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Shed lay-out affects physiological responses and semen quality of crossbred bulls during summer season

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ABSTRACT

The present study was conducted to assess the effect of sheds with two different designs on physiological responses and semen quality parameters of breeding bulls during summer season (June-August). Adult Frieswal bulls (10) were randomly distributed into two groups i.e. in traditional (TG) and modified (MG) design sheds. The sides of individual pens in TG (east-west oriented) and MG (north-south oriented) were covered and open, respectively with equal floor space/bull in both sheds. Respiration rate (RR), heart rate (HR), rectal temperature (RT), body coat and scrotal temperature were recorded in the morning (8.00 to 9.00 AM), and before and after shower in the afternoon (2.00 to 4.00 PM) at weekly interval. Biweekly semen ejaculates were evaluated for volume, concentration and initial motility. Average THI did not vary over the periods and was higher in the afternoon than in the morning in both types of the sheds. Average RT and RR in bulls of both sheds increased significantly in the afternoon than in the morning. HR increased during afternoon period in TG; however, it did not differ significantly in MG. Average RR, body coat and scrotal temperature were higher even after shower than in morning in TG, however, no difference was observed for these parameters in MG. Improvement in initial progressive motility was recorded in bulls of modified sheds after fourth fortnight. The present study revealed better physiological responses and semen quality attributes in bulls kept in modified sheds with open sides of individual pens.

Key words: Bulls, Physiological responses, Semen, Shed design

Comfortable housing for livestock is the primary requirement to express their maximum production potential. In view of this, sheds for dairy animals with different designs have been tested for the efficacy of comfortableness by measuring physiological, behavioural, productive and reproductive parameters on the housed animals. Open housing system is preferable under hot climate conditions, with varying level of protection from heat stress, depending on the ambient temperature (Blowey 1994). This system allows air to move in the space between the roof and the floor performing natural ventilation which enhances dairy cows' microclimate (Hatem 2006).

Crossbred animals having exotic blood in Indian climatic conditions are under heat stress due to high ambient temperature coupled with high relative humidity during summer months. The ability of an animal to withstand the rigors of climatic stress under warm conditions has been assessed physiologically by means of changes in body temperature, respiration rate and pulse rate (Leagates *et al.* 1991, Sethi *et al.* 1994). Crossbred bulls donate nearly 20–30% poor quality semen owing to various factors including seasonal stress rendering them unfit for use in AI (Bhakat *et al.* 2016). A rise in body temperature and consequently increased testicular temperature is a common underlying cause of infertility in bulls (Kastelic 2013). Several studies have shown that techniques as simple as shading and water sprinkling (Thirumurugan and Saseendran 2006) may improve thermal comfort inside livestock facilities, reduce thermal stress and minimize productive losses (Marcillac-embertson *et al.* 2009 and Stowell *et al.* 2009). To the best of our knowledge, there have been only a few studies comparing the sheds with different modifications for their efficacy among breeding bulls.Therefore, the present study was undertaken to see the effect of sheds of two different designs on physiological responses and semen quality parameters of Frieswal crossbred bulls during summer season.

MATERIALS AND METHODS

Animals and management: The study was conducted during summer season (June-August) in 2015 at Bull Rearing Unit of ICAR-Central Institute for Research on Cattle, Meerut, India. For this study, ten adult Frieswal (Holstein Friesian × Sahiwal) breeding bulls, 2–5 years of age, 561–720 kg weight were randomly distributed into two

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groups i.e. in traditional (TG) and modified (MG) design sheds. The experimental bulls were kept in individual pens of these sheds. The sides of individual pens in TG (east-west oriented) and MG (north-south oriented) were covered and open, respectively with equal floor space/bull in both types of sheds. The height of shed at eaves in TG and MG was 3.2 and 3.8 m, respectively. All the bulls were managed and fed under standard farm conditions. They had free access to water, fed on 22–25 kg green fodder, 6–7 kg wheat straw and 3.5 kg of concentrate mixture containing 18% crude protein and 70% total digestible nutrients per head per day. Sprinkling of water was performed to wet the animals at 9.00 AM, 11.00 AM, 1.00 PM and 3.00 PM daily for 5 min in both the sheds.

