Bulgarian Journal of Agricultural Science, 14 (No 4) 2008, 417-423
Agricultural Academy

EFFECT OF SHEARING ON SOME PHYSIOLOGICAL RESPONSES IN LACTATING EWES KEPT INDOOR

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Abstract

ALEKSIEV, Y., 2008. Effect of shearing on some physiological responses in lactating sheep kept indoor. *Bulg. J. Agric. Sci.,* 14: 417-423

The effect of early spring shearing on dynamics of some physiological responses was studied in six lactating Tsigai ewes kept in barn. Rectal temperature, pulse rate and respiratory frequency were recorded for 5 days before and 15 days after shearing twice daily in the morning (07.00 h) and in the afternoon (14.00 h). Rectal temperatures were lower in the morning both in unshorn and shorn sheep compared to the values recorded in the afternoon but the difference was significant ($P<0.05$) only in shorn ewes. Rectal temperature in unshorn sheep averaged 39.0°C in the morning and 39.2°C in the afternoon. Shearing resulted in a significant decrease in rectal temperature of 0.73 °C in the morning ($P<0.01$), and of 0.41°C in the afternoon ($P<0.05$) compared to pre-shearing levels. Heart rate in the morning prior to shearing was 82.8 ± 0.4 beats.min^{-1} and an average increase of approximately 10 beats.min^{-1} was recorded after shearing. In the afternoon, similar mean values of 102.9 ± 0.4 and 103.3 ± 0.5 beats.min^{-1} respectively were recorded in unshorn and shorn ewes. A transient elevation of 25 beats.min^{-1} accompanied by shivering was noted only in the first morning after shearing but subsequently they both disappeared indicating a downward shift in the lower critical temperature Prior to shearing, respiratory frequency averaged 36.6 ± 3.1 breaths.min^{-1} in the morning and 55.9 ± 5.8 breaths.min^{-1} in the afternoon. Shearing brought about a considerable drop in respiratory activity, which reached significantly lower mean values of 16.6 ± 0.9 breaths.min^{-1} in the morning ($P<0.01$) and 20.6 ± 1.5 breaths.min^{-1} in the afternoon ($P<0.001$). Regardless of the substantial enhancement of ambient temperatures during the daytime, respiratory activity remained almost unchanged. The results suggest that adaptation in shorn sheep was realized mainly through the activation of energy saving mechanisms which played an essential role in supporting the thermal homeostasis under cold stress induced by shearing.

Key words: lactating ewes; shearing; rectal temperature; pulse rate; respiratory frequency

Introduction

Fleece, modifying the impact of climate, plays an essential role in improving the adaptive flexibility of sheep to extreme environment. Shearing usually results in an enhancement of energy exchange between the animal and its surroundings. This, in turn, may alter the level of cold and/or heat tolerance, shift the zone of thermal indifference, and affect the welfare and productivity of sheep. It may be considered that

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the two main factors determining the point of the lower critical temperature are feed intake and body insulation (Bianca, 1968). In this respect fleece removal is one of the most stressful event in sheep's life from the point of view of both handling and thermal stress caused by shearing. Studies have found that cold stress, as a result of exposure in controlled environment (Slee, 1972; Slee, 1985) or induced by shearing at ambient temperatures below the lower critical temperature (Davey and Holmes, 1977; Holmes et al., 1992; Symonds et al., 1990) usually triggers a number of compensatory responses in order to increase heat production and to minimize heat loss to the environment. In the literature reviewed surprisingly little information was found concerning the response to shearing of lactating sheep, that may expect to have increased basal metabolic rate and heat production compared to non-producing animals (Young, 1983). Shearing sheep of different breeds in many European countries usually takes place in April-May when local weather, especially in Bulgaria, is quite variable and environmental temperatures, particularly in the night, are often quite below the critical for shorn ewes (Graham et al., 1959).

The aim of the present experiment was to investigate the effect of shearing on rectal temperature, heart rate and respiratory frequencies in lactating ewes and to assess the mechanisms of climatic adaptation under natural indoor environments.

