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Research

Effect of different types of housing on behavior of Malpura lambs during winter in semi-arid tropical environment

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ABSTRACT

During winter, different types of sheds were constructed to reduce lamb mortality. A study was conducted to assess the effect of different types of housing on the behavior of Malpura lambs during the winter in semiarid tropical condition in terms of suckling, feeding, lying, standing, social interaction, and oral stereotype. Sheds are constructed to reduce winter mortality. This study was carried out for a period of 1 month during winter (January-February). Twenty-one lambs of aged 3-5 weeks were divided into 3 groups of 7 animals each such as G-I (control, n = 7), G-II (bamboo dome, n = 7) and G-III (thermocol-insulated cold-protected shed, n = 7). The G-I lambs were maintained in normal asbestos roofed shed (side wall wire net, curtains at night time), whereas G-II lambs were maintained in a local hand-made bamboo dome structures. G-III lambs were kept in thermocol-insulated (roof and doors were made up of asbestos, thermocol, and polyvinyl chloride sheet, brick side wall) roofed shed from 6:30 PM to 7 AM. The lambs were exposed to their mother in the morning (7 AM to 7:30 AM) and evening (5:30 PM to 6 PM) for suckling. Lambs were provided with ad libitum green fodder, dry roughage, and concentrate in an open area from 8 AM to 5:30 PM. Behavioral recording was carried out for 1 animal from each group daily (once weekly for each animal) by 3 people (1 person for 1 lamb). G-III lambs showed higher weekly body weight gain and higher milk intake. Total feeding time was 22.44% higher in G-III compared to G-I lambs. Drinking time was higher in G-I lambs compared with those in the other groups. Standing time was significantly higher ($P < 0.05$) in G-II lambs, whereas lying time was higher in G-I lambs. The lambs kept in the dome showed a greater frequency of oral stereotypies. The findings from this experiment provide useful information to understand the necessity of adequate space and the effects of temperature requirements for behavioral expression and growth of lambs in semiarid tropical environments.

Introduction

Productivity of livestock is substantially increased through shelter management by mitigating environmental stress (Nienaber and Hahn, 2007). Environmental factors have a profound effect on lamb survival in extensive management (Everett-Hincks et al., 2014). Shelter may manipulate the microenvironment, which can affect lamb survival. Provision of suitable housing is one of the key factors for successful raising of lambs. Postnatal growth rate depends mainly on nutrition and management, which includes the housing system (Bach, 2012) .

In the semiarid region, sheep farming is one of the most important livelihoods for the poor and marginal farmers. During winter, lamb mortality and slow growth rate are the major constraints in sheep rearing in this region. As the farmers are poor and marginal, they need a low-cost rearing system that can protect the lambs from cold. They generally keep the lambs inside bamboo

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domes to protect them from cold. Mostly the organized farmer prefers asbestos roofing sheds. We have also constructed 2 types of novel sheds for lambs to protect them from cold. One is thermocol-insulated shed and another is low-cost bamboo dome structure. These types of sheds mainly focus on the enrichment of the microenvironment. Environmental enrichment has an effect on physiology and behavior of animals of different species (Young, 2003) and can be particularly effective in the research setting to reduce the incidence or severity of undesirable or abnormal behaviors.

Behavior is considered as "first line of defense" of animals in response to environmental change. Behavioral observation can give information on animal's preference, requirements, and internal states (Engeldal et al., 2013). Available floor space allowance may affect the feeding, lying, and standing behavior of animals (Centoducati et al., 2015). Inadequate space availability may develop abnormal behaviors that injure the animal itself or other animals in the social group (Mason et al., 2007). Environmental enrichment may reduce the frequency or severity of these behaviors or even prevent them from developing. In sheep that have inadequate space to move and lack of environmental stimulation in their housing may lead to the development of abnormal behaviors like stereotype behaviors (Price, 2008). Abnormal mouth movements like licking objects or themselves are commonly seen when animals are raised in individual crate. Keeping the animals in groups help in socialization, increases space access, and influences their activity and play (Kor et al., 2011). Although some researchers reported that the type of housing has no effect on growth performance and feed conversion ratio (Van et al., 2007; Villeneuve et al., 2009), naturally ventilated calf housing during winter has been shown to have a positive effect on feed intake and growth rate of young calves (Razzaque et al., 2009).

