

THE EFFECT OF SHEARING ON THE BEHAVIOUR OF SOME PHYSIOLOGICAL RESPONSES IN LACTATING PLEVEN BLACKHEAD EWES

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Abstract

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Rectal temperature (RT), pulse rate (PR), and respiratory frequency (RF) were collected for 6 days before shearing and for 15 days thereafter, in the morning and in the afternoon. Morning RT values were lower in unshorn and shorn sheep compared to afternoon ones but daily differences were greater after shearing. Shearing caused a significant ($P < 0.001$) drop in the morning RT values (0.61°C , 0.99°C , and 1.18°C) and a less reduction in the afternoon ones (0.13°C , 0.38°C , and 0.43°C) during the first 3 days post shearing. RT increased sharply thereafter but remained lower than in unshorn ewes up to the end of the study. An increase in PR values was observed both in the morning ($P < 0.05$), and in the afternoon ($P < 0.01$) on the first day after shearing. This transient increase was then followed by a reduction, but the values remained slightly elevated compared to pre-shearing recordings. Respiratory activity fell significantly after shearing both in the morning and in the afternoon and remained reduced throughout the study. The data suggested that shearing caused modifications in nervous control mechanisms and re-adjusting of the thermoregulatory set point to a new, more economic, level. Energy-saving mechanisms appeared to play a major role in post-shearing adaptation.

Key words: sheep, shearing, rectal temperature, pulse rate, respiratory frequency

Abbreviations: RT- rectal temperature, PR-pulse rate, RF-respiratory frequency

Introduction

Fleece is thought to be the main factor determines the adaptive capacity of sheep to a wide range of climatic conditions. The type and depth of the fleece influence its insulative properties which, in turn, affect body heat balance. Shearing, modifying the direction and magnitude of heat exchange, shifts the zone of metabolic thermoneutrality impeding the maintenance of homeothermy especially in extreme environment.

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The level of the lower critical temperature depends, beside other factors, on the normal heat production which is elevated in producing animals (Young, 1983). Degen and Young (1982) noted an increase in heat production in lactating ewes of 62 % and 50 % in the first and second months of lactation respectively, compared to non-lactating controls. This elevated metabolic rate suggests the relationship between the zone of thermal indifference and physiological state of an animal that may affect the magnitude of homeostatic

responses. The level of feed intake, which is associated with heat increment of feeding, may also contribute to the reduction of the lower critical temperature (Young et al., 1989). Studies in sheep (Davey and Holmes, 1977; McBride and Christopherson, 1984; Ekpe and Christopherson, 2000) showed that cold stress induced by shearing may drive a number of metabolic and physiological responses aimed at balancing the rate of heat production and heat loss and sustaining the stability in internal environment. Shearing of sheep, irrespective of the season, is usually associated with some degree of thermal stress that may affect the welfare and productivity of animals. With different sheep production systems shearing takes place in April to June when environmental temperatures are quite variable and often are below the critical level for shorn ewes. In the literature reviewed very scarce information was found about thermoregulation in newly shorn lactating sheep.

The objectives of the present investigation were to study the effects of shearing on the behavior of rectal temperature (RT), pulse rate (PR) and respiratory frequency (RF) in lactating Plevan Blackhead sheep and assess the involvement of different homeothermic mechanisms supporting thermal equilibrium.

Material and Methods

The experiment was performed on the local Plevan Blackhead sheep at similar age, body mass and stage of lactation. Ten ewes were selected from the flock and located under the open fronted shed and lying area of approximately 2.5 m² per ewe was ensured. Chopped hay (9.78 % crude protein, and 27.99 % crude fiber) was administered and every morning the orts were collected and weighed. Each ewe received 800 g of concentrate (13.18 % crude protein, and 6.83 % crude fiber) offered twice daily, in the morning and in the afternoon about an hour before milking and after recording of the physiological parameters. The hay and concentrate were offered separately. Diet was calculated to meet the requirements for maintenance and lactation. Water was freely available and the amount of water consumed was recorded volu-

metrically twice daily. At the end of March the sheep was shorn manually (by hand shears) and were weighed after shearing and again at the end of the observation. The fleece depth, remaining after clipping, was measured in ten positions on each side of the trunk and in three on the neck.