Materials and Methods

The present work was a part of a comprehensive survey studying the effects of shearing on production and adaptive responses in lactating sheep. Experimental design, animal used, feeding regime, and meteorological parameters (including minimum maximum and average daily temperature fluctuations, relative humidity and air velocity) during the observation period were described in details in our previous announcement (Aleksiev, 2008)

The physiological variables were recorded in six ewes for a week before and two weeks after shearing. Rectal temperature was measured by clinical electronic thermometer (Microlife MT 16C2) inserted into a depth of 10 cm. Heart rate and respiratory frequency of each individual ewe were recorded by stethoscope counting the beats and breaths respectively over two 30 sec intervals. In regard to respiration rate, simultaneous counting of breaths and flank movements were applied. At the time of measurements the sheep were moved into a smaller pen, erected in the corner of the bigger one. The animal were well habituated to the man's presence and stood restful, without any restriction, during the time when the measurements were taken. Animal behavior was evidence that the heart rate was obtained with minimal disturbance. The physiological parameters were recorded each day at 07:00 h and 14:00 h considering that these hours of the day approximately corresponded to the levels of minimum and maximum daily temperatures. The fleece depth, remaining after clipping, was measured in ten positions on each side of the trunk and in three on the neck and the mean length was 7.4 ± 0.18 mm. During the observation period air temperature and humidity and air movement were also recorded at sheep's height using thermometers for air temperature, whirling psychrometer and kata-thermometer respectively. The monitored environmental parameters were registered three times daily at 07.00, 14.00 and 21.00 h.

Descriptive statistics and simple (Pearson) correlations between ambient temperature and physiological variables were carried out using Statistica for Windows (release 6, StatSoft, Inc.) Treatment means were separated by pairwise t-test. Statistical difference was declared at $P \leq 0.05$.

Results

Rectal temperature dynamics before and after shearing of the ewes is shown in Figure 1. Rectal temperatures were lower in the morning both in unshorn and shorn sheep compared to the values recorded in the afternoon. In unshorn sheep, the difference between morning and afternoon temperatures was insignificant, while in shorn ewes daily differences in all time points were significant ($P<0.05$). Shearing resulted in a considerable decrease in rectal tempera-

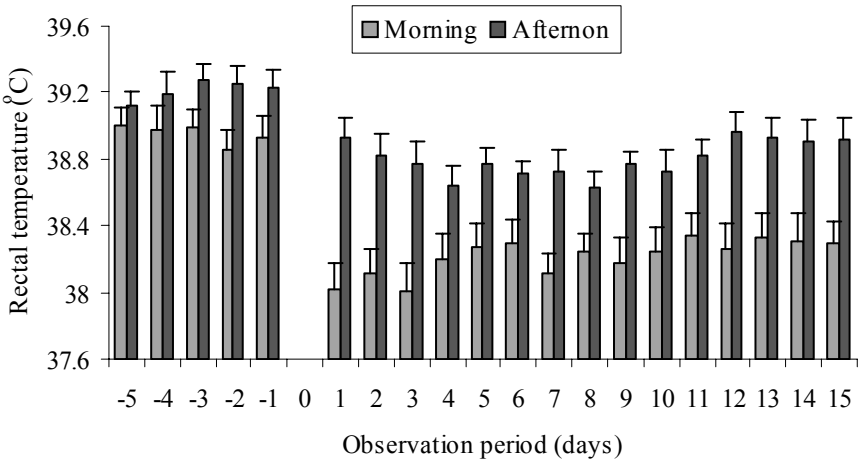

Fig. 1. Rectal temperature dynamics (°C) in unshorn and shorn ewes. Values are mean ± SE. Vertical bars represent SEM. Day 0 = shearing day

ture of 0.73 °C and 0.41°C respectively in the morning and in the afternoon compared to the pre-shearing levels. The observed reduction was significantly greater in the morning ($P<0.01$) than in the afternoon ($P<0.05$) recordings. Rectal temperature correlated positively to ambient temperature but in unshorn sheep coefficient was higher in the afternoon ($r = 0.83$), while in shorn ewes it was higher in the morning $r = 0.48$).

