Effects of Treadmill Exercise on Respiratory Moisture Losses in Goats of Different Breeds[a]

I. W. Kasa*, C. J. Thwaites[1], M. D. Hill[1] and N. D. Baillie[1]
Department of Biology, Udayana University, Bukit Jimbaran, Bali, Indonesia

ABSTRACT : Changes in respiration rate (RR), rectal temperature (RT), respiratory moisture loss (RML), packed cell volume (PCV) and haemoglobin (Hb) were monitored in 2 adults female goats each of the Saanen (S) and Toggenburg (T) breeds during 60 min of exercise (walking at 3 km/h) on a moving-belt treadmill on each of 6 alternate days. A significant time×breed interaction was observed for RR; mean values in S and T after 60 min of exercise were 130 and 223 /min ($p \leq 0.01$). The observed time×breed interaction for RT indicated that S was less stressed by exercise than T; mean values after 60 min exercise were 40.4 and 40.8℃ respectively ($p \leq 0.01$). For RML, the day×breed interaction ($p \leq 0.001$) indicated that while S had higher values on day 1, thereafter the values for T were higher. The time×breed interaction for RML/breath indicated that values for T declined more rapidly (from 9.4 to 3.1 mg/breath) than those for S (from 8.3 to 4.1 mg/breath; ($p \leq 0.01$). PCV declined during exercise ($p \leq 0.05$) by 5.5 percentage points. The exercise imposed was stressful in that it led to increases in RR, RT and RML. S was most tolerant of exercise in that it recorded lower values of RT. The fact that the RML/breath was higher during exercies in S apparently allowed it to compensate for a lower RR. Despite higher RR and RML, T also had a higher RT, suggesting either higher muscular heat production during exercise in that breed, or higher sweating losses in S. (*Asian-Aus. J. Anim. Sci. 2000. Vol. 13, No. 6 : 842-844*)

Key Words : Goats, Panting, Exercise, Thermoregulation, Respiratory Moisture Loss, Walking

INTRODUCTION

Experiments on black and white swamp buffalo in the field and on Saanen (S), Anglo Nubian (AN) and Toggenburg (T) goats in the laboratory (Kasa, 1995) revealed clear breed differences in physiological reactions during exercise, particularly for respiration rate (RR). For example, RR in S, AN and T goats after walking for 60 min at 3.8 km/h and 30℃ averaged 146, 103 and 168/min respectively. The experiment reported here was designed to test the hypothesis that, in goats, breed differences exist in the RR and RML (respiratiry moisture loss) responses to exercise in moderate heat.

MATERIALS AND METHODS

Two S and two T goat, all adult females weighing 53.0±7.0 kg and condition score 3.5, were exercised at 30℃ by walking at 3 km/h for 60 min on a moving-belt treadmill on 6 alternate days. A 2×2×4×6 factorial design (2 animals each breed, 2 breeds of S and T, 4 times of measurement at 20 minute intervals of 0, 20, 40, and 60 min and 6 days with 1 day resting in between) was used. RR (flank movements per 60 sec), RT (clinical thermometer inserted 10 cm for 60 sec), RML (open circuit respirometer with moisture in air samples measured in acid traps), PCV (packed cell volume; jugular venipuncture) and Hb (haemoglobin; Jain, 1986) were measured immediately before (time 0) and at 20, 40 and 60 min of exercise on each day.

The goats were fed a 50:50 diet of oaten chaff and sorghum grain at the rate of 1.5% of body weight, and water was available *ad libitum* except when on the treadmill. When not being exercised, the goats were housed at 20±2℃ in individual pens. Statistical analyses for repeated measures (Steel and Torrie, 1980) were conducted using the BMDP program of Dixon et al. (1983).

RESULTS

Respiration rate (RR)

A time×breed interaction ($p \leq 0.01$; table 1) indicated that while RR increased during exercise in both breeds, the change was greatest in T. After 60 min of exercise the RR of S and T averaged 126±13.2 and 226±25.5/min respectively. RR declined ($p \leq 0.01$) from the first to the sixth day of the experiment, but the difference between the breeds was greatest (124 breaths/min) on day 6.

Rectal temperature (RT)

A time×breed interaction ($p \leq 0.01$; table 1) was

* Corresponding Author: I. W. Kasa. Tel: +31-701-954 (ext. 222), E-mail: iaeup@denpasar.Wasantara.net.id.
[1] Animal Science Department, University of New Enbland, Armidale, NSW 2351, Australia.
[a] Supported by AusAID and a grant from the University of New England.
Received July 7, 1999; Accepted October 26, 1999

Table 1. Changes in respiration rate (RR/min), rectal temperature (RT; ℃), respiratory moisture loss/breath (RML/breath; mb/breath) and total respiratory moisture loss (RML; mg/min) in female Saanen (S) and Toggenburg (T) goats exercised for 60 min at 3 km/h on treadmill at 30℃

Parameter	Breed	Time during exercise (min)				
		0	20	40	60	SEM
RR	S	18^{a}	56^{b}	113^{c}	126^{c}	8.8
	T	16^{a}	100^{c}	178^{d}	226^{e}	12.3
RT	S	38.9^{a}	39.2^{b}	39.7^{c}	40.3^{d}	0.1
	T	38.9^{a}	39.3^{b}	40.1^{d}	40.8^{e}	0.2
RML/breath	S	8.2^{b}	7.7^{b}	5.1^{c}	4.1^{c}	0.9
	T	9.5^{a}	4.5^{c}	3.7^{c}	3.1^{d}	0.7
RML[1]	S	148	431	376	517	-
	T	152	450	659	701	-

[1] Calculated as: RR × (RML/breath).

