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Effect of Shed Designing on Physiological Responses and Semen Quality of Crossbred Bulls during Various Seasons

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ABSTRACT

The study aimed to evaluate the effect of shed designing on microclimatic variables, physiological responses and semen quality parameters of breeding bulls during different seasons. Thirty-one adult Frieswal (Holstein Friesian and Sahiwal cross) breeding bulls were distributed into four groups i.e. in traditional sheds (TG) having open area in north (TGN – 8 bulls) and south directions (TGS – 8 bulls) and in modified sheds (MG) having open area in east (MGE – 8 bulls) and west directions (MGW – 7 bulls). The sides of bull pens in traditional (east-west oriented) and modified sheds (north-south oriented) were covered and open, respectively. Biweekly semen ejaculates were evaluated for volume, sperm concentration and initial sperm motility. Significantly ($P<0.05$) lower THI (temperature humidity index) value in the afternoon period was observed in MG than in TG during hot and humid season. The bulls of TG had significantly higher ($P<0.05$) rectal temperature than those kept in MG during hot and humid season. Heart rate did not show any pattern in bulls during different seasons. Respiration rate (RR) in the bulls of all sheds were higher ($P<0.05$) during hot-dry and hot-humid seasons than in the other seasons, however, shed design had no effect on RR of bulls during different seasons. Significantly ($P<0.05$) higher initial motility was observed in bulls of MG than in the TG except during comfortable season. In conclusion, the modified sheds were comparatively better than traditional sheds as far as THI, physiological responses and initial progressive motility in breeding bulls are concerned.

Keywords: Crossbred bulls, housing, semen quality

Artificial insemination (AI) is one of the important tools for enhancing the reproductive efficiency in dairy cattle. The coverage of AI, particularly in our country depends on the availability of semen doses of desired bull at proper time. In the present scenario, continuous rise in population of crossbred dairy cattle has put a pressure on semen stations for higher production of semen doses. On the other hand, thermal stress is a major constraint in maintaining good quality semen production in crossbred bulls especially during hot and humid season (Sirohi *et al*., 2017). In order to prevent the effects of heat stress, the modification of the surrounding environment is the key management practice to be followed in the dairy herd (Dash *et al.*, 2016).

Changes in physiological responses (Sethi *et al*., 1994) and temperature humidity index (THI) are the widely used indices to measure the magnitude of thermal stress in animals (Dash *et al*., 2016). The effect of modifications in sheds on microclimate and animal's response has been studied in dairy cattle (Samer, 2011). Buffington and Collier (1983) mentioned that orientation of a shade structure is crucial for maintaining optimum production from dairy cows. Limited reports are available as far as testing of shed designing efficacy on the performance of breeding bulls is concerned. Therefore, the present study was undertaken to assess the effect of sheds with different designs on microclimate, physiological responses and semen quality parameters of Frieswal crossbred bulls during various seasons.

MATERIALS AND METHODS

The present study was conducted at Bull Rearing Unit of

ICAR-Central Institute for Research on Cattle, Meerut, India.

Animals and management

For this study, 31 adult Frieswal (Holstein Friesian and Sahiwal cross) breeding bulls, 2-5 years of age, 561-720 kg weight were randomly distributed into four groups i.e. in traditional sheds having open area in north (TGN – 8 bulls) and south directions (TGS – 8 bulls) and in modified sheds having open area in east (MGE – 8 bulls) and west directions (MGW – 7 bulls). The experimental bulls were kept in individual pens having covered (15 m^2) and open area (19 m^2). The floor of open area in the traditional sheds was made of cemented concrete whereas; it was earthen floor in modified sheds. The sides of individual pens in traditional sheds (east-west oriented) and modified sheds (north-south oriented) were covered and open, respectively. All the bulls were managed and fed under similar 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.

Climatic variables

Dry bulb and wet bulb thermometers were suspended 3.0 m above floor in bull pens protected from direct sunlight and water and the respective 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 (Cdb+Cwb) + 40.6, where Cdb and Cwb were dry bulb and wet bulb temperature (ºC), respectively as described by McDowell (1972). Considering the average local climatic variables round the year, the study period was divided into four seasons viz. winter (Jan, Feb and Dec), comfortable (Mar, Oct and Nov), hot and dry (Apr-Jun) and hot and humid (Jul-Sep).

