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# EFFECT OF HEAT STRESS ON BEHAVIOR, PHYSIOLOGICAL AND BLOOD PARAMETERS OF GOAT

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## ABSTRACT

The research was conducted to study the effect of heat stress on behavior, some physiological and blood parameters with nine goats of almost similar in age, sex and weight into three groups. Three groups were divided as zero hour ($T_0$), four hours ($T_4$) and eight hours ($T_8$) heat exposure. Temperature–humidity index (THI) value was calculated as 28.17 which indicate the experimental animals were in extreme severe heat stress. Skin and rectal temperature had no significant differences among the treatment groups but respiration/panting and pulse rate were increased with the increased of heat stress from $T_0$ to $T_8$ group ($P<0.01$). Significant difference was found in standing time and lying time ($P<0.01$) in experimental groups. There were significant changes ($P<0.01$) in number of urination and defecation per hour but no significant changes was found in duration per urination in heat treated groups. The amount of RBC, PCV%, Hb%, WBC were increased with the increased of heat stress ($P<0.01$). Neutrophil, eosinophil, lymphocyte and monocyte numbers increased significantly ($P<0.01$) in heat treated groups. It can be concluded that heat stress had significant changes on some behavioral, physiological and blood parameters of goat.

**Key Words:** Heat stress, Behavior, Physiological change, Blood parameter

## INTRODUCTION

Goats are very important farm animals in Bangladesh, especially the Black Bengal breed. One of the major problems facing the Black Bengal goat is the heat stress and the high ambient temperature that remains above the thermoneutral zone for at least 6 months since Bangladesh is situated between 20.34° and 26.38° North latitude and 92.41° East longitudes. The thermal environment is a major factor that can negatively affect goat performance. Increased body temperature and respiration rate are the most important signs for heat stress in goat. The increase in body temperature is associated with marked reduction in feed intake, redistribution in blood flow and changes in endocrine functions that will affect negatively the productive and reproductive performance of the sheep

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(Eltawill and Narendran, 1990). Heat stress results in the significant decrease in dry matter intake (Holter *et al.,* 1997), milk yield (West, 2003), milk quality (Beede and Shearer, 1996) and reproductive performance (Monty and Wolff, 1974). Excessive heat stress may cause hyperthermia and potentially have several physiological side effects and economical impacts on the livestock industry. These include the aberration of reproductive functions (Roth *et al.,* 2002), oxidative stress and enzymatic dysfunction (David *et al.,* 2001), electrolyte imbalances (West *et al.*, 1991), reduced meat quality (Kadima *et al.,* 2004), and eventually severe economical losses resulting from increased mortalities and decreased overall animal performance (Hahn and Mader, 1997).These physiological adjustments are essential to maintain normal body temperature and to prevent hyperthermia (Al-Haidary, 2000; Lowe *et al.*, 2001). Moreover, under these conditions the animal's productivity severely affected that result in a tremendous economic loss for the goat industry. There is a limited data available with the effect of heat stress challenge on the thermoregulatory system of goat in Bangladesh. Therefore, the present study was conducted to investigate the following specific objectives:

i) To investigate the effect of heat stress on behavior of goat.
ii) To evaluate physiological parameters in goat under heat stress.
iii) To evaluate blood parameters after heat stress.

## MATERIALS AND METHODS

Nine indigenous goats (three male and six female) were selected for the experiment which were almost similar in age and weight. The heat stress period was 18 days, from 20th September 2010 to 8th October 2010. One month was given to animal for their psychological and physiological adjustment (acclimatization). Field trial was carried out in the Sheep, Goat and Horse farm of the Department of Animal Science. Laboratory analyses of the experimental samples were carried out in the laboratory of Animal Science and Department of Physiology, Bangladesh Agricultural University, Mymensingh.

All the goats were kept in three groups (one group consists one male and two female animals) in the room separated with fence. Roughage and concentrate feed were supplied everyday at adequate amount. A large water trough was provided for each group from where clean and cool water available *ad libitum* for the animals. The house was well ventilated and the space per animal was adequate. The floor, stall, water trough, and feeder were cleaned every day. The faeces were removed carefully from the house. Three treatment groups were made as follows: 0 hours heat exposure control group; 4 hours heat exposure (10 am to 2 pm heat exposure in grazing) and 8 hours heat exposure (9 am to 5 pm heat exposure in grazing).

The initial body weight of each animal was recorded and the animals were weighed weekly by using weigh bridge and the weighing were carried out at the same time before morning feeding. The live weight gain was measured by subtracting the initial live weight from the final live weight. The rate of gain per day was calculated by dividing the total live weight gain by the number of total experimental days. The data of ambient

temperature and relative humidity of these experimental days was collected from Metrological Centre, Bangladesh Agricultural University, Mymensingh.