Shearing evoked measurable, although insignificant, increase of the mean heart rate in the morning but not in the afternoon. The mean daily heart rate in the morning in unshorn sheep was significantly ($P<0.05$) lower compared to the value recorded in the afternoon. In shorn sheep the difference between morning and afternoon measurements was only about 10 beats.min^{-1} reflecting the elevated morning rates (Figure 2). A significant increase ($P<0.05$) in the heart rate of about 25 beats.min^{-1}, compared to pre-shear-

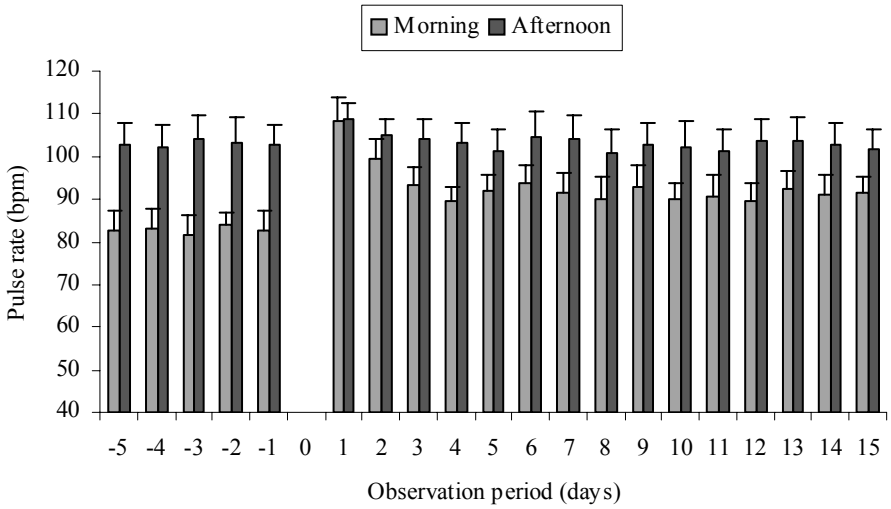

Fig. 2. Pulse rate (beats.min^{-1}) in unshorn and shorn ewes. Values are mean ± SE. Vertical bars represent SEM. Day 0=shearing day

ing level, was observed only in the morning during the first day after shearing followed by decrease, and the values remained at this level up to the end of observation. Mean heart rates in the afternoon were equal in shorn and unshorn sheep. Negative correlations between pulse rate and air temperature were found with the exception of unshorn ewes in the afternoon.

Respiratory frequency in unshorn sheep increased significantly ($P<0.05$) throughout the day reaching at 14.00 h mean values of 56 breaths.min^{-1} compared with 37 breaths/min^{-1} in the morning (Figure 3). Shearing brought about a substantial drop in respiratory frequency. Respiratory activity was significantly less both in the morning ($P<0.01$) and in the afternoon ($P<0.001$) compared to pre-shearing level. The established differences persisted up to the end of the observation regardless of the changes in ambient temperatures. After shearing, the daily changes in respiratory activity were negligible, and varied less between individual sheep. The average enhancement for the whole period between morning and afternoon measurements did not exceed 4 breaths.min^{-1}. Respiratory frequency correlated positively to air temperature and correlation coefficients had similar values in unshorn ($r = 0.66$) and shorn ($r = 0.62$) ewes in the afternoon.

