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Effect of thermal exposure on physiological adaptability and seminal attributes of rams under semi-arid environment

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ABSTRACT

Thermal stress in hot semi-arid environment is a major limitation of sheep production in tropical and subtropical climatic condition. The animals tend to maintain homeostasis through physiological adjustments in a hot environment (maximum temperature reaches up to 47.5 °C). Therefore, the present study was carried out to assess the effect of thermal exposure on physiological adaptability and seminal attributes of rams under semi-arid environment. The experiment was conducted for eight weeks involving sixteen Malpura crossbred rams (GMM: Garole X Malpura X Malpura). The rams were divided equally into two groups, designated as G1 and G2, respectively. The rams in G1 (Control) group were kept in a sheep shed under naturally prevailing environment without artificial manipulation of ambient temperature (Temperature 30.48 ± 0.38 °C; Relative Humidity 28.59 ± 1.15%). The rams of G2 group were exposed to different temperature at different hours of the day (38 °C at 1000–1100 h; 40 °C at 1100–1200 h; 42 °C at 12:00–1300 h; 43 °C at 1300–1400 h; 44 °C at 1400–1500 h and 42 °C at 1500–1600 h) in a climatic chamber for thermal exposure. Physiological responses, blood biochemical profile, blood endocrine profile, sexual behavior and seminal attributes were measured for both the groups. Thermal exposure significantly ($P < 0.05$) increased the water intake; respiration rate, rectal temperature and skin temperature at afternoon in rams. Exposure of rams to thermal stress (G2) significantly ($P < 0.05$) increased cortisol level and decreased tri-ido-thyronine level. The latency period after the first ejaculation, decreased significantly ($P < 0.05$) in G2. The percentage of rapid motile sperm, linearity and average path velocity of sperm were also altered significantly ($P < 0.05$) in thermal exposed rams as compared to control. However, comparable feed intake, body weight, and major blood biochemical parameters, as well as acceptable semen quality attributes of all the rams indicated that the Fec B gene introgressed Malpura cross rams adapted to the thermal exposure under semi-arid tropical climate.

1. Introduction

Climate change is a major threat to the sustainable livestock production in many parts of the world (Gaughan and Cawsell-Smith, 2015). The hot semi-arid environment is a considerably large agro-climatic zone in both tropical and subtropical latitude with a dense indigenous sheep population (Kumar et al., 2015). The impact of climate change is predicted to be more alarming in the warmer part of the world relative to other regions, posing a greater challenge to sheep rearing. Moreover, it is well established that the high producing animals are more susceptible to thermal stress (Martello et al., 2010).

Generally, sheep as homeotherms maintain their body heat balance by dissipation of excess heat from their bodies when exposed to elevated ambient temperatures (Sejian et al., 2010b). Exposure to high ambient temperatures further increases the effort to dissipate body heat, resulting in increase of respiration rate and body temperature (De et al., 2014). Respiratory evaporative cooling is employed more prominently for heat dissipation than sweating as wool coat reduces the ability of evaporative cooling (Marai et al., 2007). The skin serves as a large dissipative surface organ for the heat exchange between the body and the environment (Adboun et al., 2012). When the dissipative equilibrium of this heat exchange is altered, it is reflected in terms of altered rectal temperature (McManus et al., 2009) as well as the variations in physiological parameters, hormone secretion and blood metabolites (Marai et al., 2006).

In tropical and subtropical areas, indigenous sheep tend to breed throughout the year, although sexual activity is slightly contained during the summer months (Marai et al., 2004). Heat stress is the

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major limiting factor in arid and semi-arid regions for animal productivity due to disrupted physiology and reproductive performances of the animals (Hansen, 2004). Heat stress negatively affects the semen attributes, such as sperm concentration, sperm motility, sperm viability, sperm morphology and acrosome integrity (Naqvi et al., 2012). Exposure to higher temperature to testes impairs spermatogenesis by elimination of spermatogonial germ cells in the seminiferous tubules and degeneration of Sertoli and Leydig cells (Perez-Crespo et al., 2008; Paul et al., 2008, 2009). However, semen characteristics are not immediately affected by changes in testicular temperature because damaged spermatogenic cells do not immediately become part of ejaculation, owing to the storage period in the epididymis.

Moreover, the erratic nature of climatic variabilities, especially precipitation pattern coupled with high environmental temperatures in semi-arid tropics accentuates the cumulative effect of climatic stress (Indu et al., 2015). All these limitations together make this region difficult for the sustainable livestock production (De et al., 2015). However, indigenous sheep breeds, evolved naturally and adapted to hot climatic conditions, are less affected when exposed to such conditions (Marai et al., 2007). Although, the reproductive efficiency of sheep inhabiting in this region is relatively low (Arora and Garg, 1998). The animal generally adapts to the hot climate at the cost of productive and reproductive performance.

Fecundity is one of the most important economic traits in sheep. *Fec B* gene introgression is one of the probable ways to improve fecundity in sheep. However, there is little information regarding adaptability and reproductive performance of *Fec B* introgressed in tropical native breeds. Therefore, the present study was carried out to assess the effect of thermal exposure on physiological adaptability and seminal attributes in *Fec B* introgressed rams under semi-arid environment.