Climatic variables: Two data loggers (ELBS ® -2, Lascar Electronics Ltd, Wiltshire SP5 2SJ UK) suspended 3.0 m above floor in bull pens protected from direct sunlight and water were used to record the temperature (°C) and relative humidity (%) every one hour inside the pens. Dry bulb and wet bulb temperatures were recorded at 9.00 AM and 2.00 PM. The THI (temperature humidity index) was calculated according to the following formula:

$$THI = 0.72\ (C_{db}+C_{wb}) + 40.6$$

Where, C_{db} and C_{wb} were dry bulb and wet bulb temperature (°C), respectively as described by McDowell (1972).

Measurement of physiological responses and coat temperature: Respiration rate (RR), heart rate (HR), rectal temperature (RT), body coat and scrotal temperature were recorded in the morning (8.00 to 9.00 AM), and before and after shower in the afternoon (2.00 to 4.00 PM) at weekly interval. HR was measured using a stethoscope at 4/5 intercostal space, the RR was obtained by observation of flank movements for 1 min and the RT was measured with a mercury thermometer with sensitivity to 0.2°F inserted into the animal's rectum for 2 min.The body coat and scrotum temperature was measured by infra-red thermometer [display, digital; model, OkatonTempTestr IR; source of power, battery (9 V); unit, °C , °F; range 18~260 °C (0–500 °F); accuracy, ±2% of reading; response time, 500 mSec; distance to spot size (D:S), 6:1].

Semen collection and assessment: Semen samples were collected by artificial vagina technique twice a week from each bull. The fresh ejaculates were subjected to evaluation for volume (ml), initial progressive motility (%) and sperm concentration (×10^6/ml). Initial progressive motility was scored at 200× magnification with phase contrast microscope equipped with a warm stage. Initial progressive motility (%) was observed at four to five areas of the slide before recording of average values. The concentration of spermatozoa was measured with Accucell photometer (IMV Technologies, France).

Statistical analysis: The experimental data were analyzed using t-test and analysis of variance, followed by a Duncan's post hoc test to determine significant differences in all the parameters recorded between groups and fortnights using the SPSS/PC computer programme (Version 16.0, SPSS, Chicago, IL, USA). Differences with values of P<0.05 were considered to be statistically significant.

RESULTS AND DISCUSSION

Climatic variables: Mean ambient temperature in TG and MG was 30.9±0.63 (range 23.5 to 43.5) and 30.2±0.66°C (range 24–41.5), respectively during the trial period (Table 1). During this period, mean relative humidity in TG and MG was 69.34±5.27 (range 24 to 94) and 70.55±5.87% (range 23 to 93.5), respectively. Samer (2011) also did not observe significant effect on diurnal maximum temperatures due to orientation of sheds.

Mean THI values at 9.00 AM and 2.00 PM in both types of sheds during trial period are given in Table 2. Mean THI did not vary over the periods in both the sheds. THI was higher (P<0.05) in the afternoon than in the morning in both types of the sheds. It is clear that the morning and afternoon THI exceeded critical value of 72 and ranged between 76.0 and 96.8 in TG and between 74.8 and 95.3 in MG indicating that crossbred bulls were in different stages

Table 1. Average ambient temperature and relative humidity inside the experimental sheds

Fortnight	Ambient temperature (°C)		Relative humidity (%)	
	TG	MG	TG	MG
I	33 (23.5-43)	32.5 (24-41.5)	50.7 (24-86.5)	49.5 (23-83)
II	31.5 (24-43.5)	30.7 (24-40)	65.42 (29-93)	66.5 (35-92.5)
III	30.1 (24.5-40.5)	29.4 (25-37.5)	76.2 (45-94)	77.9 (50-93.5)
IV	30.5 (26-38)	29.7 (25.5-34.5)	73.9 (52.5-90)	76.34 (60.5-88.5)
V	29.4 (25-38.5)	28.7 (25.5-35)	80.5 (50.5-92)	82.5 (63-91)

Values within the parentheses are daily range of climatic variables

Table 2. Mean±SE values of THI inside the experimental sheds

Fortnight	Traditional shed (TG)		Modified shed (MG)	
	Morning	Afternoon	Morning	Afternoon
I	85.46±0.42	89.56±1.92	84.38±0.43	87.83±2.10
II	82.05±1.02^b	85.20±1.17^a	81.10±1.07^b	83.98±1.06^a
III	80.74±0.78^b	85.72±0.94^a	80.26±0.67^b	83.92±0.80^a
IV	82.32±0.53^b	85.08±0.66^a	81.56±0.30^b	83.32±0.58^a
V	83.66±0.75	83.80±1.09	83.01±0.38	83.44±0.99
Overall	82.85±0.80^b	85.87±0.97^a	82.06±0.73^b	84.49±0.84^a