Measurement of physiological responses

Respiration rate (RR), heart rate (HR) and rectal temperature (RT) were recorded in the morning (8.00 to 9.00 AM) at fortnightly 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 ºF inserted into the animal's rectum for 2 minutes.

Semen collection and assessment

Semen samples were collected by artificial vagina technique twice in a week from each bull. The fresh ejaculates were subjected to evaluation for volume (ml), initial progressive motility (%) and sperm concentration ($X10^6$ / ml). Initial progressive motility was scored at 200X magnifications 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 analysis of variance, followed by a Duncan's post hoc test to determine significant differences in all the parameters recorded between the seasons 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

Effect on climatic variables

Average THI values of morning and afternoon periods in experimental sheds during various seasons are presented in Fig. 1 and Fig. 2, respectively. Though the overall mean THI values during morning period between sheds had no difference but were within the comfortable range. Overall mean THI values of the afternoon period in TGN, TGS, MGE and MGW were 77.33 ±0.63, 77.70 ±0.59, 76.77± 0.59 and 76.85 ±0.60, respectively which indicated mild stress on the animals. During hot and dry and hot and humid season mean ambient temperature in traditional and modified shed was 30.9±0.63 and 30.2±0.66ºC, respectively. However, highest ambient temperature was 2ºC lesser in modified than in traditional shed. During this period, mean relative humidity in traditional and modified shed was 69.34±5.27 and 70.55±5.87%, respectively. Similarly, Samer (2011) also did not observe significant effect on diurnal maximum temperatures due to orientation of sheds.

Minimum THI values during winter (52.48) and comfortable season (60.04) were recorded in MGW shed and in the afternoon during hot and dry summer (69.04) and in the morning during hot and humid summer (76.96). Maximum THI in the afternoon during hot and dry (96.76) as well as hot and humid (89.56) was recorded in TGN shed. The variation in THI might be due to shed height, air movement (shed orientation) and exposure of covered and open area to sun rays.

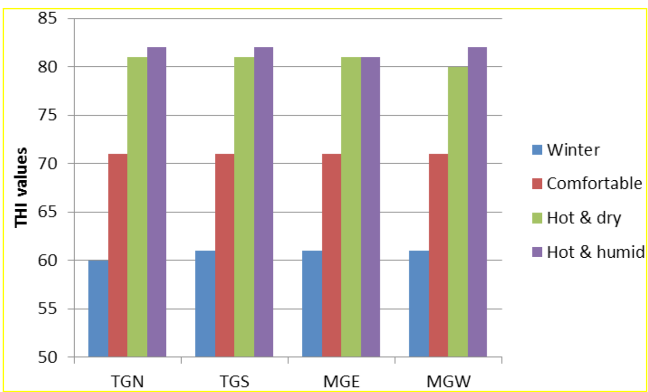

Fig. 1: Mean THI values during morning period in experimental sheds

TGN: Traditional shed with open area in north direction; TGS: Traditional shed with open area in south direction; MGE: Modified shed with open area in east direction; MGW: Modified shed with open area in west direction

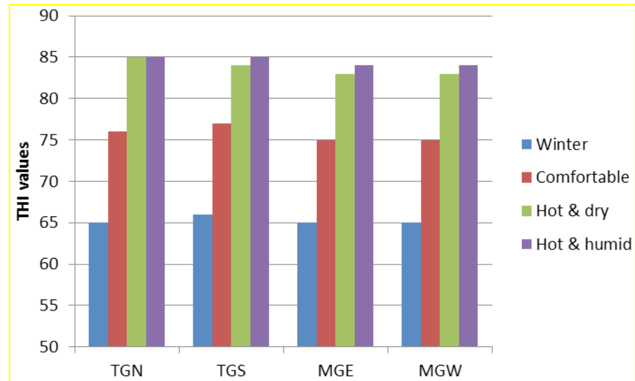

Fig. 2: Mean THI values during afternoon period in experimental sheds

TGN: Traditional shed with open area in north direction; TGS: Traditional shed with open area in south direction; MGE: Modified shed with open area I n east direction; MGW: Modified shed with open area in west direction

