A comparison of physical examination and clinicopathologic parameters between sheared and nonsheared alpacas (*Lama pacos*)

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Abstract

The purpose of this study was to determine the physiological changes associated with chronic heat stress in sheared versus nonsheared alpacas. Fourteen intact male adult alpacas were randomly assigned to one of the two groups: Group S alpacas were sheared to within 2 cm of their skin; Group NS alpacas were not sheared. These animals were maintained from June through August in east central Alabama. Data collected in the morning, every two weeks, included vital signs, body weight, body condition score, complete blood counts, serum chemistries and electrolytes, whole blood selenium, and plasma cortisol. S and NS groups were contrasted using the repeated measures analysis of variance, and pertinent correlations with weather parameters were calculated. Clinical heat stress was not evident in any animals during the study. Significant differences between treatment groups were seen in rectal temperature \( P \leq 0.0095 \), sodium concentration \( P \leq 0.0219 \), and blood urea nitrogen (BUN) \( P = 0.0189 \). The mean rectal temperature of the NS group was above the normal range on five sampling times compared to only once for the S group. However, mean sodium and serum urea nitrogen levels were within normal limits in both groups at all sampling times. Rectal temperature of only the S group was positively correlated to weather parameters. Sodium of both S and NS groups and BUN of the NS group were negatively correlated with weather parameters. This study indicates that there are differences between sheared and nonsheared alpacas in physical examination and clinicopathologic parameters that can be correlated with changes in ambient conditions. These differences suggest that nonsheared alpacas are less heat tolerant than sheared alpacas. Therefore, shearing is recommended for animals exposed to similar conditions. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: Heat stress; Heat stress index; Ambient conditions; Rectal temperature

1. Introduction

With the increasing popularity of South American Camelids (SACs) in the United States, heat stress has been recognized as a significant cause of illness in these animals. Of the SACs treated for recumbency at the Auburn University Large Animal Clinic from January 1993 to August 1998, 25% (15 out of 60) were diagnosed with heat stress. Almost half (7 out of 15) of those SACs diagnosed with heat stress either died or were euthanized.

Since the consequences of heat stress can be debilitating and even deadly, prevention is crucial. There are numerous strategies for preventing heat stress, including provision of shade, fans, swimming pools, etc. However, there is evidence in other species that these modifications are not as effective in the

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Southeast compared to more arid regions of the South (Fuquay, 1981). There is also some debate about shearing of fiber for prevention of heat stress. Since the fiber coat can act as insulation against radiant heat from the sun (Fowler, 1998b; Fowler, 1994; El-Ganaieny et al., 1992; Klemm, 1969), recommendations against shearing or only partial shearing have been made (Fowler, 1998b). These recommendations, along with the reluctance of owners to shear the fiber for aesthetic reasons, leads to many animals not getting shorn prior to the hot season. It is the experience of the authors however, that clinical hyperthermia is seen only in animals that are only partially sheared or have full fiber coats.

The clinical syndrome of acute heat stress or hyperthermia is well described (Fowler, 1998b; Fowler, 1994). However, the chronic effects of prolonged high ambient temperatures, which occur in the southern states, have not been described. The purpose of this study was to determine the physiological changes associated with chronic heat stress in sheared versus nonsheared alpacas in the Southeastern United States.

2. Materials and methods

Fourteen intact male adult alpacas were stratified by age and body condition score, then randomly assigned (coin toss) to one of the two groups: Group S alpacas were sheared to within 2 cm of their skin; Group NS alpacas were not sheared. The alpacas were not stratified by color before they were randomized, but both groups had the same number of dark and light animals. All of the alpacas were originated in Ohio, then spent four months in Georgia before arriving in east central Alabama (location of the study) in December. Both groups of alpacas were maintained in the same paddock, with adequate artificial shade from June through September. The diet consisted of pasture supplemented with 0.25 pounds per head of a corn-based concentrate mix. Data were collected every 14 days starting in June (two weeks following shearing of Group S) and ending in September. Data were collected in the morning hours, and included rectal temperature, heart rate, respiratory rate, body weight, body condition score, complete blood counts, serum chemistries and electrolytes, whole blood selenium, and plasma cortisol.

Daily maximum (MXT) and minimum (MNT) ambient temperatures, maximum relative humidity (MRH), and the livestock heat stress index (LHSI; Hahn, 1995) for the area were acquired from the Agricultural Weather Information Service, Inc. (Auburn, AL). The number of hours spent in each of three categories (alert, danger, emergency) were added to obtain the total number of hours spent in each category per day. The hours spent in each category each day were then multiplied by a rank score (1 for alert; 2 for danger; 3 for emergency) and the products were added to calculate a daily LHSI value. The maximum ambient temperature and relative humidity each day were added to obtain an additional heat index (HI) Measurements of the maximum and minimum ambient temperature, maximum relative humidity, LHSI and HI for the 14 days prior to each sampling time were used to calculate 14 day means and standard deviations for each of these weather parameters.