Means with different superscripts between columns under one group differ significantly (P<0.05) of heat stress during the entire experimental period. No statistical differences were observed for THI values between the sheds. Almost similar to our findings, Jat *et al*. (2005) recorded THI (81.52±0.35) in the morning and (85.71±0.51) in the evening inside of the sheds during same season. A high air velocity under high shade structures enhances the aeration; consequently, maximum temperatures, and THI recorded beneath high sheds were less than those recorded beneath low sheds (Samer 2011). The severity of heat stress in the present study is supported by the failure of the ambient temperature to decline below 23.5°C during cooler part of the day, thus reducing the ability of the bulls to dissipate heat.

Physiological responses: Mean RT, RR and HR of the experimental animals in the morning, and before and after shower in afternoon are given in Table 3. Mean RT in bulls of TG and MG during afternoon period was significantly higher (P<0.05) than in the morning. Sprinkling of water was not an efficient method to reduce RT of bulls significantly as the RT remained higher than that of the morning. Overall RT was higher (P<0.05) in TG (101.48±0.35°F) than in MG (101.11±0.35°F). This difference might be due to more exposure of bulls to sun rays during day time in TG (open side facing towards south direction) and consequently rise in RT of bulls. Stowell *et al.* (1998) reported that more exposure of sun rays to north had the least day time heat gain.

Mean RR also in bulls of TG and MG during afternoon period was significantly higher (P<0.05) than in the morning. The higher RR in the afternoon period might be attributed to the increased physiological response to get rid of the heat load by pulmonary evaporative cooling through respiratory channel (Gangwar *et al.* 1988). RR did not decrease significantly after sprinkling in TG, however, it decreased (P<0.05) in MG and was comparable with that of morning values. This might be due to higher evaporative cooling in MG because of open sides and higher roof height of the individual pens. Overall RR was higher (P<0.05) in MG (33.78±0.50/min) than in TG (32.02±0.55/min). In agreement to the present study, Cardoso *et al.* (2015) found that Girlando animals had one of the lowest rectal temperatures, but showed one of the highest respiratory rates. The animal increased its breathing rate trying to increase the loss of excessive heat and maintaining a low rectal temperature (McManus *et al.* 2014). North-south direction of MG shed might be a possible reason for higher RR in this group. But, contrary to this, Samer (2011) observed that respiration rates for cows housed under high sheds were less than those measured for animals housed under low sheds (differences were found to be significant).

Mean HR increased significantly in the afternoon than in the morning in TG, however, after sprinkling it returned to that of morning values. But in MG, non-significant rise of HR was observed during afternoon, which decreased significantly (P<0.05) upon sprinkling. Overall HR was higher (P<0.05) in MG (67.29±0.65/min) than in TG (65.22±0.59/min). Regan and Richardson (1938) observed a decrease in HR whereas, Gaalas (1945) and Blaxter and Prince (1945) observed an increase in HR with increase in environmental temperature. Ganaie *et al.* (2013) reported that pulse rate did not exhibit consistent and a definite trend with changing environmental conditions. The ibid workers have noticed contradictory HR response with respect to the environmental temperature. Probably it is not the absolute environmental temperature which triggers a particular type of physiological response beyond the zone of thermo-neutrality, rather the total heat load of body initiates a series of responses to maintain homoeostasis. Increased HR coupled with the increased RR act concomitantly for higher pulmonary evaporation.

Body coat and scrotal temperature: Scrotal and body coat temperature increased significantly (P<0.05) in the afternoon and decreased after shower in both sheds. Showering was less effective in TG where average body coat and scrotal temperature after shower remained higher (P<0.05) than in morning whereas, it brought the body coat and scrotal temperature equal to that of morning values in MG. Average daily coat temperature irrespective of black or white coat was significantly higher in TG than in MG. Samer (2011) also observed significant effect of showering on dairy cows in reducing the skin temperature.