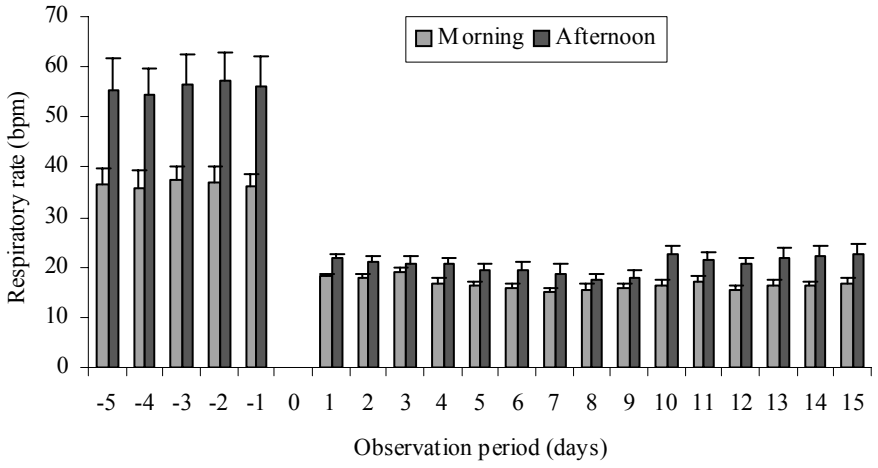

Fig. 3. Respiratory activity (breaths.min^{-1}) in unshorn and shorn ewes. Values are mean ± SE. Vertical bars represent SEM. Day 0=shearing day

Discussion

Rectal temperature is considered an important physiological characteristic, and its daily pattern is a net result of both heat exchange to the environment and heat production by the animal (Lowe et al., 2001). In this study, shearing resulted in an increased heat loss to the environment, uncompensated by an adequate enhancement of heat production, which led to a significant drop of both morning and afternoon rectal temperatures. The observed dynamic in rectal temperature before and after shearing might be attributed to the environmental and internal inputs. This suggestion was confirmed by the pattern of changes of the physiological response and its relation to air temperature. Daily increase in rectal temperature in shorn and unshorn ewes was mainly a result of increased physical activity and digestion of food as important sources of heat production. In the shorn sheep, however, the daily rise was appreciably greater, indicating increased sensitivity to environmental temperature, especially in the morning hours. The results obtained here differed from those of Piccione et al. (2002) who, in a similar study, reported a long-term elevation in rectal temperature in three breeds of sheep after shearing under ambient temperatures quite higher (16-28°C) than in

the present study. The differences in metabolic adaptation found in the present investigation and those stated by Piccione and coworkers are hardly a result of breed differences but rather of the age of sheep. Thus, in the cited article the sheep studied were yearlings and have not yet experienced shearing by this age. Bianca (1970) also noted that the thermoregulatory capacity is a function of age and the zone of thermal indifference changes with age, which could influence the type and magnitude of the responses. Heat dissipation depends on surface area and might be affected by feeding level and physiological state. In the present study sheep were four years old and at the time of shearing they were still acclimatized to the winter temperatures. The latter may suggest an elevated basal metabolic rate, lowered critical temperature and altered metabolic response. Our results are in accordance with findings of Webster and Johnson (1968), who reported that in sheep kept in short and full fleece prior to shearing rectal temperature declined to the same extent after removal of the fleece but the short fleeced sheep continued to regulate their RT at a lower level than fully fleeced sheep. Slee (1974) also remarked that the acclimation to cold retained several weeks after ceasing of the cold exposure. In the present study, regardless of the daily air temperature elevation, rectal temperature in the shorn ewes in the afternoon did not exceed the morning level recorded before shearing. The results support the assumption that a new set point was established in the process of adaptation in shorn sheep, which is in conformity with the statement of Cabanac (1975), and Hammel et al. (1963). The observed reduction in rectal temperature after shearing may also contribute to the lowering of the temperature gradient between the core and the periphery, minimizing in this way the rate of heat transfer between tissues and heat loss to the environment. During the last few days of the present study, the levels of rectal temperature in the afternoon started to increase, which might be attributed to some extent to the gradual elevation of ambient temperatures.