The experimental bulls were under thermal stress during both hot and dry and hot and humid seasons. THI values during hot and dry and hot and humid seasons were significantly higher (P<0.05) in all the sheds than during winter and comfortable seasons. Significantly lower THI value in the afternoon period was observed in modified than traditional sheds during hot and humid season. Air velocities recorded under high sheds were higher than those recorded under low sheds which enhances the aeration, differences were significant (P<0.01); consequently, maximum temperatures and THI recorded

Table 1: Mean ± SE of rectal temperature, heart rate and respiration rate of experimental bulls during different seasons

Season	Rectal temperature (ºF)				Heart rate (beats / min)				Respiration rate (breaths / min)			
	Group				Group							
	TGN	TGS	MGE	MGW	TGN	TGS	MGE	MGW	TGN	TGS	MGE	MGW
1	100.21 ±0.15^{a}	100.18 ±0.14^{a}	100.17 ±0.13^{a}	100.18 ±0.12^{a}	66.0 ±2.10^{ab}	67.7 ±1.41	69.74 ±1.36^{a}	69.12 ±1.16	17.10 ±0.51^{aA}	17.98 ±0.61^{aA}	19.95 ±0.70^{B}	18.62 ±0.84^{aAB}
2	100.58 ±0.17^{aA}	100.20 ±0.08^{aB}	100.59 ±0.14^{bA}	100.08 ±0.13^{aB}	61.50 ±2.16^{c}	64.0 ±1.70^{A}	66.89^{A} ±1.62^{ab}	66.67 ±0.90^{A}	20.50 ±1.08^{aA}	22.95 ±1.26^{bAB}	24.19 ±0.62^{aB}	22.67 ±1.03^{bAB}
3	101.01 ±0.10^{bA}	101.07 ±0.09^{bA}	101.12 ±0.10^{cA}	100.63 ±0.11^{b}	67.86 ±2.2^{a}	66.86 ±1.77	70.07 ±1.02^{a}	68.64 ±1.20	27.77 ±1.79^{b}	25.80 ±1.05^{c}	24.70 ±0.66^{a}	24.00 ±1.23^{b}
4	101.14 ±0.09^{bAB}	101.26 ±0.08^{bA}	100.92 ±0.07^{cBC}	100.77 ±0.09^{bC}	61.78 ±1.61^{bcA}	67.48 ±1.04^{B}	64.00 ± 0.85^{bA}	69.00 ±0.73^{B}	28.07 ±0.74$^{bA B}$	29.85 ±0.64^{dA}	28.94 ±0.50^{AB}	24.71 ±1.21^{cB}
Overall	100.80 ±0.07	100.80 ±0.06	100.72 ±0.06	100.43 ±0.07	64.29 ±1.09	66.87± 0.71	67.50 ±0.63	68.56 ±0.57	23.81 ±0.79	24.66 ±0.56	24.79 ±0.44	22.74 ±0.66

Means bearing different superscripts in lower case letters in column and upper case letters in rows differ significantly (P<0.05); Season 1: Winter; 2 Comfortable; 3 Hot and dry: 4 Hot and humid under high sheds were less than those recorded under low sheds (Hatem *et al.,* 2006). However, Buffington and Collier (1983) said that preferred orientation was east-west. In the present study, the role of shed designing might be important one for creating differences in microclimatic variables.

Effect on physiological responses

Mean rectal temperature (RT), heart rate (HR) and respiration rate (RR) of experimental bulls kept in sheds with different designs are given in Table 1. Significantly higher (P<0.05) RT in all the bulls was recorded during hot and dry and hot and humid seasons than in winter and comfortable seasons. The observed RT was within the normal physiological range during the study period. No effect of design of shed on RT was observed during winter season. Lowest RT during hot and dry season was recorded in the bulls of MGW. The bulls of traditional sheds had significantly higher (P<0.05) RT than those kept in modified sheds during hot and humid season. This difference might be due to higher evaporative cooling in modified sheds because of open sides and higher roof height of the individual pens.