Skin temperature and rectal temperature were recorded with Digital Thermometer. Respiration rate and panting rate were recorded by observing the flank movement of goat. The characteristics of eating and rumination behavior were determined continuously for 18 consecutive days. The jaw movement was recorded by close supervision. Standing time, lying time, no. of urination/hr and no. of defecation were determined with close observation and watch. Rumination time and bolus time were determined with stop watch. The jaw movement was recorded by close contract to find out chewing rate and number of chews per bolus. Pulse rate was measured from base of tail by touching. Blood was collected from jugular vein with the help of syringe for the determination of amount of RBC and WBC, PCV%, HB% and ESR. Packed cell volume (PCV) and haemoglobin (Hb) concentration were determined by microhaematocrit and cyanmethemoglobin methods, respectively. White blood cell (WBC) counts were performed using a haemacytometer technique. Differential leucocytes counts were performed according to the method described by Schalm *et al.,* (1975), while haemoglobin genotype were determined by cellulose acetate electrophoresis, after the haemolysate was prepared according to the method described by Deedo (1973).

Data were analyzed statistically using the analysis of variance technique in a computer using SPSS statistical computer package programmed in accordance with the principle of Completely Randomized Design (CRD). Duncan's Multiple Range Test was done to compare variations among treatments means where ANOVA showed significant differences.

## RESULTS AND DISCUSSION

### *Severity of heat stress in the study areas*

Means of estimating the severity of heat stress was proposed using both ambient temperature and relative humidity, termed as the temperature humidity index (THI) (LPHSI, 1990; Marai *et al.,* 2001). The values obtained indicate the following: <22.2 = absence of heat stress; 22.2 to <23.3 = moderate heat stress: 23.3 to <25.6 = severe heat stress and 25.6 and more = extreme severe heat stress (Marai *et al.,* 2001). In the present study during experimental period average temperature was 28.74 $^0$C and average relative humidity was 87.83%. Hence, THI value was 28.17 which indicate all the experimental animals were in extreme severe heat stress (Marai *et al.,* 2001).

Table 1 shows the skin temperature, rectal temperature, respiration/ panting rate and pulse rate in control ($T_0$), and high temperatures- ($T_4$ and $T_8$) exposed goats. There were no changes to skin and rectal temperatures in goats exposed to heat treatments. These results are inconsistent with those of Fahmy (1994) and Marai *et al.,* (1997), who reported that heat stress increased both skin and rectal temperatures in goats. The reason for the discrepancy between our results and theirs as regards the response of skin and rectal temperatures to

heat stress might be due to using different experimental conditions and/or breed and age of goats. The respiration rate tended to increase with $T_4$ heat stress, was increased with $T_8$ heat stress compared to the control group. The present results were in agreement with Habeeb *et al.,* (1992), who reported that respiration rate can be elevated through heat stress in goats. During summer, the respiration rate is higher than in winter for goat (Fahmy, 1994) and when walking (Khan and Ghosh, 1989). In other words, the heat stress during summer is characterized by an increase in respiration rate. With regard to the effect of humidity, when a load of high relative humidity was superimposed upon an already high ambient temperature; there was a further increase in respiratory frequency in goat. This was related to an increase in the perception of warmth (Marai *et al.,* 1997).

Table 1. Effect of heat stress on physiological parameters of goat

| Physiological variables | $T_0$ | $T_4$ | $T_8$ | Levels of sig. |
|---|---|---|---|---|
| Skin Temp., $^0$F | 99.6 ± 2.1 | 102.3 ± 1.2 | 103 ± 2.0 | NS |
| Rectal Temp., $^0$F | 100.1 ± 2.0 | 102.9 ± 2.1 | 104.3 ± 1.2 | NS |
| Respiration/Panting rate, per min | $32.7^b$ ± 2.2 | $111^{ab}$ ± 2.0 | $119.3^a$ ± 0.8 | ** |
| Pulse rate, per min | $74.3^c$ ± 1.2 | 82.3 $^b$± 2.2 | $87.3^a$ ± 0.8 | ** |

$^{a\text{-}c}$Means (± SE) within a row showing different superscripts are significantly different ($P<0.05$). DMRT test were applied to compare means

Goats exposed to heat exposure showed higher pulse rate compared to the control group. The pulse rate reflects primarily the homeostasis of circulation along with the general metabolic status. The rate increases on exposure to high environmental temperature (Aboul-Naga, 1987). During summer, the pulse rate was significantly higher than during winter, in goat (Ismail *et al.,* 1995). The same trend was observed in grazing goat (Khan and Ghosh, 1989).