Semen characteristics: The results of the seminal parameters (Table 4) showed that semen volume and spermatozoa concentration did not vary (P>0.05). Similar findings were observed by Barros *et al.* (2015). Sperm motility is one of the important parameters for accepting

Table 3. Mean±SE values of physiological parameters and body coat & scrotal temperature of experimental bulls

Parameter	Traditional shed (TG)			Modified shed (MG)		
	Morning	Afternoon before shower	Afternoon after shower	Morning	Afternoon before shower	Afternoon after shower
RT (°F)	101.03±0.06^{c}	101.68±0.06^{b}	101.73±0.06^{ab}	100.9±0.06 ^{c}	101.17±0.06 ^{b}	101.23±0.06^{ab}
RR (per minute)	28.55±0.95^{c}	34.84±0.95^{a}	32.69±0.95^{ab}	33.56±0.87 ^{b}	36.06±0.87 ^{a}	31.71±0.87^{bc}
HR (per minute)	64.00±1.02^{c}	67.33±1.03^{a}	64.33±1.02^{bc}	67.82±1.13^{ab}	69.55±1.13 ^{a}	64.50±1.13 ^{c}
Body coat Black	32.54±0.24 ^{c}	37.49±0.24 ^{a}	35.23±0.24^{b}	31.77±0.18 ^{b}	34.89±0.18 ^{a}	31.58±0.18 ^{b}
temp. (°C) White	31.95±0.27 ^{c}	36.78±0.27 ^{a}	34.22±0.27 ^{b}	31.38±0.30 ^{b}	34.56±0.30 ^{a}	31.27±0.30 ^{b}
Scrotal temp. (°C)	31.57±0.26 ^{c}	35.21±0.26 ^{a}	33.36±0.26 ^{b}	31.31±0.23 ^{b}	34.06±0.23 ^{a}	31.26±0.23^{bc}

RT, Rectal temperature; RR, respiration rate; HR, heart rate. Means with different superscripts between columns under one group differ significantly (P<0.05)

Table 4. Mean±SE values of semen characteristics of experimental bulls

Fortnight	Semen volume (ml)		Sperm concentration (million/ml)		Sperm motility (%)	
	TG	MG	TG	MG	TG	MG
I	4.09±0.37	4.32±0.27	1162.52±99.13	960.19±105.70	64.85±2.31	68.06±2.43
II	3.67±0.40	4.11±0.34	995.59±78.83	776.95±70.52	61.11±2.74	67.37±2.52
III	4.11±0.28	4.78±0.36	1012.85±110.60	923.04±116.08	65.38±2.17	67.83±1.40
IV	4.01±0.34	4.40±0.33	1055.86±119.26	833.40±88.98	48.21±3.64	56.00±4.20
V	4.59±0.45	5.14±0.54	1185.22±152.97	924.44±141.23	46.11±5.73[b]	64.38±4.74[a]
Overall	4.09±0.15	4.55±0.18	1082.41±38.77[a]	883.60±33.89[b]	57.10±4.15	64.70±2.28

Means with different superscripts between groups under one parameter differ significantly (P<0.05)

semen samples for freezing. Initial motility during first three fortnights had no change, however, decreased significantly during last two fortnights in both TG and MG. However, initial motility started improving during the last fortnight in MG whereas, it deteriorated further in TG. This witnessed better effect of evaporative cooling after three fortnights in MG. Thus, appearance of deteriorating effect of elevated temperature not only depends on the extent of heat stress but also on the duration of thermal insult. Deteriorating effects are also visible when the spermatozoa originating from the seminiferous cycle at the time of thermal insult, appears in the ejaculate. Semen characteristics are not immediately affected by changes in testicular temperature because damaged spermatogenic cells do not enter ejaculates for some time after heat stress (Hansen 2009). Wettemann and Boehmer (2014) also reported that motile sperms decreased significantly after 8 weeks of initiation of heat stress in cattle.

The present investigation revealed that average THI was significantly higher in the afternoon than in the morning in both types of the sheds. Heart rate increased during afternoon in traditional sheds; however, it did not differ significantly in modified sheds. Average RR, body coat and scrotal temperature after shower were significantly higher than in morning in traditional sheds, however, no difference was observed for these parameters in modified sheds. Improvement in initial progressive motility was recorded in bulls of modified sheds after fourth fortnight. We have concluded that crossbred bulls kept in modified sheds with open sides (north-south oriented) had better physiological responses and semen quality attributes.

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