The physiological parameters were recorded each day at 0700 h and 1400 h considering that these hours of the day approximately corresponded to the levels of minimal and maximal daily temperatures. RT was measured by clinical electronic thermometer (Microlife MT 16C2, Microlife corporation, Switzerland) inserted into a depth of 10 cm. PR and RF of each individual ewe were calculated from two 30 sec sections of recordings the beats and breaths respectively by stethoscope. In regard to RF, thoracic excursion was also monitored. On shearing day, in the morning, all measurements were recorded in unshorn ewes, whereas in the afternoon they were recorded in already shorn sheep, approximately 3 h after shearing. At the time of measurements the sheep were moved into a smaller pen, built in the corner of the bigger one. The animals were well accustomed to the man's presence and stood restful, without any restriction, during the time when the measurements were taken. Thus the monitored parameters were obtained with minimal disturbance. 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 kathermometer respectively. The monitored environmental parameters were collected three times daily at 0700, 1400 and 2100 h.

The results were presented as means and standard error of the mean. Treatment means were separated by pair wise t-test. Statistical difference was declared at $P \leq 0.05$. Data were analyzed using package software STATISTICA.

Results

Environmental parameters including minimal maximal and mean daily temperatures are presented in Figure 1. Throughout the observation period tempera-

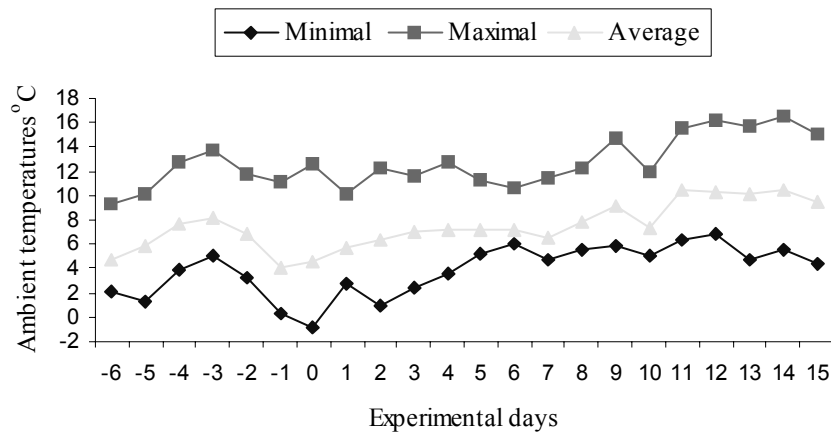


Fig. 1. Mean, minimum and maximum daily temperatures throughout the observation period. Day 0 = shearing day

tures were below the critical level which was found to be 18°C for a shorn sheep fed at ad libitum level (Blaxter, 1967). The mean coat depth after shearing was 6.9 ± 0.22 mm.

Air velocity under the shed was influenced by that in the open and the recordings at different controlled points varied from 0.07 to 2.4 m.s⁻¹ throughout the study and would not be expected to influence sizably the rate of heat loss. Relative humidity throughout the observation varied between 39 and 81% being lowest at noon and highest in the morning.

RT dynamic throughout the experimental period is shown in Figure 2. RT both in unshorn and shorn sheep were lower in the morning. Morning and afternoon RT values differed slightly in unshorn sheep whereas

in the shorn ones the differences between the mean daily values were greater and differed significantly on day 2, 7, and 14 ($P < 0.05$); on day 8, 12 and 15 ($P < 0.01$); and on day 3 ($P < 0.001$). Shearing brought about considerable fall of RT at all controlled post shearing time points in the morning ($P < 0.001$) and at most points in the afternoon ($P > 0.05$ on day 1; $P < 0.05$ on days 3, 5, and 13; $P < 0.01$ on each other day of the study) compared to the morning and afternoon values respectively recorded on the day before shearing. The rate of decline of RT noted on day 1, 2, and 3 was greater in the morning (0.61, 0.99, and 1.18°C) and less in the afternoon (0.13, 0.38, and 0.43°C) compared to the pre-shearing values. From day 4 onwards the morning RT sharply increased and

