passage of digesta through the gastro-intestinal tract (Westra and Christopherson, 1976; Kennedy et al., 1977). Kennedy and Milligan (1978) reported that fermentation activity in the rumen of sheep was decreased by about one third as a result of cold exposure (-5°C). Higher DM and NFE digestibility in crossbred calves housed under thatched roof compared to loose house was reported in a study conducted in India (Yazdani and Gupta, 2000). But the digestibility of other nutrients remained unaffected. However, in our study, housing didn't have any significant effect on the nutrient digestibility in-spite of significant differences in the THI possibly because, the extent and duration of stress as a result of housing or climatic condition in open corral was less and/or the Malpura breed used in this study was well adapted to the semi arid conditions. The DCP and ME intakes also showed a trend similar to that of dry matter intake and housing had no significant effect on their intake.

Blood parameters

Blood haemoglobin (Hb) and blood glucose concentrations are presented in Table 3. Blood Hb was 13.97, 14.13 and 13.15 in sheep housed under shed and 15.27, 13.63 and 14.82 in those in open corral. The blood glucose concentration was 59.67, 59.70 and 52.33 in sheep under shed and 61.00, 61.00 and 57.83 in open corral, during monsoon, winter and summer, respectively. Young (1975) has reported that an increased sympathetic activity

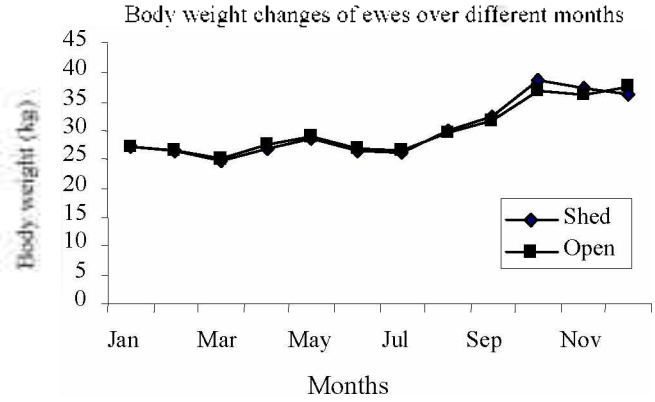

Figure 1. Body weight changes of sheep under the two housing systems.

could elicit the cardiovascular and metabolic responses during cold exposure at -5°C to -7°C, such as increased heart rate, blood haematocrit and plasma concentration of glucose. The increased sympathetic activity and the catacholamines also play a role in the development and maintenance of acclimative changes found to occur in animals as a consequence of prolonged exposure to cold. Although there was significant difference in the physiological responses like skin temperature, respiration rate and energy expenditure between sheep housed under shed and in open corral (Bhatta et al., 2004a) the blood parameters were similar under both the housing systems. The recorded differences in the physiological responses may be temporary adjustments by the sheep.

Body weight changes, survivability and wool yield

There was no significant effect of housing on the body weight changes (Figure 1), survivability of ewes (survivability was 100 per cent over a period of one year) as well as greasy fleece yield (GFY). The GFY (g/kg BW) was 18.13 and 14.57 during spring and autumn clips in the sheep housed under shed and the corresponding values were 17.82 and 13.76 in the sheep housed in the open corral.

CONCLUSIONS

The summer and monsoon seasons are very harsh in semiarid regions of Rajasthan due to hot and humid conditions and the 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, there was significant effect on the physiological responses and energy expenditure of sheep maintained under the two housing systems. It can be concluded that different housing systems didn't have any significant effect on the nutrient intake and utilization in native sheep breeds like Malpura. The most possible reason could be that this breed is very well adapted

Table 4. Effect of two housing systems on nutrient intake and utilization of sheep during three seasons

Parameters	Season	Housing		Significance
		Shed	Open	
Dry matter intake g day^{-1}	monsoon	965	971	NS
	winter	614.5	624.5	NS
	summer	981.8	1,001.2	NS
Dry matter intake g kg BW^{-1}	monsoon	30.38	33.15	NS
	winter	24.87	25.30	NS
	summer	38.17	38.89	NS
Dry matter intake g kg W$^{0.75}$	monsoon	72.11	77.02	NS
	winter	55.45	56.35	NS
	summer	87.08	86.37	NS
Digestibility of nutrients				
Dry matter	monsoon	45.92	43.64	NS
	winter	45.13	45.02	NS
	summer	50.30	55.02	NS
Crude protein	monsoon	54.83	50.60	NS
	winter	51.17	49.49	NS
	summer	52.87	55.92	NS
NDF	monsoon	49.09	46.35	NS
	winter	48.87	46.94	NS
	summer	36.47	42.26	NS
ADF	monsoon	36.07	37.38	NS
	winter	38.07	37.29	NS
	summer	35.62	36.60	NS
Cellulose	monsoon	49.77	46.84	NS
	winter	65.69	63.75	NS
	summer	57.97	64.84	NS
Nutrient intake				
DCPI g day^{-1}	monsoon	71.01	71.01	NS
	winter	30.76	30.45	NS
	summer	78.33	84.26	NS
DCPI g kg BW^{-1}	monsoon	2.23	2.24	NS
	winter	1.24	1.23	NS
	summer	3.12	3.21	NS
DCPI g kg W$^{0.75}$	monsoon	5.30	5.21	NS
	winter	2.77	2.77	NS
	summer	6.97	7.26	NS
MEI MJ day^{-1}	monsoon	13.09	13.18	NS
	winter	7.85	7.98	NS
	summer	11.48	11.70	NS
MEI MJ kg BW^{-1}	monsoon	0.41	0.42	NS
	winter	0.32	0.33	NS
	summer	0.45	0.45	NS
MEI MJ kg W$^{0.75}$	monsoon	0.98	0.96	NS
	winter	0.71	0.72	NS
	summer	1.01	1.02	NS

NS: Non significant $p<0.05$.

to the semi-arid conditions. However, while deciding housing for different breeds of sheep (both crossbred and native) other parameters like physiological responses, energy expenditure, health conditions and economic aspects should be taken into consideration.

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