Table 2 shows the eating time and chewing rate in control ($T_0$), and high temperatures ($T_4$ and $T_8$) exposed goats. Heat-treated goats showed an elevation in eating time compared to control goats. No significant changes were observed in chewing rate of goats from any of the heat treatment groups. Goat exposure to heat takes more time for eating but total dry matter intake is low. Studies show dry matter intake to decrease significantly following exposure to heat stress in Croix, Karakul, Rambouillet breed of sheep (Monty *et al.,* 1991), Sardinian and Comisana goat (Nardon *et al.,* 1991). The decrease in concentrate intake by goat was estimated to be approximately 13%, without altering the roughage consumption, when kept at 35$^o$C in a climatic chamber (Nardon *et al.,* 1991). The daily feed intake and feed conversion also significantly decreased in kid under hot conditions in a climatic chamber (30.5$^o$C), compared to a group under shelter (19.3$^o$C) during spring.

Table 3 shows the rumination time, number of rumination per minute, number of boli per rumination, bolus time, and number of chew per bolus in control ($T_0$), and high temperatures- ($T_4$ and $T_8$) exposed goats. There were no changes to rumination time, bolus time, and number of chew per bolus in goats exposed to different heat treatments.

However, relative to control groups, the number of rumination per hour and boli per rumination was decreased by $T_4$ HS and $T_8$ HS. There was a consistent interruption of respiration corresponding to rumination contractions.

Table 2. Effect of heat stress on eating behavior of goat

| Eating behavior | $T_0$ | $T_4$ | $T_8$ | Levels of sig. |
|---|---|---|---|---|
| Eating time, min | $300.0^{c} \pm 15.1$ | $366.7^{b} \pm 6.0$ | $380.0^{a} \pm 5.0$ | ** |
| Chewing rate, per min | 90.3 ± 2.3 | 92.3 ± 2.2 | 92.1 ± 1.1 | NS |

$^{a-c}$Means (± SE) within a row showing different superscripts are significantly different ($P<0.05$). DMRT test were applied to compare means

Table 3. Effect of heat stress on rumination parameter of goat

| Rumination variables | $T_0$ | $T_4$ | $T_8$ | Levels of sig. |
|---|---|---|---|---|
| Rumination time (min/hr) | 11.3 ± 1.2 | 9.7 ± 1.2 | 8.3 ± 1.2 | NS |
| Number of rumination/hr | $0.33^{a} \pm 0$ | 0.29b ± 0 | $0.21^{c} \pm 0$ | ** |
| Number of boli/rumination | $21.2^{a} \pm 1.1$ | $18.7^{b} \pm 2.0$ | $16.4^{c} \pm 1.1$ | * |
| Bolus time (sec) | 32.3 ± 2.2 | 31.0 ± 1.0 | 30.3 ± 1.2 | NS |
| No of chew / bolus | 48.3 ± 1.8 | 47.7 ± 2.2 | 46.0 ± 1.0 | NS |

$^{a-c}$Means (± SE) within a row showing different superscripts are significantly different ($P<0.05$). DMRT test were applied to compare means

The cessation of panting during rumination prevents a major heat loss mechanism. It is envisaged that during very severe heat stress that rumination would effectively cease, leading to an exacerbation of the problem of inanition. Rumination time is decreased cause of heat exposure. It is approximately 76%. In high heat treatment, the reduction of ruminating time seems a result of increase in the number of times the sheep chews, which is related to the eating efficiency per hour (Hirayama *et al.* 2000).

Table 4 shows the standing time and lying time in control ($T_0$), and high temperatures- ($T_4$ and $T_8$) exposed goats. Heat-treated goats showed an elevation in standing and lying time compared to control goats. The table also shows the number of urination per hour, duration per urination, and number of defecation per hour in control ($T_0$), and high temperatures- ($T_4$ and $T_8$) exposed goats. There were no changes to duration per urination in goats exposed to different treatment. However, the number of urination and defeacation were showed significantly decreased in heat treated groups compared to control goats. It has been showed that heat can be lost from an animal body to environment by evaporation of respiratory secretions, sweat or saliva. Loss of water via evaporation in sheep has been found to increase from 1L/24 hrs to 2.9L/24 hrs as temperature increases 28$^{o}$C-38$^{o}$C (Blaxter, 1959). Therefore, number of urination is higher in non-exposure group than exposure groups.