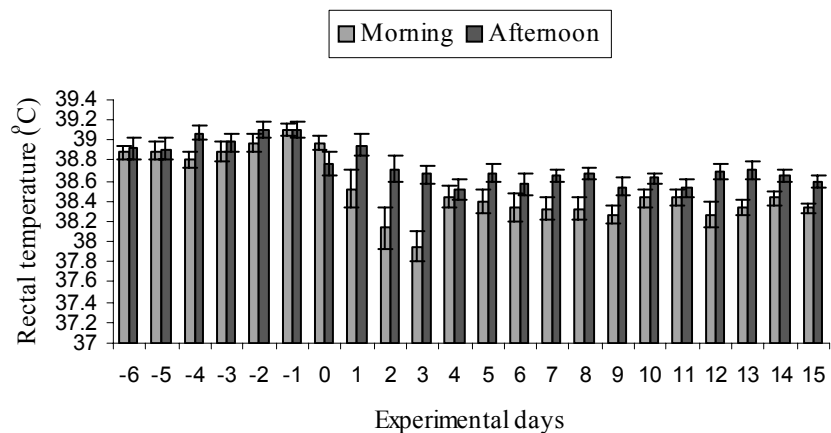


Fig. 2. Rectal temperature dynamic (°C) in unshorn and shorn sheep. Day 0 = shearing day

both morning and afternoon values remained almost constant up to the end of the study.

Shearing caused a detectable increase in PR (Figure 3). On shearing day, afternoon PR values exceeded the morning ones, recorded in still unshorn ewes, by approximately 10 beats. min⁻¹ (P < 0.05). Further increase of 6.7 beats.min⁻¹ in the morning (P < 0.05) and 12.2 beats.min⁻¹ in the afternoon (P < 0.01) was recorded on day 1 after shearing. On day 2 and 3 there was an increase in PR in the morning and in the afternoon of 8.7 beats.min⁻¹ (P < 0.05) and 8.6 beats.min⁻¹ (P > 0.05) respectively, compared to the pre shearing day. On day 4 onwards morning PR decreased and both morning and afternoon values

remained almost constant throughout the study and slightly elevated compared to those recorded before shearing.

There was a remarkable decrease in respiratory activity after shearing both in the morning and in the afternoon. The established morning and afternoon RF values in shorn ewes differed significantly (the levels of significance varied from P<0.05 to P<0.001) at all monitored time points compared to the corresponding levels recorded on the day before shearing (Figure 4). The observed fall in RF persisted throughout the post shearing period. Water intake sharply dropped after shearing and remained at this reduced level throughout the observation period (Figure 5).

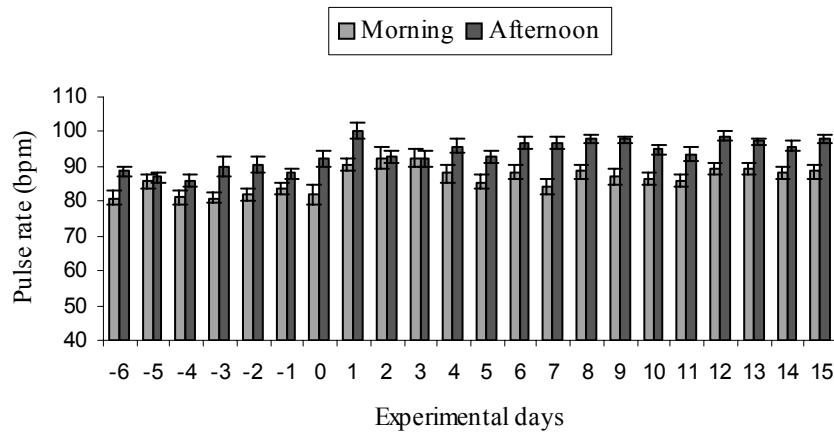


Fig. 3. Pulse rate (beats per minute) in unshorn and shorn sheep. Day 0 = shearing day

