Behavioral response of pregnant ewes to high ambient temperature in loose housing system

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Abstract: In order to investigate the behavioral responses of pregnant ewes to high ambient temperature in a loose housing system , eighty-seven pregnant ewes (Chinese little fat-tailed sheep, Ovis aries) from the same loose house were chosen, and nine ewes with the similar body weight and age were marked for later individual behavioral observation. The ambient temperature and relative humidity were recorded, and the individual behaviors of the pregnant ewes were observed continuously from 04:50 to 20:00 once every other day for 14 days. The behavioral state of all the pregnant ewes was recorded once every hour from 5:00 to 20:00, the number of pregnant ewes selecting specific lying areas (designated as area A and area B), was recorded at 15 minute intervals from 12:00 to 17:00 everyday. The final results show that the behavioral durations are significantly different in eating and drinking, rumination, rest, and locomotion for pregnant ewes (P <0.05). The time spent in lying for rumination or rest is significantly longer than that for locomotion (P <0.05). Temperature has a significant effect on the number of pregnant ewes lying on the floor (P <0.05). There are significant differences for pregnant ewes' preference of area A and area B for lying at temperatures ranging from 27.0℃ to 31.0℃ (P <0.05). The results indicate that the lying behavior is significantly more than the locomotion behavior for the pregnant ewes in the loose housing systems under the high ambient temperature.

Keywords: pregnant ewes, loose housing, behavior, high temperature

DOI: 10.3965/j.issn.1934-6344.2008.01.031-036

Citation: Geng Ailian, Zang Qiang, Chen Gang, Shi Zhengxiang, Li Baoming. Behavioral response of pregnant ewes to high ambient temperature in loose housing system. Int J Agric & Biol Eng. 2008;1(1): 31－36.

1 Introduction

Housing systems for sheep have been discussed for many years[1,2], the advantages of which are to mitigate the deterioration of the grassland ecological environment, and improve the welfare and health of livestock[1,3,4], and the disadvantage is the barren environmental condition, especially in confined areas which may cause the sheep's behavioral restriction or deprivation[5].

The effects of a housing system and its environment on sheep behaviors have been studied extensively[6-12]. The behavioral normality or not can directly reflect on the animal's needs and stress for the environment, especially under high ambient temperatures. During a hot season with strong sun radiation, sheep get a larger quantity of heat, which affects the normal work of the thermoregulatory system, the feed intake and normal behaviors of the animals[13,14], and further causes the decrease in growth performance, and abnormality of physiological indexes[15,16]. Abdalla et al.[17] studied the physiological responses of pregnant and lactating ewes for high ambient temperatures, and indicated that the ewes' respiratory frequency and heart rate increased, water intake increased, and feed intake decreased under heat stress.

Animals, which can maintain their physiological responses within normal limits under stressful environmental conditions may be considered to be adapted to that environment and worth raising in commercial conditions[18]. Chinese little fat-tailed sheep are China-bred native sheep used for meat and fur, and one of the few sheep breeds in the world with the characteristics of estrus year around, a high reproductive rate and multi-embryo performance[19]. In 2000, the Chinese government initiated a new program that prohibited grazing for grassland conservation, which forced the use of housing systems for raising sheep in

Received date: 2008-07-28 Accepted date: 2008-08-06

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China[20] and the Chinese little fat-tailed sheep was regarded as an important breed suitable for the housing system[21]. However, information about the effect of ambient high temperature on the behavioral response for Chinese little fat-tailed sheep in a commercial condition has not been available. As a result, the objective of this present work is to investigate the behavioral response of pregnant Chinese little fat-tailed ewes for high ambient temperature in a loose housing system, and provide some references for feeding management and environmental control for the future sheep industry.

2 Materials and methods

2.1 Experimental site

The experiment was conducted at Hongwu Sheep Farm, Chifeng City, Inner Mongolia Autonomous Region, China at a 116°21'E longitude, 41°17'N latitude, and at an altitude of 1250 m above sea level. Winters are long and cold, summers are short and hot, and there are large temperature differences between day and night. The annual average temperature is −7.0℃, the average ambient temperature is 18.0−23.0℃ in the summer, and the annual highest extreme temperature is 35.0−40.0℃, often occurring from July to August. The average annual rainfall is 375 mm, and there was very little rainfall during this experimental period.