2. Materials and methods

2.1. Site of study

The experiment was conducted for a period of eight weeks, excluding 14 days of the adaptation period to the diets and daily management especially in the climatic chamber. Location of the study was the experimental animal farm of Indian Council of Agricultural Research-Central Sheep and Wool Research Institute (ICAR-CSWRI), Avikanagar, located in the semi-arid region of India (Longitude 75°28´ E, Latitude 26°26´N and Altitude 320 m above mean sea level). The annual ambient temperatures range between and 3 °C and 46 °C and annual relative humidity ranges between 10% and 85%. The rainfall in this area is erratic and distributed throughout the year. Annual precipitation ranges from 200 to 500 mm. The experiment was carried out during March and April months. The mean environmental temperatures and relative humidity during the study period (8 weeks) are depicted in Table 1.

2.2. Animals

The experiment was conducted on GMM (Garole×Malpura×Malpura) crossbred rams. Malpura is a triple (meat, milk, wool) purpose and hardy sheep breed, which originated in the arid and semi-arid areas of North-Western tropical India. They are well known for their hardiness and adaptability to the local environment. The *FecB* gene was introgressed into the Malpura by crossing with Garole sheep to increase the prolificacy. Sixteen Malpura cross rams of 3- 4 years of age, having an average body weight of 45.51 ± 1.67 kg were used in this study. All rams were confirmed to be *Fec B* gene carrier status by forced RFLP-PCR technique using already standardized protocol (Wilson et al., 2001; Kumar et al., 2006).

2.3. Climatic chamber and thermal exposure

All the animals of thermal exposure (G2) group were acclimatized initially to the climatic chamber management for a period of 14 days at ambient temperature in the chamber (without artificial manipulation), whereas the control group (G1) was kept in sheds with asbestos roofing. The maximum and minimum temperature during that period was similar in both G1 and G2 i.e. maximum temperature was 35.39 ± 0.50 °C and minimum temperature was 18.81 ± 2.63 °C. The climate controlled chamber was kept within a complete outer building. The chamber was made up of stainless steel and of strong built to sustain inside air temperature and humidity. Also, it had a provision of programmable temperature and humidity regulator which helped to generate desired temperature and humidity as per requirement of the experiment. The rams of G2 were subjected to thermal stress by exposing them to varying temperatures during different hours of the day, i.e. 38 °C at 1000–1100 h; 40 °C at 1100–1200 h; 42 °C at 12:00–1300 h; 43 °C at 1300–1400 h; 44 °C at 1400–1500 h and 42 °C at 1500–1600 h in the climatic chamber. The thermal control protocol inside the climatic chamber was based on the simulation model developed in accordance with local climate prevailed over the years. Therefore, it was near-natural thermal stress model for sheep under this hot semi-arid tropical climate (Indu et al., 2015).

2.4. Experimental procedure

The present study was carried out on sixteen rams for an eight week period. The rams were randomly allotted into two groups, i.e. G1 (n=8; control) and G2 (n=8; thermal exposure). The rams of G1 group were maintained in the sheep shed with asbestos roofing in naturally prevailed ambient air temperature and humidity (without artificial manipulation). The rams of the G2 group were kept inside the climate controlled chamber from morning 0800 h to evening 1730 h as detailed previously. After that they were kept (1730–0800 h) in shed similar to the control group. All the experimental rams were stall-fed in feed-trough individually from morning 0800 h to evening 1700 h only. During this period all the animals had access to *ad libitum* feed and clean drinking water individually in separate troughs. In the morning all the animals were offered with a concentrate mixture @ 400 g per animal. Ingredient of the feed mix was as follows: barley, 650g/kg;

Table 1.
Meteorological data during experimental period.

	Group	0800 h	0900 h	1000 h	1100 h	1200 h	1300 h	1400 h	1500 h	1600 h
Temp (°C)	**G1**	25.3 ± 0.3	24.6 ± 0.7	28.6 ± 0.7	30.7 ± 0.5	32.3 ± 0.5	33.7 ± 0.5	33.6 ± 0.7	34.9 ± 0.4	34.3 ± 0.4
	G2	27.7 ± 0.9	26.7 ± 1.1	32.2 ± 1.3	38.5 ± 0.9	41.9 ± 0.3	43.3 ± 0.2	44.2 ± 0.2	43.5 ± 0.2	42.4 ± 0.2
RH (%)	**G1**	22.0 ± 2.2	23.2 ± 2.3	24.2 ± 1.0	27.8 ± 0.8	31.2 ± 0.4	32.0 ± 0.7	31.3 ± 0.8	33.1 ± 0.5	33.1 ± 0.6
	G2	57.2 ± 3.3	43.3 ± 3.9	30.5 ± 3.2	24.9 ± 2.2	20.8 ± 0.7	20.3 ± 0.5	19.7 ± 0.4	19.7 ± 0.4	20.0 ± 0.4

Temp, temperature; RH, relative humidity.
G1, control; G2, thermal exposure.
The temperature and humidity data of every day recording of 8 weeks during the experimental period.