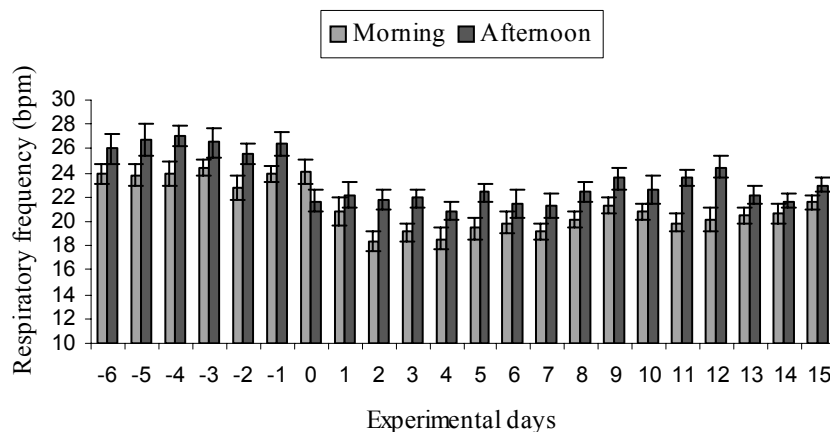


Fig. 4. Respiratory frequency (breaths per minute) in unshorn and shorn sheep. Day 0 = shearing day

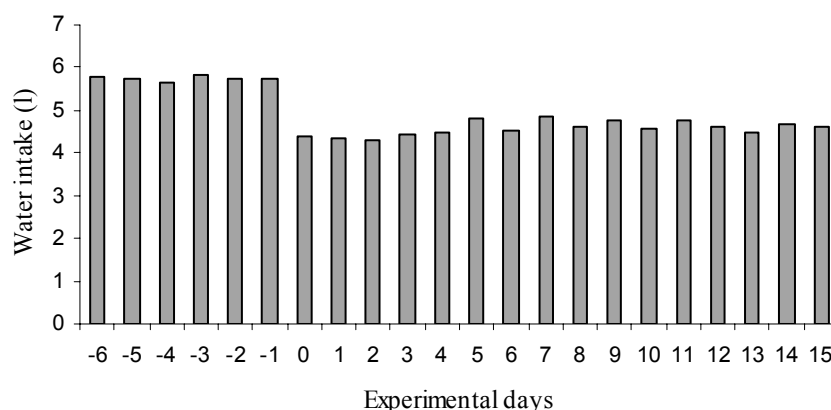


Fig. 5. Mean daily water intake (l per head) in unshorn and shorn sheep. Day 0 = shearing day

Discussion

The ability to thermoregulation is a basic physiological attribute in mammals but metabolic efforts for body temperature maintenance, especially in the cold, are strongly influenced by the effectiveness of external insulation. Shearing facilitates heat dissipation which implies changes in body heat content that ultimately affects body temperature. Thus, even on the shearing day there was a fall of RT in the afternoon compared to both the morning and afternoon levels recorded in unshorn sheep. This was evidently a result of increased heat losses indicating an ineffectiveness of the peripheral insulation to prevent heat losses. RT continued to decrease, but to a greater extent in the morning, up to day 3 after shearing, indicating that the amount of metabolic heat did not match accelerated heat loss particularly during night hours. From the other hand, the lowered heat production may be considered as an adaptive response aimed at reducing the maintenance energy requirement. Individual sheep varied substantially from one another in their RT values after shearing indicating that the capacity of an individual in adjusting to its environment is genetically controlled. In shorn sheep daily differences in RT was greater compared to the differences between morning and afternoon values in unshorn ewes? This may reflect both an increased sensitivity to night temperatures and/or a modification of circadian body temperature rhythm induced by shearing. RT dynamic largely re-

flects periods of daily activity and rest (Bianca, 1968). It exhibits circadian rhythm (Mohr and Krzywanek, 1990) that may, however, be modified by various routine factors of management such as shearing (Piccione and Caola, 2002) causing changes in metabolic pattern and RT fluctuations. Piccione et al. (2002) reported a long term elevation of RT in three breeds of young sheep after shearing at ambient temperatures much higher compared to those recorded in the present work. Differences in adaptive responses stated in the current and previous (Aleksiev, 2008) work as well as in another studies (Piccione et al., 2002) may be due to breed as well as seasonal (Richards et al., 1991) and age related differences in the metabolic capacity of sheep. In the current study, the lack of metabolic overshoot demonstrated that cold exposure have driven the heat retention mechanisms rather than substantial increase in heat production that may result in RT elevation. Besides, ambient temperatures may have not reached a certain threshold level to drive an adequate metabolic over reaction in lactating sheep. RT in the morning showed an appreciable increase on day 4 after shearing that may be due to both an elevation of ambient temperatures, particularly minimal, and further development of homeothermic mechanisms. In shorn sheep RT in the morning and in the afternoon retained at almost constant but a lower level compared to that in unshorn sheep up to the end of the study. The observed changes in RT suggest that cold exposure probably have led to modifications in ner-

vous control mechanisms which co acted in re-adjusting of the thermoregulatory responses. This, in turn, caused a lowering of the temperature set point to a new, more economic level. The results correspond with the concept of adjustable set points (Cabanac, 2006) as well as the findings of Webster and Johnson (1968) and Donnelly et al. (1974) who also stated that the establishment of a new thermoregulatory set point was associated with a reduction of RT in shorn sheep.

