Effects of Heat Exposure and Restricted Feeding on Behavior, Digestibility and Growth Hormone Secretion in Goats

Takuji Hirayama* **and Kazuo Katoh**[1]
Graduate School of Agricultural Science Tohoku University, Aoba-ku, Sendai-shi, 981-0914, Japan

ABSTRACT : Heat stress is known to affect physiological systems in goats. This study investigated changes in nutrient digestibility, behavior and growth hormone secretion among goats in a hot environment (H; 35±1.2°C, [RH] 80±7.2%, 13 d), and in a thermoneutral environment (T; 20±0.6°C, [RH] 80±3.4%, 20 d), and accompanied by the same restricted diet as provided in the hot environment. The following results were obtained: rectal temperature and water intake were higher in the H treatment than in the T treatment or TR treatment, while hay consumption was lower. CP, NDF and ADF digestibility was highest in H treatment. Time spent eating in the H treatment was also the highest, followed in order by T treatment and TR treatment. Ruminating time was lower in H treatment than in T treatment or TR treatment, and reposing time was highest in the TR treatment. Growth hormone concentrations in T increased 4.5 h after feeding. In H, growth hormone concentrations increased 0.5 h after feeding. However, growth hormone concentrations were not changed following TR feeding. In conclusion, heat exposure in goats decreased feed intake, but increased digestibility. However, when goats in a thermoneutral environment received the same restricted feeding as they received in the hot environment, digestibility increased. Between the H treatment and TR treatment, the changes in digestibility were accomplished by coordinate changes in hormone secretion in order to maintain body homeostasis. To maintain energy balance under a hot temperature or a restricted feeding condition, goats may control their metabolism by changing growth hormone release. ***(Asian-Aust. J. Anim. Sci. 2004. Vol 17, No. 5 : 655-658)***

Key Words : GH Secretion, Goat, Heat Stress, Feed Restriction

INTRODUCTION

To maintain body homeostasis, domestic animals respond to hot environments in various ways, such as changes in rectal temperature and respiration rate (Sano et al., 1985). Decreased metabolism is associated with a decrease in voluntary feed intake (Nardone et al., 1997), and the adaptation of endocrine mechanisms also seems to play a considerable role. In cattle, the adaptation to thermal stress involves changes in catabolic hormone concentrations; decreased concentrations of growth hormone and corticoid which before bringing about a reduction in the basal metabolic rate (Beede and Collier, 1986).

On the other hand, in high ambient temperature environments, although feed intake decreases, digestibility tends to either not change (Olbrich et al., 1972) or to increase (Colditz and Kellaway, 1972). It is generally true that when intake down, digestibility increases irrespecti ve of the animal's energy status. This in because the digesta passage rate slows down and gives gut microbes and enzymes more time to act on the feed. However, animal production, such as milk yield and daily gain, generally stagnates during heat stress (McGuire et al., 1989; Knapp and Grummer, 1991). These adaptations to the heat stress are related to the production the changing utilization in absorbed energy. The mechanism by which heat stress affects synthetic adaptations in ruminants, such as the relationship between movement of feed intake and hormone secretion, remains unclear even though this relationship is part of the mechanism by which a hot environment affects hormone secretion and nutrient digestibility.

Therefore, the objective of this study was to examine the effects of heat exposure on nutrient digestibility, and growth hormones secretion and behavior such as eating, ruminating and reposing in goats.

MATERIALS AND METHODS

Animal care and use

All animals received humane care as outlined in the Guide for the Care and Use of Experimental Animals (University of the Ryukyu, Animal Care Committee). This study was granted a permit (No. 2755) by the Animal Care Committee of the University of the Ryukyu.

Animals, diets and environments

Three Saanen fistulated male goats weighing 24±3 kg were used. The goats were fed alfalfa hay. CP, NDF and ADF values were the same for all groups and they were 18.5, 50.8 and 43%, respectively. Water and salt block were provided *ad libitum*. The goats were housed in metabolism crates in a zootron artificial climate station.

An abstract of the time schedule in this study is shown in Figure 1. The goats were exposed first to a hot

* Corresponding Author: Takuji Hirayama. Faculty of Agriculture, University of the Ryukyus, Nishihara-machi, Okinawa-ken, 903-0213, Japan. Tel: +81-98-895-8821, Fax: +81-98-895-8821, E-mail: donald@agr.u-ryukyu.ac.jp
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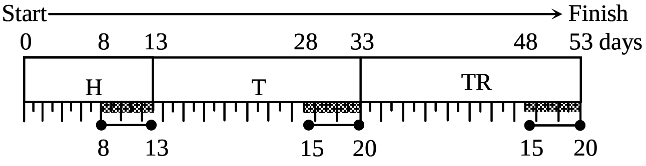