Table 4. Effect of heat stress on standing and lying time, urination and defecation behavior of goat

| Parameters | $T_0$ | $T_4$ | $T_8$ | Levels of sig. |
|---|---|---|---|---|
| Standing time (min) | $390.0^{c} \pm 5.0$ | $444.7^{a} \pm 2.0$ | $430.0^{b} \pm 5.0$ | ** |
| Lying time (min) | $90.0^{a} \pm 2.0$ | $35.3^{c} \pm 2.2$ | $50.0^{b} \pm 1.0$ | ** |
| No of urination per hr | $2.3^{a} \pm 0.2$ | $1.3^{b} \pm 0.3$ | $0.83^{c} \pm 0.0$ | ** |
| Duration per urination (sec) | $4.7 \pm 0.2$ | $4.0 \pm 0.5$ | $4.0 \pm 0.1$ | NS |
| No of defecation per hr | $1.3^{a} \pm 0.2$ | $0.75^{b} \pm 0.1$ | $0.75^{b} \pm 0.0$ | ** |

[a-c]Means (± SE) within a row showing different superscripts are significantly different (P<0.05). DMRT test were applied to compare means.

Table 5 shows the blood parameter in control ($T_0$), and high temperatures- ($T_4$ and $T_8$) exposed goats. The amount of RBC, PCV%, Hb%, WBC were significantly higher (P<0.01) in eight hour heat exposure group than four hour and zero hour exposure group. Four hour heat exposure group were significantly higher (P<0.01) than non-exposure group. In the present study, both PCV and hemoglobin were increased in the heat stress group and this is not in agreement with the findings of Srikandakumar *et al.* (2003) in sheep and Abdel Samee *et al.* (1992) in goats. This increase of hemoglobin and PCV levels could be due to either increased unattack of free radicals on the RBC membrane, which is rich in lipid content, and ultimate lysis of RBC or adequate nutrient availability for hemoglobin synthesis as the animal consumes more feed or decreases voluntary intake under heat stress (Srikandakumar *et al.*, 2003).

Table 5. Effect of heat stress on blood parameter

| Blood parameter | $T_0$ | $T_4$ | $T_8$ | Levels of sig. |
|---|---|---|---|---|
| RBC | $11.2^{c} \pm 0.6$ | $11.9^{b} \pm 0.5$ | $12.9^{a} \pm 0.5$ | ** |
| PCV% | $27.3^{c} \pm 0.6$ | $28.3^{b} \pm 0.6$ | $29.3^{a} \pm 1.0$ | ** |
| HB g% | $8.3^{c} \pm 0.4$ | $8.9^{b} \pm 0.4$ | $9.9^{a} \pm 0.7$ | ** |
| WBC | $7.6^{c} \pm 0.3$ | $8.2^{b} \pm 0.7$ | $9.1^{a} \pm 0.3$ | ** |

[a-c]Means (± SE) within a row showing different superscripts are significantly different (P<0.05). DMRT test were applied to compare means

Table 6 shows the differential leukocyte levels in control ($T_0$), and high temperatures- ($T_4$ and $T_8$) exposed goats. The amount of Neutrophil, Esonophil, Lymphocyte and Monocyte were significantly higher (P<0.01) in eight hour heat exposure group than four hour and zero hour exposure group. Four hour heat exposure group were significantly higher (P<0.01) than non-exposure group. There is a great variation in the haematological and biochemical parameters as observed between breeds of goats (Azab and Abdel-Maksoud 1999, Tambuwal *et al.,* 2002). However, the values obtained in this study fell within the broad range recorded for Red Sokoto goats (Tambuwal *et al.,* 2002), thus suggestive of a

well developed immune system in the WAD goats with such number of immune cells to offer good health.

Table 6. Effect of heat stress on differential Leucocyte Count (DLC)

| DLC | $T_0$ | $T_4$ | $T_8$ | Levels of sig. |
|---|---|---|---|---|
| Netrophil | $28.0^{b} \pm 1.0$ | $29.0^{a} \pm 1.0$ | $30.3^{a} \pm 1.5$ | ** |
| Esonophil | $3.7^{c} \pm 1.2$ | $5.0^{b} \pm 0.6$ | $6.0^{a} \pm 0.6$ | ** |
| Lymphocyte | $65.3^{c} \pm 0.6$ | $66.\ 7^{b} \pm 1.0$ | $69.0^{a} \pm 1.5$ | ** |
| Monocyte | $2.7^{c} \pm 0.6$ | $4.3^{b} \pm 0.6$ | $5.3^{a} \pm 0.6$ | ** |

[a-c]Means (± SE) within a row showing different superscripts are significantly different ($P<0.05$). DMRT test were applied to compare means

Neutrophil is the main defender of the body against infection and antigens. High levels may indicate an active infection; a low count may indicate a compromised immune system. Lymphocytes are involved in protection of the body from viral infections. Elevated levels may indicate an exhausted immune system. Monocytes are helpful in fighting severe infections and are considered the bodies' second line of defense against infection and the largest cells in the blood stream.

## CONCLUSION

It can be concluded that heat stress had significant changes on some behavioral, physiological and blood parameters of goat than non heat treated group. Therefore, further study should be taken to normalize the behavioral, physiological and blood parameters of heat treated groups with some ameliorative treatment to goat.

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