The growth of lamb depends on milk intake. Therefore, understanding of suckling behavior is necessary for the sheep industry. Postnatal growth rate depends on nutrition and management (i.e., grouping strategies and housing systems). Many studies have been done on suckling behavior of lambs (Nowak et al., 1997). Housing can affect the feeding, drinking, standing, and resting behavior of sheep (Sevi et al., 2009; Caroprese et al., 2009). If the housing conditions do not facilitate this behavioral synchrony, the conditions may directly increase the frequencies of physical displacements and disturbed resting (Bøe et al., 2006).

This experiment was conducted on Malpura lambs. Malpura breed originated and it is well adapted to the environment of arid and semiarid tropical regions of India. There has been limited study regarding the effect of environment factors or housing system on the behavior of sheep. Most of the behavioral studies were carried out under grazing conditions. Hence, an attempt has been made in this study to establish the effect of housing on the behavior of lambs. We sought to determine the effect of different types of housing during winter on behavior and growth performance of lamb.

Materials and methods

Site of the study

The experiment was carried out at the sheep farm of ICAR-Central Sheep and Wool Research Institute, Avikanagar, Rajasthan, for a period of 35 days (5 weeks) during January and February. The institute is located at the longitude of 75°28′E and latitude 26°26′N and at an the altitude of 320 m above the mean sea level in the semiarid region of the country. The average annual ambient temperature and humidity ranged from 3°C (minimum) to 46°C (maximum) and 10% (minimum) to 85% (maximum), respectively. The annual rainfall of this area is erratically distributed throughout the year, which ranged from 200 to 500 mm. The mean maximum temperatures, minimum temperatures, relative humidity, and temperature − humidity index during the study period (35 days) in different sheds are summarized in Table 1. The temperature − humidity index was calculated using the formula given by Marai et al. (2007).

Experimental animals and management

Twenty-one Malpura lambs aged 3-5 weeks with an average body weight of 9.97 ± 0.51 kg were used in this study. The present study was carried out for 35 days. Twenty-one lambs were randomly allotted into 3 groups of 7 lambs each such as, G-I (n = 7; control), G-II (n = 7; bamboo dome), and G-III (n = 7; thermocol-insulated cold-protected shed). During the first 7 days, lambs were kept in different sheds for adaptation. The lambs were kept in different shelters during night time (6:30 PM to 7 AM). The lambs were exposed to their mother once in the morning (7 AM to 7:30 AM) and again in the evening (5:30 PM to 6 PM) for suckling in an open area where they were kept during the day times. They were provided with ad libitum green fodder, dry roughage, concentrate (barley, 650 g/kg; groundnut cake, 320 g/kg; minerals, 30 g/kg including 10 g/kg NaCl; crude protein, 180 g/kg; and total digestible nutrients, 650 g/kg) and water in an open space of 9 m × 5.4 m from 8 AM to 5:30 PM.

Housing system

The lambs of the control group (G-I) were maintained in asbestos-roofed shed. The height of the roof was 2.55 m at the center and 1.73 m at the side. The length and width were 2.6 m and 2.5 m, respectively. Four sides of the shed were covered by wire net fencing. During night time, the sides were covered with curtains to protect them from chilling draught. Seven lambs were kept in this system, each having floor space allowance of 0.93 m^2, and cubic air space per lamb was 1.99 m^3.

The lambs of the second group (G-II) were kept in the dome-shaped structure which was constructed of bamboo. The height of the dome was 0.48 m; the diameter was 0.9 m and in each dome, 2 lambs were kept. Floor space allowance for each animal was 0.32 m^2; cubic air space per lamb was 0.08 m^3. The domes were kept inside the asbestos-roofed shed. Four bamboo domes were used to keep the 7 experimental lambs. One extra lamb (non experimental lamb) was kept along with the last lamb in the fourth dome to make it consistent.

The lambs of the third group (G-III) were maintained in thermocol-insulated cold-protected shed. The height of the shed

Table 1
Meteorologic data during the experimental period in different housing

Weather parameters[a]	G-I	G-II	G-III
Minimum temperature (°C)	8.5 ± 0.7^{e}	14.6 ± 0.5^{c}	11.8 ± 0.6^{d}
Maximum temperature (°C)	25.0 ± 0.3^{c}	23.9 ± 0.4^{cd}	22.6 ± 0.4^{d}
Relative humidity (%)	59.2 ± 4.5	66.4 ± 2.0	56.4 ± 3.7
Temperature − humidity index[b]	12.5 ± 0.9^{d}	16.1 ± 0.6^{c}	14.0 ± 1.0^{cd}
Wind velocity (m/s)	5.58 ± 0.4	5.58 ± 0.4	5.58 ± 0.4

G-I, control; G-II, dome; G-III, thermocol insulated.
Values within a row with different superscripts (c, d, e) differ significantly at $P < 0.05$.
[a] The meteorologic data were recorded at 7 AM and 2 PM.
[b] Temperature − humidity indices (THI) were calculated with the formula of THI = db °C − [(0.31 − 0.31 RH) (db °C − 14.4)], given by Marai et al. (2007).