Data obtained through physical examinations and blood analyses were analyzed as dependent variables, contrasting S and NS groups through time, using the repeated measures analysis of variance (StatView: Abacus Concepts, Berkely, CA). Parameters that were significantly different ($P < 0.05$) between treatment groups were contrasted by multiple comparisons between times using the General Linear Model analysis (SAS: SAS Institute, Cary, NC). Parameters that were not significantly different between treatment groups were collapsed across treatment groups and the mean of all fourteen animals were correlated with the weather parameters (Fischer’s r to z, StatView). If parameters were significantly different between treatment groups, the treatment groups were analyzed separately for correlations with weather parameters. This project was approved by the Auburn University Animal Care and Use Committee (#9709-R-1011).

3. Results

Clinical heat stress was not evident in any animals during the study. Significant differences between treatment groups were seen in rectal temperature ($P = 0.0095$), sodium concentration ($P = 0.0219$), and blood urea nitrogen (BUN) ($P = 0.0189$). Means and standard deviations for each sampling time for rectal temperature, sodium and BUN are shown in
Significant positive and negative correlations ($P \leq 0.05$) of measured parameters with weather data are shown in Table 1.

The mean rectal temperature of the NS group was above the normal range on five sampling times compared to only once for the S group (Fig. 1). A significant treatment effect on rectal temperature was seen at the second, fifth and sixth sampling times compared to the corresponding previous sampling times. Rectal temperature for group S was positively correlated to MXT, MNT, and HI, whereas rectal temperature was not significantly correlated with any weather data for group NS (Table 1).

The NS group had significantly different sodium concentrations than the S group at the fourth and fifth sampling times compared to the corresponding previous sampling times (Fig. 2). BUN showed significant differences in treatment groups at the sixth and
seventh sampling times compared to the corresponding previous sampling times (Fig. 3). However, the mean sodium and BUN concentrations for both groups remained in the normal range throughout the study. Sodium was negatively correlated with MXT, MNT, LHSI, and HI for both S and NS groups. BUN was negatively correlated with MXT, MNT, and HI only for the NS group. Although means of both sodium and BUN remain in the normal range for both groups, a marked drop in both sodium and BUN in the NS group compared to the S group occurs at the fourth sampling time. This corresponds to increasing averages of maximum and minimum ambient temperature, humidity, and both heat stress indexes (Figs. 4–5).

Fig. 3. Means and standard deviations of blood urea nitrogen in sheared (●) and nonsheared (▼) alpacas at eight sampling times. Shaded area represents the normal range (Garry et al., 1995). Sampling times that had a significant ($P \leq 0.05$) treatment effect compared to the previous sampling time are denoted by superscript a.

Fig. 4. Means and standard deviations of maximum and minimum ambient temperatures and maximum relative humidity calculated from measurements taken the 14 days prior to each sampling time.
4. Discussion

There are four mechanisms of heat dissipation in animals: radiation, conduction, convection and evaporation (Fuquay, 1981; Mount, 1979). The first three mechanisms listed are only effective if there is a temperature gradient from the animal to the environment; i.e. the air around the animal is cooler than the temperature of the animal. At high ambient temperatures that approach or exceed the body temperature, the first three mechanisms are ineffective, and the animal must rely on evaporative cooling mechanisms: sweating and increased respiration (Hahn, 1994; Fuquay, 1981). However, if the relative humidity is also high, evaporative cooling is less effective (Hahn, 1994; Fuquay, 1981; Mount, 1979). Exposure of cattle to high ambient temperature and relative humidity (i.e. high LHSI and HI values), even for periods as short as one week, can reduce production and even prove deadly (Hahn and Mader, 1997).

Diurnal ambient temperature patterns are also important. An animal can endure high ambient temperatures if heat gain during the daytime hours can be balanced with heat loss during the nighttime hours. However, if nighttime ambient temperatures remain high, especially if the relative humidity is high, there is no time for recovery (Fuquay, 1981). There is evidence in dairy cattle that nighttime temperature may be more important than daytime temperature in determining health and production (Fuquay, 1981).

The presence of a fiber coat also influences thermoregulation. SACs have relatively fiberless regions in the axillary, groin, and perineal regions of their bodies, which together have been termed the thermal window (Fowler, 1994). This thermal window allows heat dissipation by conduction, convection and evaporation. Although the fiber coat can actually keep animals cool in a hot environment by blocking radiant heat (Fowler, 1998b), the fiber coat impedes evaporative cooling from the skin (Klemm, 1969), leaving respiration as the only means of thermoregulation at high ambient temperatures in nonsheared animals (Hofman

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Table 1

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<th>MXT</th>
<th>MNT</th>
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<td>Blood urea nitrogen (S)</td>
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<td>Blood urea nitrogen (NS)</td>
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a maximum ambient temperature.

b minimum ambient temperature.
c maximum relative humidity.
d livestock heat stress index.
e calculated heat stress index.
and Riegel, 1977). When high ambient temperatures are exacerbated by high humidity, evaporative cooling through respiration becomes less effective, and may not be enough to allow thermoregulation in non-sheared animals. Also, the fiber coat can actually generate heat at high humidity levels, further increasing the heat load on the animal exposed to high ambient temperatures (Klemm, 1969; Macfarlane, 1968). Studies in sheep and goats have shown that although hot, arid environments are tolerated better by animals with full fleece, hot humid environments are better tolerated by those that are sheared (Klemm, 1969; Eyal, 1963a). If shade is provided, sheared sheep tolerate hot, dry heat as well or better than nonsheared sheep (Acharya et al., 1995; Khalil, 1990; Klemm, 1969; Eyal, 1963a). It must be kept in mind that the previously referenced studies looked at short term effects (hours to 5 days), and did not study the long term effects of heat stress.