2.2 Experimental animals and management

Eighty-seven pregnant, multi-parous Chinese little-tailed ewes from the same house and paddock were chosen, and nine of the ewes with similar body weight and age (in the third month of pregnancy, age of 2.0−2.5 years, body weight 61.7±4.10 kg) were marked for later individual behavioral observation. The ewes' basal diet is composed of the following: silage, 1.00 kg; green grass, 1.50 kg; corn + straw powder, 0.75 kg; mixed concentrated feed, 0.60 kg; salt, 0.01 kg; and carrot, 0.30 kg. The duration of the experiment was 28 days and was conducted from July to August, which is usually the hottest period in a year. Sheep were housed year-round in buildings with windows and attached to an open paddock. The building was naturally ventilated with windows on two sidewalls. Feed and water troughs were placed along the walls in the house and paddock, respectively. The feed was supplied manually to the ewes three times a day (4:50, 10:50 and 17:30), and drinking water was available continuously to the animals in sufficient quantity. The indoor floor was made of solid brick and manually cleaned every morning.

2.3 Measurement of ambient temperature and relative humidity

Ambient temperature and relative humidity were measured using Thermo Recorder RS-11 Sensors (Especmic, Japan). Nine sampling points were placed in the house at a height of 0.90 m from the floor, and similar sampling points outside the house were put at a height of 3 m from the floor. All data loggers were programmed to record values at half-hour intervals and measurement ranges were −20.0−80.0℃ with an accuracy of ±0.35℃ for the ambient temperature, and 10%−95% of ±3% for the relative humidity.

2.4 Behavioral observations

Individual behavioral observations were done using the continuous method of recording through the digital video recorder (Sony DSR-PD190P) from 04:50 to 20:00 once every other day, for 14 days. The time spent in eating and drinking, rumination, rest, locomotion, and other behaviors were recorded. The description of the behavioral variables is shown in Table 1.

Table 1 Description of behavioral variables.

Behavioral variables	Description
Eating	Individual actively engages in the ingestion of feed
Drinking	Drinking from water trough
Ruminating	Individual chews its cud in any postures
Resting	Individual takes rest in standing or lying posture with evident wakefulness but not doing any activity like rumination, or evident somnolence with closed eyes (sleeping)
Locomotion	Individual walks, trots or runs around house or paddock
Other	Other unlisted activity, includes social and aggressive interactions, investigation around, being alarmed or startled, scratching oneself

During the observation, the behavioral state of all the pregnant ewes were recorded once every hour from 5:00 to 20:00 every day, using the method of instantaneous scan sampling.

The number of pregnant ewes selecting to lie on the floor and selecting a specific lying area was recorded at 15 minute intervals from 12:00 to 17:00 every day. The two lying areas are area A, close to a door and window with good natural ventilation and without sunshine; and area B, a corner with sunshine and less ventilation, respectively in the loose house to study the preference of pregnant ewes for lying areas.

2.5 Statistical analysis

Behavioral data were analyzed using Observer Video Pro (Noldus Information Technology, Ltd. Co., Netherlands). All statistical analyses were performed using the SPSS 11.0 for windows. A Mann-Whitney

U-test was used to analyze the duration of the behaviors among pair-wise comparisons of pregnant ewes. The posture of the sheep for rumination and rest were analyzed using a Wilcoxon signed ranked test. The McNemar test was used to analyze the pregnant ewes' preference selection of area A or area B. $P<0.05$ was regarded as statistically significant.

3 Results

3.1 Ambient temperature and relative humidity in the loose house

The varying curves of ambient temperature and relative humidity in the loose house are shown in Figure 1. The result shows that the average ambient temperature inside the house is 21.1−28.5℃ and the average relative humidity is 48.7%−87.2%. The ambient temperature is usually lower inside than outside the house, and the relative humidity is higher in the house than outside during the day. The inside temperature and humidity basically change with the changes of the outside temperature and humidity, but the highest and lowest temperatures are 31.5℃ and 18.6℃ inside the house, 35.4℃ and 16.3℃ outside the house, respectively.

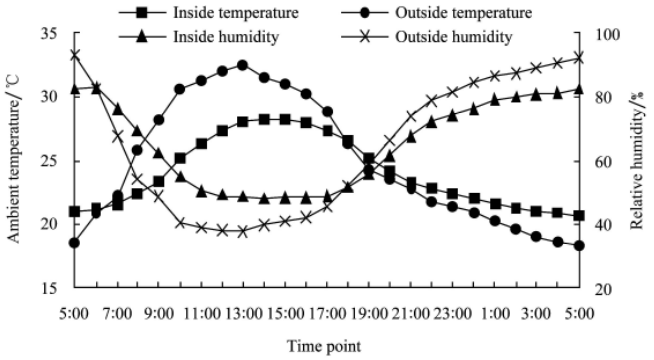

Figure 1 Varying curves of ambient temperature and relative humidity inside and outside the house

3.2 Daily behavioral changes of pregnant ewes

Figure 2 shows the daily behavioral changes of pregnant ewes. The animals eat and drink more in the morning, less with the increase of ambient temperature at noon, and reach a peak at dusk with the decrease of the ambient temperature, which is similar to the eating behavior of the Angora goat[22]. The eating time also occurred during the periods of 05:00−06:00, 10:30−11:30, and 16:00−18:00. The rumination time is close to the eating time, and often there is rumination after eating.