Table 2
Behavior observed during sucking period in Malpura lambs

Sucking behavior	Definition	Unit	Reference
Sucking bout	Period during which the lamb had the ewe's teat in its mouth for 5 seconds or longer. If sucking stopped and started again within 5 seconds, only 1 bout was scored. A new bout was scored if the interval was longer than 5 seconds	Frequency	Cimen, 2007.
Attempted bout	The lamb had the ewe's teat in its mouth for less than 5 seconds. Sucking was interrupted because of ewe movement, other lambs, or the lamb leaving the udder	Frequency	Dwyer et al., 2004.
Total sucking duration	The sum of all sucking bout durations in the observation period	Seconds	Hess et al., 1974.
Mean sucking bout duration	Total sucking duration divided by the number of sucking bouts in the observation period	Seconds	—
Teat switching	The lamb stopped sucking one teat and went to the other teat to continue sucking	Frequency	De Passille and Rushen, 2006.
Butt	The lamb hit the udder with a rapid, upward movement of the head, which usually caused the udder to lift	Frequency	De Passille and Rushen, 2006.

The suckling behavior observed twice daily at 7 AM to 7:30 AM and 5:30 PM to 6 PM.

was 2.4 m at the center and 1.9 m at the side. Length and width were 4.0 m and 2.8 m, respectively. The floor of the shed was lied 0.5 m below ground level. Side wall was constructed with brick. Four 0.9 × 0.5 m ventilators were used for cross-ventilation. The roof and the door were made of 3 layers: the upper layer of asbestos, the middle layer (40-mm thick) of thermocol, and the lower layer of polyvinyl sheet. The floor space allowance for each animal was 1.6 m^2. Cubic air space per lamb was 3.44 m^3. Seven lambs were reared in this system.

In all 3 systems of housing, the floor was kachcha floor (made up of mud) with sand bedding. The lambs were kept in each of these rearing systems from evening 6:30 PM to next day morning 7 AM. Lambs of all the 3 groups were kept in a common open area (9 × 5.4 m) during the daytime to record the behavioral observations.

Behavioral monitoring and recording

To estimate milk intake, weight of an individual lamb was taken before and after suckling each time. The suckling behavior observations were carried out twice daily from 7 AM to 7:30 AM and 5:30 PM to 6 PM. All the suckling behaviors measured (Van Welie, 2009) are given in Table 2. The other behaviors such as eating of green fodder, eating of dry roughage, eating of concentrate, drinking, standing, and resting (sleeping or lying down) were observed from 8 AM to 5 PM (Table 3). All these behaviors were recorded in terms of the total duration. Other activities like licking feeder, licking waterer, licking fences, licking inanimate objects, smelling others, playing, and self-licking were recorded in frequency. One lamb from each group daily (weekly once of each animal) was taken for these behavioral observations. Three persons were involved in recording the behavior of lambs (1 person for 1 lamb of each group) on a rotation basis. The body weight of individual lamb was taken every day morning before milk intake during the experimental period. The average weekly gain was calculated by dividing the initial and final body weight differences of each week by total number of days in a week (7 days).

Statistical analysis

The effect of different types of housing was analyzed through the general linear model procedure by analysis of variance for repeated measurements. A post hoc analysis was performed using Tukey tests for pairwise comparison of significant effects of different housing systems (G-I, G-II, and G-III). The pairwise comparison of different weeks' effect (1st, 2nd, and 3rd week) was done based on estimated marginal means in the repeated measures analysis. Data were presented as mean ± standard error, and statistical analysis was carried out using SPSS software, version 14.0 (SPSS Inc. Chicago, IL). The level of statistical significance was set at $P < 0.05$.