Heart rate may be used as an indicator of energy expenditure in animals (Brosh, 2007) and a constant value of energy expenditure per heart beat was found in cattle (Brosh et al., 1998). Webster (1967), considering the possibility of using the heart rate for prediction of energy expenditure in sheep, pointed out that results could be influenced by emotional disturbance of the animals if they are not well habituated to the environment. The last could not be related to the animals used in this study as they were previously reared in a small flock in confinement, and were well accustomed to worker's presence and withstood restfully all recording procedures. The transient elevation in heart rate, especially during the first day after shearing, could not be a result of handling stress but rather indicated that, in the morning, sheep were well out of the zone of thermal indifference. This evoked an activation of appropriate mechanisms for heat production required to match the enhanced heat loss (Jansky, 1973). Thus, in the morning during the first day after shearing, the sheep showed signs of shivering, manifested as tremor in the facial muscles of the shoulder. Shivering accompanied by an elevated heart rate suggested that vasoconstriction and elevated basal metabolic activity were insufficient to maintain thermal equilibrium. These signs disappeared the next morning, which might be a result of replacement of shivering by nonshivering thermogenesis, increase of ambient temperatures, as well as the further improving of peripheral adaptation. The similar values of the heart rates in shorn and unshorn sheep in the afternoon suggested that at this time of the day shorn ewes were close to their thermoneutral zone. The observed increase in heart rate in shorn sheep of approximately 10 beats.min^{-1} in the morning, compared to pre-shearing level, reflected a relatively unessential enhancement of basal metabolic activity. This finding is consistent with the conclusion of Slee (1971) that an increase of heart rate of 20 beaths.min^{-1} represents an increase in resting metabolic rate of approximately 30%. The elevation in the heart rate immediately after shearing and gradual decline during the next days may also indicate a downward shift in the lower critical temperature.

Hypoventilation is an effective means of maintaining body temperature in cold environment, providing an adaptive benefit in energy conservation by reducing respiration heat loss (Diesel et al., 1990). The res-

piratory activity was considerably higher in unshorn sheep both in the morning and in the afternoon but about twofold drop was observed after shearing. The decreased respiratory frequency in shorn sheep, brought about by both endogenous and environmental inputs, may be considered as a thermoregulatory adjustment to the environmental temperature directed at heat conservation (Cabanac, 2006). Ambient temperatures, especially in the morning, were well below the critical but in the afternoon they reached the values close to the thermoneutrality for shorn sheep in high plane of nutrition (NRC, 1981). The daily temperature elevation did not measurably affect the respiratory rate in shorn ewes. Even in the afternoon, respiratory activity did not reach the morning levels recorded in unshorn sheep, and remained almost unchanged over the course of the study. This could be attributed to modifying of the thermoregulatory set point in anticipation of night cooling. Respiratory frequency in the afternoon, similarly to the observed changes in rectal temperatures, tended to increase towards to the end of the experiment. Donnelly et al. (1974) noted similar changes in respiratory activity during the warmest part of the day in Merino wethers two weeks after shearing. They concluded that these changes might be contributed to the reduction of the critical temperature and increased resistance to body cooling. In the case of our study and that of Donnelly and coworkers it is difficult from the data available to distinguish the possible effect of air temperature elevation and/or wool re-growth on the responses studied. It must be taken into account that shearing did not measurably affect feed intake but resulted in a substantial drop of water intake that occurred in parallel with changes in respiratory frequency. (Aleksiev, 2007). This might be associated with the reduction of respiratory activity and, therefore, the decrease in the water turnover for evaporative cooling. The remarkable decline in respiratory frequency and the negligible increase of heart rate suggest that, in the conditions of this study, the adaptation in shorn sheep was realized mainly through activation of the energy saving mechanisms like peripheral adaptation and reduction of evaporative cooling.

Conclusions

The synchronous changes of physiological responses observed in this study emphasized the complexity of climatic adaptation. Shearing of ewes induced considerable decline in rectal temperature that could indicate both increased heat loss and the shift of the thermoregulatory set point directed at energy preservation. The elevation of the heart rate in shorn sheep in the morning may be associated with an increased metabolic rate in order to match the enhanced heat production for maintenance of the thermal homeostasis at sub critical temperatures. The fall in heart rate after the initial elevation may indicate a possible drop in the lower critical temperature. The mean morning elevation of heart rate brought about by shearing did not exceed 10 beats.min^{-1} indicating a relatively negligible increase of metabolic heat production. Hypoventilation is an energy saving response and the considerable depression of respiratory activity in shorn sheep was apparently directed to reducing the evaporative heat loss to the environment. The observed changes of the monitored variables suggest that the mechanisms of heat conservation play an essential role in supporting of the thermal homeostasis under mild cold stress induced by shearing.

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Received January, 12, 2008; accepted for printing March, 12, 2008.