The alpacas in this study originated from the northern states, and although they had spent several months in the southeast prior to the start of the study, they had not experienced a summer in the southeast. As can be seen in Fig. 4., during the present study, the MRH remained at or near 100% for the entire study period, and during the middle part of the study, MXT, MNT, LHSI and HI were high (Figs. 4 and 5). Despite these potentially stressful conditions, none of the alpacas in this study showed clinical evidence of heat stress, and the only apparent production difference between the two groups was that towards the end of the study, the sheared group gained weight, whereas the nonsheared group only maintained its weight. In cattle, feed intake decreases as ambient conditions worsen (Hahn, 1994). In sheep, shorn animals ate less than unshorn animals when exposed to full sun (Acharya et al., 1995). One of the limitations of measuring body weight as an indicator of stress is that the body weight reflects both tissue loss and water retention, both of which occur during heat stress. Therefore, depending on the magnitude of change of each of these responses, body weight can increase, decrease, or remain unchanged (Habeeb et al., 1992).

There may be several reasons for the lack of overt signs of heat stress in this study, despite some significant differences between groups in physical exam and clinicopathologic parameters. There are anecdotal reports from SAC owners and veterinarians that alpacas are more tolerant of heat than llamas. This may be due to the smaller average size of alpacas compared to llamas. Also, heat stress is commonly secondary to other diseases, injuries, or other stresses, such as routine maintenance procedures. Of the heat stress cases seen at the Auburn University Large Animal Clinic during the time period stated previously, 33% (5 out of 15) were secondary to other diseases, most commonly internal parasitism. The alpacas in this study were disease free, on a high plane of nutrition, and did not undergo any stress other than data collection. Furthermore, it is the experience of the authors that overconditioned animals are less heat tolerant, and the alpacas in this study were not overconditioned.

Normal diurnal patterns of core body temperature in llamas and alpacas lag behind the diurnal ambient temperature pattern by 6–8 h. (Bligh et al., 1975). In cattle, during hot weather, the lag time between rises in diurnal ambient temperature and rises in core body temperature decreases, and both the mean rectal temperature and the magnitude of change from peak to trough of the diurnal body temperature increase (Hahn and Mader, 1997). Rectal temperatures were recorded in the morning hours in this study to decrease the acute influence of the high afternoon ambient temperatures so that the chronic effects of ambient temperature might be determined. In this study, the nonsheared alpacas had significantly higher rectal temperatures than the sheared alpacas, even in the morning hours. This indicates that the NS group was less heat tolerant than the S group. Rectal temperatures were significantly correlated to ambient conditions only in the sheared group. This may be due to the erratic changes in mean rectal temperatures seen in the NS groups.

Several physiologic mechanisms occur following heat stress that can alter clinicopathologic parameters. Following heat stress, total body water and protein catabolism increases, and insulin, aldosterone, and thyroid hormones decrease. It is also of interest that in cattle, early morning sampling showed more differences between groups in different environments (sprinklers, roof insulation) in blood profiles than afternoon sampling (Fuquay et al., 1979).

This study showed that shearing had a significant effect on BUN, and that the decrease in BUN in the nonsheared group was significantly correlated with all of the ambient conditions except MRH. In cattle, BUN
determined at three week intervals during the summer months were correlated with maximum temperature on the day of sampling (Fuquay et al., 1979). The decrease in BUN was expected, most likely due to increased salivary excretion to compensate for decreased rumen ammonia from decreased food intake (Habeeb et al., 1992). Creatinine was not affected by shearing in this study, and remained in the normal range for both groups.

With expected shifts in total body water following heat stress, it is not surprising that serum electrolyte concentrations change. However, the direction of change can be unpredictable (Habeeb et al., 1992). Since much of the work in this area has been performed in lactating dairy cows, which have significant production demands on electrolytes that the alpacas in this study did not, comparisons may not be valid. This study showed that shearing had a significant effect on sodium concentration. Sodium decreased in both groups but was more pronounced in the nonsheared group. This could reflect a higher increase in total body water in the nonsheared group compared to the sheared group. Sodium concentrations of both groups were significantly correlated with ambient conditions.

5. Conclusion

This study indicates that there are differences between sheared and nonsheared alpacas in physical examination and clinicopathologic parameters that can be correlated with changes in ambient conditions. These differences suggest that nonsheared alpacas are less heat tolerant than sheared alpacas. Therefore, shearing is recommended for animals exposed to similar conditions.

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References