Results

Weekly body weight gain

The effect of housing on body weight and weekly body weight gain of lambs is summarized in Table 4. The initial body weight at the start of the experiment did not differ significantly among the experimental groups. Housing had statistically no significant effect on final body weight and weight gain of lambs. However, the lambs kept in thermocol-insulated shed (G-III) had 24.87% higher body weight gain than the control lambs, whereas lambs kept in the dome had 20.77% higher body weight gain than that of the control lambs. Experimental weeks, and interaction between group and experimental week also had non-significant effect on body weight gain.

Milk intake and suckling behavior

The effect of different types of housing on milk intake and suckling behavior is summarized in Table 5. Milk intake did not significantly differ among different treatment groups. None the less, but it was 25.64% higher in lambs that were kept in the thermocol-insulated shed. No significant difference was found in milk suckling behavior of lambs of the different groups, but they showed a trend

Table 3
Description of the behavior recorded in Malpura lambs

Behavior	Description	Unit
Eating concentrate	Standing beside the concentrate feed trough while eating, chewing, and swallowing	Time (minute)
Eating green fodder	Standing beside the greed fodder trough while eating, chewing and swallowing	Time (minute)
Eating dry fodder	Standing beside the dry fodder trough while eating, chewing and swallowing	Time (minute)
Drinking	Head lowered directly over water trough.	Time (second)
Standing	Standing anywhere in the pen but not eating but may be chewing cud	Time (minute)
Lying	Lying in any position	Time (minute)
Playing	Lamb running, jumping or frolicking, in a coordinated manner, with no apparent purpose	Frequency (number of times in a day by each lamb)
Oral stereotype	Chewing, nosing or biting, licking feeder, waterer, fences, or inanimate object	Frequency (number of times in a day by each lamb)

Behaviors were observed from 8 AM to 5 PM.

Table 4
Effect of different type of housing on average body weight and average weekly body weight gain in Malpura lambs

Weight measure	G-I	G-II	G-III	SE	*P* value
Initial weight (kg)[a]	9.97	9.97	9.88	0.55	0.998
Final body weight (kg)[b]	13.17	13.90	13.97	0.60	0.756
Weekly body weight gain (kg)[c]	0.80	0.97	1.00	0.12	0.471

G-I, control; G-II, dome; G-III, thermocol insulated.
[a] Initial weight (kg) was taken at the starting of the experiment from 7 lambs of each group.
[b] Final body weight (kg) was taken after 28 days from the starting of the experiment from 7 lambs of each group.
[c] The average weekly gain (kg) was calculated by dividing the initial and final body weight differences of each week by total number of days in week (7 days).

involving time to suckle. It was found that the lambs in thermocol-insulated shed and those in dome took more time to seek their mother during milking than the control lambs. Sucking bout was higher in the lambs that are kept in the dome, whereas attempted bout was higher in thermocol-insulated shed lambs. Sucking time was lowest in the lambs of the dome. It was found that teat switching was higher in control group lambs compared with lambs kept in the dome and thermocol-insulated sheds. There was lower butting in animals kept in the dome than the controls and those in the thermocol-insulated shed.

Feed intake, standing, lying, and playing behavior of lamb

The effects of different types of housing on the behavior of lambs are summarized in Table 6. Concentrate, green fodder, and dry fodder feeding time did not differ significantly among the groups, but total feeding time differed among the groups and it remains higher in the thermocol-insulated cold-protected lambs compared to other groups. The lambs kept in the thermocol-insulated shed (G-III) spent 10.51%, 25.19%, and 22.44% higher time in green fodder, dry fodder, and total feed intake time, respectively, compared with control (G-I) group lambs. The experimental week had a significant ($P < 0.01$) effect on the dry fodder and total feeding time of the lambs. It showed an increasing trend as the week progressed. Furthermore, the interaction between the groups and experimental weeks did not have a significant effect on any of the feed intake time.

The different types of housing had a significant ($P < 0.05$) effect on the standing behavior of lambs. There was a significantly ($P < 0.05$) higher standing time in lambs housed in the dome compared with control and cold-protected lambs. Lying time did not differ significantly among the groups, but it showed a reverse trend of standing time. The experimental week had a significant ($P < 0.01$) effect on lying time of the lambs. Furthermore, the interaction between the groups and experimental weeks did not have a significant effect on the standing or lying time.