[a,b,c,d] Within parameters, means with different superscripts differ at $p \leq 0.05$.

also observed for RT, with values for S being lower than for T at all times, and values for T increasing most rapidly during exercise. Between the 6 days of the experiment mean RT after 60 min of exercise declined by 0.8℃ ($p \leq 0.01$) in both breeds.

Respiratory moisture loss/breath (RML/breath)

RML/breath was inversely related to RR (correlations of -0.8 and -0.9 in S and T respectively; $p \leq 0.01$) and declined progressively during exercise in both breeds (table 1). The time × breed interaction ($p \leq 0.05$) indicated that these changes were greater and occurred most rapidly in T. RML/breath did not differ significantly between days.

Respiratory moisture loss (RML)

The effect of time (0 to 60 min) on RML was highly significant ($p \leq 0.01$). Values initially rose from about 150 mg/min before exercise to about 440 mg/min after 20 min in both S and T. Thereafter, RML in T continued to increase until 60 min (to 701 mg/min), whereas that in S reached a peak of 576 mg/min at 40 min (table 1).

The day × breed interaction ($p \leq 0.01$) for mean RML during exercise indicated that values were non-significantly higher in S and T on day 1 (474 ± 95 vs 442 ± 92 mg/min respectively), but that on each of the following 5 days RML in T was higher than in S (mean values 427 ± 74 and 376 ± 62 mg/min respectively; $p \leq 0.05$). Within breeds, RML did not differ significantly between days 2 and 6.

Packed cell volume (PCV) and haemoglobin (Hb)

Both PCV and Hb declined ($p \leq 0.05$) during exercise, by means of 5.5 percentage points and 1.5 g/dl respectively. Breed differences in PCV and Hb were non-significant. Mean values of 34.0 and 32.0 (SEM-0.5)% and 10.3 (SEM-0.2)g/dl were recorded in S and T respectively.

DISCUSSION

Overall, it can be concluded that an increase in RR during exercise was accompanied by a proportional increase in RML in both the goat breeds studied. That result is consistent with heat-stressed lambs (not exercised) was approximately proportional to RR.

RR, RT and RML and increased with time during exercise, but lower values of each parameter in S indicate that breed was more tolerant of exercise than T. The reasons for that breed effect are not clear, but differences in basal metabolic rate, heat production during exercise, and the efficacy of alternate avenues of heat loss require investigation. It is possible, for example, that the thicker, more ruffled hair coat of T may have interfered with both radiative and evaporative heat losses from the skin. It is known (Judson et al., 1976; Bird et al., 1981; Harman and Pethick, 1994) that exercise leads to an increase in oxygen uptake and blood glucose entry, but breed differences in such parameters have not yet been investigated.

As RR increased during exercise in the current goats, RML per breath declined from 8.2-9.2 to 3.1-4.1 mg/breath. In lambs, Alexander and Williams (1962) recorded a more marked deadline in RML/breath, from 20 to 4 mg/breath, during acute heat stress. The biological significance of the small, but statistically significant, reductions in PCV and Hb during exercise is not likely to be great since both values are well within the normal range (Jain, 1986).

IMPLICATIONS

The fact that the current results clearly indicate that the Toggenburg goats used were less tolerant of

exercise than Saanens has implications for the selection of breeds for regions in which the ability to tolerate periods of exercise in warm/hot environments (30℃ was used in the current work) is an important aspect of adaptation. The results also suggest the need for further study of differences in heat production during exercise, of sweating as an alternate source of evaporative heat loss, and of the role of the fleece in inhibiting cutaneous heat loss from livestock during exercise.

REFERENCES

Alexander, G. and D. Williams. 1962. Temperature regulation in the new-born lamb. VI. Heat exchanges in lambs in a hot environment. Aust. J. Agric. Res. 13:122-143.

Bird, A. R., K. D. Chandler and A. W. Bell. 1981. Effect of exercise and plane of nutrition on nutrient utilization by the hind limb of sheep. Aust. J. Biol. Sci. 34:541-549.

Harman, N. G. and D. W. Pethick. 1994. The effect of sustained exercise on glucogenesis, glycoenolysis and glycogen synthesis in Merino sheep. Aust. J. Agric. Res. 45:1189-1202.

Jain, N. C. 1986. Schalm's Veterinary Haematology. 4th. Ed. Lea and Febriger, London, UK.

Judson, G. J., O. H. Filsell and I. G. Jarrett. 1976. Glucose and acetate metabolism in sheep at rest and during exercise. Aust. J. Bio. Sci. 29:241-222.

Kasa, I. W. 1995. Heat tolerance and evaporative cooling in goats, cattle and buffalo under tropical conditions and during exercise. Ph.D. Thesis, University of New England, Armidale, New South Wales.

Steel, R. G. D. and J. H. Torrie. 1980. Principles and Procedures of Statistics (2nd Ed.). McGraw-Hill, London, UK.