Shearing caused an increase in PR and even on shearing day the mean afternoon value was higher than that recorded in unshorn sheep. This PR rise reflected the fast activation of the homeothermic mechanisms associated with heat production. Further increase on day 1 after shearing, compared to pre shearing levels, may be associated with the need of additional endogenously generated heat required to meet increased heat loss. Similarity in daily PR levels on days 2 and 3 after shearing was achieved at the expense of the morning PR increase which probably reflected metabolic elevation during cool night hours. From day 4 after shearing the morning HR decrease but both morning and afternoon levels remained slightly elevated and the difference between them was greater compared to that noted in unshorn sheep. The observed pattern in PR dynamic evidently reflected the changes of metabolic activity aimed at elevation of the heat production especially during the early post shearing period. According to Brosh (2007) and Webster (1967) PR may be used as an indicator for energy expenditure in ruminants. Slee (1971) concluded that an increase of PR of 20 beats.min⁻¹ represents an increase in basal metabolic rate of approximately 30 %. The magnitude of the stated PR changes after shearing in our study may suggest that, in general, the increase in basal metabolic activity has been negligible. The following decline of PR, after its initial increase during the first few days post-shearing, may reflect a downwards shift in the lower critical temperature and the replacement of adaptive mechanisms.

Pulmonary ventilation control is aimed to balance metabolic needs with homeothermy (Mortola and Frappell, 2000). The RF decrease was more pro-

nounced during the first few days after shearing but persisted up to the end of the study. The morning and afternoon levels remained considerably lower than that observed in unshorn ewes. The results also indicated that at this time of the year the unshorn sheep have been very close to their minimal respiratory activity. Hypoventilation reduces the respiratory evaporative heat loss and is an effective means of body temperature maintenance in cold environment (Diesel et al., 1990). Shearing reduced RF and evaporative heat loss and affected considerably daily water intake. It declined sharply even on shearing day and remained at this reduced level throughout the study. This voluntary dehydration associated with a reduction in the total body water content may contribute to maintenance of the homeothermy. Sizable decline of RF was observed even on shearing day in the afternoon indicating fast activation of responses aimed at energy conservation. Daily temperature elevation during the post-shearing period did not have recognizable effect on respiratory pattern of the shorn sheep.

Similar pattern of RF and RT dynamics was observed over the post-shearing period. The initial decline during the first few days after shearing was followed by an increase, but the values of both parameters did not reach pre-shearing levels and remained lowered compared to unshorn sheep. These changes indicated both an increased heat losses and adequate activation of heat conservation mechanisms. Within a few hours after shearing PR exhibited an elevation compared to the levels recorded in the afternoon in unshorn sheep that reflected an enhancement of heat production. After the initial transient elevation PR showed a trend to normalize following activation and development of the homeothermic mechanisms. The data confirm the statement of Hensel (1968) that acute regulations against cooling occur within short time intervals recruiting a sequence of adaptive responses with different time constants.

Slee (1987) also pointed the time-relationship between homeostatic responses as well as the existence of considerable overlap. The early responses often are transient and less economic reactions compared to those developing thereafter.

Conclusion

Collectively, our data indicated that the changes of all monitored physiological parameters occurred predominantly during the first 3 days after shearing. These changes started within a few hours after fleece removal showing that post-shearing adaptation evoked both rapidly acting and slowly developing responses. Adaptations involved a downward shift of the thermoregulatory set point that would be expected to reduce maintenance energy requirements. The magnitude and duration of adaptive responses suggested that energy-saving mechanisms appeared to play a substantial role in post-shearing adaptation.