Table 5
Effect of different type of housing on milk intake and suckling behavior in Malpura lambs

Behavior	G-I	G-II	G-III	SE	*P* value
Average daily milk intake (kg)	0.62	0.58	0.78	0.51	0.138
Seeking of mother (seconds)	50.78	61.50	56.06	8.35	0.669
Sucking bout (number of times)	8.44	9.44	7.39	1.00	0.375
Attempted bout (number of times)	7.44[ab]	6.11[b]	10.51[a]	1.21	0.05
Sucking time (seconds)	218.75	181.44	216.14	28.13	0.589
Teat switching (number of times)	10.00	8.28	8.83	1.44	0.693
Butting (number of times)	38.33	30.27	36.50	5.53	0.571

G-I, control; G-II, dome; G-III, thermocol insulated.
Observations were taken for 1 lamb from each group daily (weekly once of each animal; 7 animals in each group) for 3 weeks. The suckling behavior observations were carried out for 1 hour twice daily from 7 AM to 7:30 AM and from 5:30 PM to 6 PM. Values within a row with different superscripts (a, b) differ significantly at $P < 0.05$.

Social interaction and oral stereotype

The effects of different types of housing on social interaction and oral stereotype are described in Table 7. Play in lambs was noticed in the form of locomotor plays like jumping and social play like pushing and butting each other. Playing behavior was not significantly influenced by the type of housing. There was higher playing frequency in the lambs kept in the dome compared with others. The playing frequency also decreased as the experimental week progressed. There was no significant difference in smelling others and self-licking among different groups.

Housing system had statistically a non-significant effect on the frequency of abnormal behavior of lambs. The frequency of licking feeder and licking the waterer was higher in lambs kept in the dome, whereas the frequency of licking fences was higher in lambs kept in the thermocol-insulated shed. The experimental weeks and the interaction between the treatment and experimental weeks had no significant effect on abnormal behavior of lambs.

Discussion

It is known that rearing animals in a cold environment can affect the growth performance (Pouliot et al., 2009). In the present study, the lowest temperature was found in control group's shed. The reduction in growth rate in G-I is expected response of low temperature because of increased maintenance requirements to maintain homeostasis (Pluske et al., 2010). We also found 0.17 kg and 0.20 kg higher weekly weight gain in lambs kept in bamboo dome and thermocol-insulated house, respectively, than those in the control group. It is a well-established fact that body weight increases with the increase of feed intake. In the present study, the significantly ($P < 0.05$) higher total feeding time and higher milk intake in the lambs kept in the thermocol-insulated shed partially explains the higher weight gain of lambs kept in thermocol-insulated shed.

Exposure of livestock to higher or lower temperatures than the thermoneutral zone affects voluntary food intake (Soren, 2012). Ames and Brink (1977) concluded that ambient temperature significantly influences the performance and nutritional parameters in the growing lambs. Similarly, in the present study, we found a significantly ($P < 0.05$) higher feed intake time in G-III compared to other two groups. It might be because of the existence of ideal ambient temperature throughout the day and night in thermocol-insulated shed of G-III lambs. The increased feeding in calves during the preweaning life may be supportive of the early rumen development and early weaning program (Babu et al., 2004). An increase in total feed consumption time in G-III lambs in the present study elicits the fact for an economic early weaning program.

It was found that the lambs in the G-I group spent more time to drink water than those in the other groups. The increase in water intake time might be needed to meet their water requirement as the lambs of this group drank less milk than the others.

Rearing of lambs in bamboo domes (G-II) significantly increased the standing time and reduced the lying time in the open area in the present study. This pattern might be due to of the height and space allowance of the dome (height at the center, 0.48 m; floor space, 0.32 m^2), where the lambs of G-II were kept at night that possibly was less comfortable for standing. Therefore, the lambs kept inside the dome might have spent less lime in standing or movement and they maybe spent most of their

Table 6
Effect of different type of housing on feed intake, drinking, standing, lying and playing behavior in Malpura lambs

Item	G-I	G-II	G-III	SE for group	*P* value of group effect	1st week	2nd week	3rd week	SE for week	*P* value of week effect
Concentrate (min)	30.17	31.00	37.89	5.01	0.505	31.61	43.89	23.56	5.41	0.175
Green (min)	23.78	23.72	26.28	5.46	0.931	19.56	25.94	28.28	4.39	0.245
Dry fodder (min)	68.61	61.00	85.89	9.80	0.217	47.83[a]	61.28[a]	106.39[b]	8.76	0.001
Total feeding (min)	122.56[a]	115.72[a]	150.06[b]	13.27	0.05	99.00[a]	131.11[b]	158.22[b]	11.77	0.02
Drinking (S)	91.61	73.50	74.00	17.22	0.704	57.83	88.89	92.39	15.21	0.385
Standing (min)	69.06[a]	116.22[b]	67.94[a]	11.45	0.014	72.06	87.56	93.61	9.10	0.275
Lying (min)	181.11	120.89	161.06	17.03	0.068	189.67[b]	144.33[a]	129.06[a]	13.13	0.003