Usually the first rumination appears 30−50 minutes after eating, and the rumination peak appears during 8:00−10:00 and 13:00−16:00.

Rest is one of the most important behaviors of pregnant ewes. Sleep often appears soon after rumination, and usually sleeps while lying down. During the daytime, the pregnant ewes' rest often occurs during 8:00−10:00 and 12:00−17:00, when the ambient temperature usually reaches 27.0−31.0℃, the hottest time in a summer day.

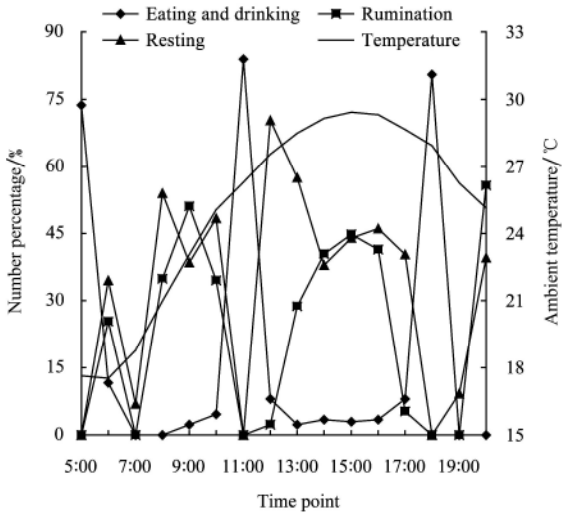

Figure 2 Daily behavioral changes of pregnant ewes

3.3 Behavioral patterns analysis of pregnant ewes

According to the records and calculation, the average time periods spent in eating and drinking for pregnant ewes were 246.78 minutes, 248.56 minutes in rumination, 317.67 minutes in resting, 91.00 minutes in locomotion, and 6.00 minutes in other behaviors. Rest periods are the longest, occupying 34.91%, and the shortest is for other behaviors, only 0.99%. The duration ratio for eating and drinking, rumination, and rest behaviors was 1:1.01:1.29. Chen et al.[23] observed the behaviors of Chinese little-tailed sheep in a loose housing system for 24 hours, and indicated that the duration ratio for eating and drinking, rumination, and rest behaviors was 1:1.68:1.75. The result shows that a pregnant ewe spends more time in rumination and rest, which may be related to the stage of pregnancy.

The eating peak was observed between 05:00 and 06:00 and between 10:30 and 11:30, and was related to the time when feed was provided. Sheep spent the longest continuous time for eating and the rumination peak was observed between 08:00 and 10:00 with a second peak between 13:00 and 16:00. Most rumination was observed between 9:00 and 15:00 (Figure 3).

3.4 Choice of behavioral posture

The rumination and rest behavior of pregnant ewes may occur at standing and lying postures. Time spent in rumination and rest in the lying posture was significantly longer than the time spent standing by pregnant ewes

(P<0.05). Pregnant ewes spent the longest time resting in the lying posture (Figure 4).

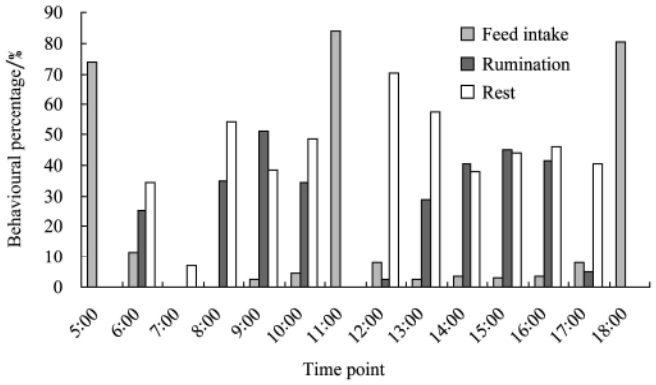

Figure 3 Behavioral duration for pregnant ewes.