Figure 1. Schematic outline of experimental and sampling procedures in a trial that evaluated heat stress and feed restriction effects on goat physiology. All three goats used in this study were housed together in the same room and exposed first to a hot environment (H; 35±1.2°C, relative humidity [RH] 80±7.2%, 13 d) and then exposed to a thermoneutral environment (T; 20±0.6°C, [RH] 80±3.4%, 20 d), and then goats were fed at the restricted feeding same as H environment (TR; 20±0.6°C, [RH] 80±3.4%, 20 d). Darkened areas represent sampling periods. Blood samples were collected at 0.5, 1.0, 2.0, 3.0, 4.5 and 6.0 h post-feeding.

environment (H; 35±1.2°C, relative humidity [RH] 80±7.2%, 13 d) then to a thermoneutral environment (T; 20±0.6°C, [RH] 80±3.4%, 20 d), after which they were given the same restricted feeding that they received during H, but this time in a thermoneutral environment (TR; 20±0.6°C, relative humidity [RH] 80±3.4%, 20 d). They were given the free access during H and T and then restrict their feed offer during TR to what they achieved during H. The goats were allowed to adjust to the first environment (H) for 7 d before the experimental sampling; they were allowed to adjust to the second environment (T) for 15 d before the sampling; and for 15 d to the final environment (TR). The 7 d period for adjustment to the hot environment was chosen in light of data showing that plasma insulin concentration was stable from 6 d following heat exposure in heifers (Itoh et al., 1997). The treatments were not performed on the animals in a crossover manner, because the effect of previous heat exposure on a subsequent thermoneutral period was judged to be greater than the effect of aging by 53 d. The chamber was lit at 150 lx day and night.

Sampling and analysis

Total fecal collections were made at 1 d intervals for 5 d for use in digestibility analyses of neutral detergent fiber (NDF), acid detergent fiber (ADF) and crude protein (CP). An aliquot of feces from each collection and smashed hay was dried at 65°C for 48 h. The sample feces and fed hay were frozen at -20°C after being smashed, and remained frozen until analyzed. The concentrations (g/100 g, DM) of NDF, ADF and CP in the fed hay and feces were determined by the method of AOAC (1980) and the procedures of Goering and Van Soest (1970). Behavioral patterns, such as time spent for eating, ruminating, and reposing, were video recorded and ruminating was determined from the jaw movements. During each treatment period, blood samples for measure of growth hormone concentrations were collected at 0.5, 1.0, 2.0, 3.0, 4.5 and 6.0 h post-feeding. Plasma blood was obtained by centrifugation at 3,000 g for 10 min within 30 min after the blood was collected and was frozen at -20°C until it was thawed for analysis. Plasma growth hormone was assayed by the double antibody method using antiserum NIDDK-anti-oGH-2 (AFP-C0123080). The minimum level of detection for this assay was 0.2 ng/ml. Statistical analyses of all data were used the GLM procedure (SAS, 1988).

Table 1. Digestibility of experimental groups

	H	T	TR
Rectal temperature (°C)	40.0±0.2[a]	38.4±0.2[b]	38.4±0.2[b]
Dry matter intake (g/d)	477±33[b]	985±118[a]	421±27[b]
Water intake (L/d)	2.4±0.4[a]	1.9±0.3[b]	1.3±0.1[c]
Digestibility (%)			
Dry matter	39.4±1.5	32.2±0.2	35.6±3.4
Crude protein	76.7±2.2[a]	70.4±2.9[b]	60.6±1.5[c]
Neutral detergent fiber (NDF)	61.8±3.7[a]	61.4±3.1[a]	52.2±1.8[b]
Acid detergent fiber (ADF)	68.0±3.1[a]	68.0±3.1[a]	49.2±1.9[b]

Values are expressed as a mean±SE for each period goats. Means in the same raw having different superscripts are significantly different (p<0.05). Just difine H, T and TR. e.g. T, neutral environment and free feeding. H indicate means of hot environment (35°C) and free feeding. T indicate means of neutral environment (20°C) and free feeding. TR are values of neutral environment (20°C) and restricted feeding of same levels as H environment.

RESULTS

Rectal temperature, feed and water intake and digestibility

The effects of heat exposure on physiological responses and digestibility are shown in Table 1. During heat exposure, rectal temperature and water intake were higher (p<0.05) than in the T treatment and TR treatment. Consumption of hay was lower in the H treatment (p<0.05), about 48% of that in the T treatment. Digestibility of CP was higher in the order of H treatment, TR treatment, and T treatment (p<0.05). Digestibility of NDF and ADF was higher (p<0.05) in the TR treatment and H treatment than in T treatment.

Behavior patterns

Figure 2 shows the behavior times, such as time spent eating, ruminating, and reposing in each environment. Eating time was higher in the order of the H treatment, T treatment and TR treatment (p<0.05). Heat exposure decreased ruminating time (p<0.05) to about 76% of that in the T treatment and TR treatment. Reposing time in TR treatment was increased (p<0.05) to about 128% of that in T treatment and H treatment.