G-I, control; G-II, dome; G-III, thermocol insulated; SE, standard error.
Concentrate, green fodder, dry fodder, total feeding, and standing and lying times were estimated in minutes. Drinking time was estimated in seconds. Playing behavior was estimated in frequency, that is, number of times the playing behavior was demonstrated by a lamb.
Observations were taken for 1 lamb from each group daily (weekly once of each animal; 7 animals in each group) for 3 weeks. They were provided with ad libitum green fodder, dry roughage, concentrate, and water in an open space from 8 AM to 5:30 PM.
Values within a row with different superscripts (a, b) differ significantly at $P < 0.05$.

time lying inside the dome because of very close proximity of pen mates (Averós et al., 2014). These lambs might have compensated for the less time spent standing and more lying time inside the dome (6:30 PM to 7 AM) with more standing time and less lying time in the open area (6:30 PM to 7 AM). The significant decrease in lying time as the week progressed is possibly because of the higher activity levels of lambs at increasing age.

Generally, less opportunity for socialization and limited space availability in an individual pen reduces the playing behavior in calves (Babu et al., 2004). In the present study, the animals of G-II did not get any chance for social interaction from 6:30 PM to 6:30 AM as they remain confined in the dome. Therefore, in the daytime they showed a higher frequency of play behavior in terms of social interaction.

Sheep housed individually showed abnormal oral behavior (Lauber et al., 2012). In the present study, the lambs in the G-II were kept in bamboo dome, where only 2 lambs were kept together in the narrow space and they showed more oral stereotypies than other two groups. Andrighetto et al. (1999) also indicated that the frequency of abnormal oral behavior increased in calves when they were housed in narrow crates as compared to group housed and possibly because of the lack of freedom of movement in crates (Fraser and Broom 1990). Similarly, in the present study, lack of space for movement in the bamboo dome houses of lambs (G-II) maybe reduced the possibility to exhibit their normal behavior and it eventually lead them alternatively to show abnormal behaviors like oral steriotypes.

Table 7
Effect of different type of housing on social behavior and oral stereotype in Malpura lambs

	G-I	G-II	G-III	SE	*P* value
Social behavior					
Playing (number of times/day/lamb)	0.61[a]	1.39[b]	0.33[a]	0.06	0.03
Smelling other (number of times/day/lamb)	0.00	0.28	0.11	0.08	0.174
Self-licking (number of times/day/lamb)	0.39	0.56	0.83	0.30	0.355
Oral stereotype					
Licking feeder (number of times/day/lamb)	0.17	0.39	0.33	0.16	0.485
Licking waterer (number of times/day/lamb)	0.22	0.44	0.28	0.13	0.279
Licking fences (number of times/day/lamb)	0.78	0.94	1.06	0.25	0.383
Licking inanimate object (number of times/day/lamb)	0.56	0.50	0.39	0.27	0.798

G-I, control; G-II, dome; G-III, thermocol insulated; SE, standard error.
Observations were taken for 1 lamb from each group daily (weekly once of each animal; 7 animals in each group) for 3 weeks. The abnormal behaviors were observed during 8 AM to 5:30 PM.
The abnormal behavior observed in terms of frequency, that is, number of times the particular abnormal behavior is performed by a lamb from 8 AM to 5:30 PM in a day.
Values within a row with different superscripts (a, b) differ significantly at $P < 0.05$.

Conclusions

The present study reveals that the lambs kept in thermocol-insulated cold-protected (G-III) shed spent significantly more time in total feed intake, which inturn caused higher final body weight and higher weekly weight gain. The standing time was significantly higher but lying time was lower in lambs reared in bamboo dome. It is difficult to infer on the basis of the oral stereotypies noted in this study, a general conclusion about the rearing system for animal welfare. Yet, based on overall behavioral analysis and performance of lamb could conclude that, the thermocol-insulated housing showed better welfare compared to normal and bamboo dome housing during the peak winter season of semi-arid tropical conditions. Further research is required in this line with a more number of lambs and precision housing to understand the welfare implication in relation to housing.

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Conflict of interest

The authors declare no conflict of interest.

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