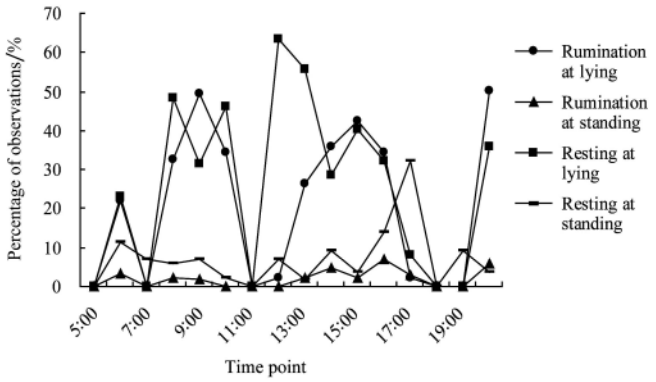

Figure 4 Posture choices of pregnant ewes for rumination and rest

3.5 Effect of ambient temperature on selection of lying areas by pregnant ewes

The number of pregnant ewes in the lying posture was used to evaluate behavior under different thermal conditions. Temperature had a significant effect on the number of pregnant ewes lying on the floor (P<0.05). An average of 27 ewes (31.0%) was lying on a solid brick floor for rumination and rest when temperatures were 21.0−23.0℃, 65 ewes (74.7%) were lying at temperature of 25.0−27.0℃, and 85 ewes (97.7%) were lying at 29.0−31.0℃.

The number of pregnant ewes lying in area A or area B in the house was calculated from 12:00 to 17:00 when the temperature was higher than 27.0℃ (Table 2). The results indicate that the pregnant ewes prefer lying in area A more than in area B (P<0.05) during this period. 82.76% of the sheep lay in area A when the ambient temperature was about 30.1℃. The number of pregnant ewes selecting area A increased from 66.0% to 83.0% with the increase of temperature, whereas the number of ewes choosing area B decreased from 31.0% to14.0% for each hour during this period.

Table 2 Effect of ambient temperature on preference of lying areas of pregnant ewes (means±S.E.)

Time point	Ambient Temperature /℃	Percentage of ewes lying in area A /%	Percentage of ewes lying in area B /%	P value
12:00	27.6	65.52±5.13[a]	31.03±4.99[b]	
13:00	28.7	68.97±4.99[a]	27.59±4.82[b]	
14:00	29.5	74.71±4.69[a]	22.99±4.54[b]	
15:00	30.1	82.76±4.07[a]	13.79±3.72[b]	
16:00	29.3	80.46±4.28[a]	18.39±4.18[b]	
17:00	28.1	75.86±4.61[a]	22.99±4.54[b]	0.001

[a,b] Means with different superscripts in the same row differ significantly (P<0.05).

4 Discussion

Behavior is considered to be a reliable indicator of comfort and welfare of the animals[8,11]. The current results indicated that there were significant differences in durations of eating and drinking, rumination, rest and locomotion for pregnant ewes. The study shows that pregnant ewes had the longest time for resting in a lying posture, and this could relate to the stage of pregnancy. The sheep spends little time in eating between 12:00 and 17:00, which suggests that feed, should be supplied to pregnant ewes when the temperature is lower, for example at dusk, to facilitate higher feed intake in a day. Group-housed animals prefer inactive behavior such as lying[24] to reduce physical interactions with its partners[25]. Lying was the major posture for rumination and rest activities. During rumination and rest, lying behavior is easily affected by sudden noises, the condition of the floor and the ambient temperature. The present study indicated that the ambient temperature was a key factor influencing the lying areas preference for pregnant ewes, especially under high ambient temperature. More pregnant ewes chose area A for lying at higher temperatures, which facilitates heat dissipation quickly due to conduction, but they had to change their postures or even lying areas continuously to find a better environment under the high temperature, which consequentially affected the remaining pregnant ewes, and further affected the development of embryos. Johnson[26] provided Merino sheep with sun-proof shading in a free-ranging system, and Hassanin[27] provided Barki rams with asbestos shading in the paddock outside the house, and found that the shade could delay the heat stress for the animals, keep the animals in normal physiological responses, and avoid the appearance of abnormal behaviors. So it is suggested that the loose house where the pregnant ewes live should be

provided with some sun-proof shade to create more areas that allow sheep to dispersedly lie for rumination and rest in the summer.

Less time was used on other behaviors such as social and aggressive interactions, investigating around, being alarmed or startled, scratching oneself, etc. Abnormal behaviors such as gnawing, sneezing and fighting were not observed during the study. The behavioral responses might be indicators of physiological adaptation of pregnant ewes to the living environment. The effects of the additional lying behaviors on the health of pregnant ewes and their embryo need to be studied further in the future.

5 Conclusions

The present study indicates that in loose housing systems under high ambient temperatures, pregnant ewes are more inclined to lie down and rest than move around, and it is suggested that some sun-proof shade should be provided to create more appropriate areas to allow sheep to dispersedly lie down for rumination and rest in the summer.

Acknowledgements

The authors wish to thank the National “Eleventh Five-year Science and Technology Plan” (2006BAD14B01 and 2006BAD14B02) and the Co-Construction Item of the Constructive Program from the Beijing Educational Committee (XK100190650) for providing financial support.

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