References

- Aleksiev, Y., 2008. Effect of shearing on some physiological responses in lactating ewes kept indoor. *Bulg. J. Agric. Sci.*, **14**: 417-423.
- Bianca, W., 1968. Thermoregulation. In: E Hafez, E. S. Ed. Adaptation of domestic animals. Lea & Febiger. Philadelphia. Pp. 97-118.
- Blaxter, K. L., 1967. The energy metabolism of ruminants. *Hutchinson and Co. Ltd*, London, UK.
- Brosh, A., 2007. Heart rate measurements as an index of energy expenditure and energy balance in ruminants: a review. *J. Anim. Sci.*, **85**: 1213-1227.
- Cabanac, M., 2006. Adjustable set point: to honor Harrold T. Hammel. *J. Appl. Physiol.*, **100**: 1338-1346.
- Davey, A. and C. Holmes, 1977. The effect of shearing on heat production and activity of sheep receiving dried grass or ground hay. *Anim. Prod.*, **24**: 355-361.
- Degen, A. and B. Young, 1982. Intake energy, energy retention and heat production in lambs from birth to 24 weeks of age. *J. Anim. Sci.*, **54**: 353-362.
- Diesel, D., A. Tucker and D. Robertshaw, 1990. Cold-induced changes in breeding pattern as a strategy to reduce respiratory heat loss. *J. Appl. Physiol.*, **69**: 1946-1952.
- Donnelly, J., J. Lynch and M. Webster, 1974. Climatic adaptation in recently shorn Merino sheep. *Int J Biometeorol.*, **3**: 233-247.
- Ekpe, D. and R. Christopherson, 2000. Metabolic and endocrine responses to cold and feed restriction. *Can J. Anim. Sci.*, **80**: 87-95.
- Hensel, H., 1968. Adaptation to cold, 183-193. . In: Hafez, E. S. Ed. Adaptation of domestic animals. *Lea & Febiger*. Philadelphia, pp. 97-118.
- McBride, G. E. and R. J. Christopherson, 1984. Effect of cold exposure on milk production and energy balance in the lactating ewe. *Can. J. Anim. Sci.*, **64**: 379-389.
- Mohr, E. and H. Krzywanek, 1990. Variations in core temperature rhythms in unrestrained sheep. *Physiol. Behav.*, **48**: 467-473.
- Mortola, J. P. and P. B. Frappell, 2000. Ventilatory response to changes in temperature in mammals and other vertebrates. *Annu. Rev. Physiol.*, **62**: 847-874.
- Picione, G. and G. Caola G, 2002. Influence of shearing on the circadian rhythm of body temperature in the sheep. *J. Vet. Med. A.*, **50**: 235-240.
- Piccione, G., G. Caola and R. Refinetti, 2002. Effect of shearing on the core body temperature of three breeds of Mediterranean sheep. *Small Rum. Res.*, **46**: 211-215.
- Richards, P. B., M. W. Hyder, J. Fry, N. D. Costa, R. T. Norris and A. R. Higgs, 1991. Seasonal metabolic factors may be responsible for death in sheep exported by sea. *Aust. J. Agr. Res.*, **42**: 215-226.
- Slee, J., 1971. Physiological factors affecting the energy cost of cold exposure. *P. Nutr. Soc.*, **30**: 215-221.
- Slee, J., 1987. Sheep. In: Johnson H. D. Ed. Bioclimatology and the adaptation of livestock. *Elsevier*. Pp. 229-244.
- STATISTICA, 2001. (version 6, StatSoft, Ink, Tulsa, OK, USA).
- Symonds, M., M. J. Bryant and M. A. Lomax, 1990. Metabolic adaptation during lactation in winter shorn sheep. *J. Agr. Sci.*, **114**: 201-205.
- Webster, A., 1967. Continuous measurement of heart rate as an indicator of energy expenditure of sheep. *Brit. J. Nutr.*, **21**: 769-785.
- Webster, M. E. and K. L. Johnson, 1968. Some aspects of body temperature regulation in sheep. *J. Agr. Sci.*, **71**: 61-66.
- Young, B., 1983. Ruminant cold stress: effect on production. *J. Anim. Sci.*, **57**: 1601-1607.
- Young, B., B. Walker, A. Dixon and V. Walker, 1989. Physiological adaptation to the environment. *J. Anim. Sci.*, **67**: 2426-2432.

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