Plasma growth hormone

The concentration of blood growth hormone in each

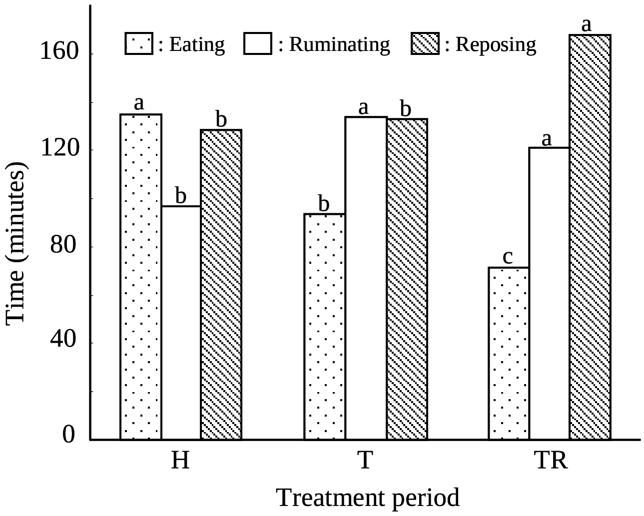

Figure 2. Intake behavior of goats exposed to heat stress and feed restriction. Means at the same behavior having different superscripts are significantly different (p<0.05).

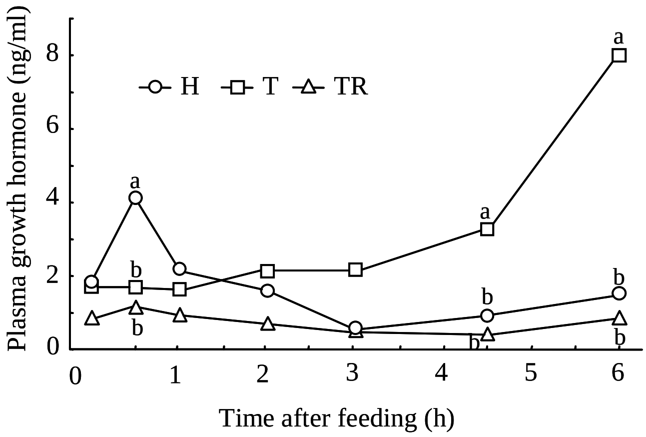

Figure 3. Growth hormone concentration in the jugular vein of goats subjected to heat stress and feed restriction. Means at the same time having different superscripts are significantly different (p<0.05).

environment is shown in Figure 3. In H environment, growth hormone concentrations increased 0.5 h after feeding. In T environment, growth hormone concentrations increased 4.5 h after feeding. No significant changes in growth hormone level were detected in TR.

DISCUSSION AND CONCLUSION

Increased rectal temperature and water intake, along with decreased feed intake, are well known as responses of ruminants to heat exposure (Collier et al., 1982; McGuire et al., 1989). Furthermore, increased digestibility of CP was agreed to a finding of the previous study (Hirayama et al., 2002). This increase in apparent digestibility may be a complement to the low levels of energy resulting from the decreased feed intake. In deed, the TR treatment which was a thermoneutral environment accompanied by the same restricted feeding as consumed in the H treatment, also led to increased digestibility. The digestibility of feed hay is affected by both the amount of intake and the degree of fill in the rumen (Knapp and Grummer, 1991). The increase in digestibility in the thermoneutral restricted feeding environment might have resulted from the decrease in feed intake, similar to that occurring in the H treatment. The concentrations of acetic and butyric acid in rumen fluid are related to dietary fiber digestibility, especially NDF digestibility (Mcleod et al., 1990) in the H treatment. Increases in the concentrations of acetic acid and butyric acid were in agreement to a finding of the previous study (Hirayama et al., 2000). Amount of cellulose content in the alfalfa are generally low. The increase of acetic and butyric acid concentration in the H treatment might have resulted from the encouragement of the fermentation rate of NDF that the low ratio of cellulose.

Extension of eating time is a well-established response of ruminants exposed to heat (Hayasaka and Yamagishi, 1990). Rumination is especially affected in eating behavior such as eating time or amount of eating (Hirayama et al., 2001). The extension of eating time in H might have been caused by a decrease in the bolus size of each feeding, which would reduce the level of feed intake. Such decreases might have been occurred as part of the control of calorigenesis in order to maintain body homeostasis.

The plasma growth hormone concentration is determined by the balance between the rates of utilization and production for energy. Therefore, the hot environment should be understood to change both the absorption and metabolic rates. In H and TR environment, the changes of growth hormone secretions might have resulted from the negative feed-back by the somatotrophs in pituitary gland (Fuquay, 1981). The increased growth hormone concentration after feeding in T might have been caused by the energy absorption and production. However, growth hormone secretion is relative to the concentration of hormone secretions from thyroid gland (Hoshino, 1996). Thus, further experiments are required to determine the relationship between growth hormone secretion and thyroid gland hormone secretion in a hot environment.

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