Mean HR did not show any pattern like RT in bulls during different seasons kept in sheds of different designs. Shed design had no effect on HR of bulls during winter and hot and dry seasons. Lowest HR was recorded in TGN bulls during comfortable season, however, no difference was observed for HR between other sheds. Significantly higher (P<0.05) HR was recorded in bulls of TGS and MGW during hot and humid season. Ganaie *et al.* (2013) reported that pulse rate did not exhibited consistent and a definite trend with changing environmental conditions. The possible reason might be the total heat load of body which initiates a series of responses to maintain homoeostasis but not the absolute environmental temperature which triggers a particular type of physiological response.

Average RR in the bulls of all sheds were higher (P<0.05) during hot and dry and hot and humid seasons than in the other seasons. Similar to these results, Naik *et al*. (2013) found significantly higher (P<0.01) mean pulse rate of Punganur cattle during summer (64.03) than during monsoon or winter seasons. McManus *et al.* (2014) reported that the animal increased its breathing rate trying to increase the loss of excessive heat and maintaining a low rectal temperature. However, shed design had no effect on RR of bulls during different seasons. Overall lowest RR was recorded in the bulls of MGW.

Effect on semen quality

Mean semen volume (ml), spermatozoa per ejaculate (billion) and initial progressive motility (%) of experimental bulls kept in sheds with different designs are given in Table 2. Semen volume was significantly (P<0.05) lower during hot and humid period than the other seasons in traditional sheds, however, no effect of season

Table 2: Mean ± SE of semen volume, spermatozoa per ejaculate and initial progressive motility of experimental bulls during different seasons

Season	Semen volume (ml)				Spermatozoa per ejaculate (billion)				Initial progressive motility (%)			
	Group				Group							
	TGN	TGS	MGE	MGW	TGN	TGS	MGE	MGW	TGN	TGS	MGE	MGW
1	4.43 ±0.12 ^{aA}	4.30 ±0.15 ^{abA}	4.83 ±0.15 ^{a}	3.67 ±0.11 ^{a}	4.03 ±0.21 ^{a}	4.00 ±0.20 ^{a}	4.27 ±0.24	3.65 ±0.20	53.94 ±1.58	61.05 ±1.37 ^{a}	65.76 ±1.44 ^{aB}	64.09 ±1.46 ^{AB}
2	4.09 ±0.18 ^{aAC}	4.74 ±0.20 ^{aB}	4.44 ±0.17 ^{abAB}	3.83 ±0.14 ^{abC}	4.22 ±0.27 ^{aAB}	4.31 ±0.28 ^{abAB}	4.47 ±0.31 ^{A}	3.59 ±0.24 ^{B}	50.56 ±1.91 ^{B}	56.08 ±1.47 ^{bcA}	56.80 ±2.13 ^{bA}	60.35 ±1.49 ^{A}
3	4.32 ±0.13 ^{aA}	4.39 ±0.14 $^{a\ bA}$	4.41b ±0.12 ^{A}	3.78 ±0.12 ^{a}	4.89 ±0.23 ^{A}	4.56 ±0.21 ^{bAB}	4.55 ±0.20 ^{AB}	4.02 ±0.22 ^{B}	50.83 ±1.42 ^{C}	59.46 ±1.02 ^{abA}	64.03 ±1.09 ^{aB}	60.99 ±1.31 ^{AB}
4	3.99 ±0.12 ^{bA}	4.13 ±0.11 ^{bA}	4.51 ±0.11 ^{ab}	4.17 ±0.11 ^{bA}	4.08 ±016 ^{a}	4.21 ±0.19 ^{ab}	4.56 ±0.20	4.11 ±0.20	50.23 ±1.48 ^{B}	53.98 ±1.15 ^{Bc}	60.27 ±1.30 ^{bA}	62.06 ±1.09 ^{A}
Overall	4.22 ±0.07	4.34 ±0.07	4.53 ±0.07	3.89 ±0.06	4.33 ±0.11	4.29 ±0.11	4.49 ±0.11	3.89 ±011	51.43 ±0.79	57.45 ±0.62	62.02 ±0.71	61.94 ±0.66

Means bearing different superscripts in lower case letters in columns and upper case letters in rows differ significantly (P<0.05); Season 1: Winter; 2 Comfortable; 3 Hot and dry: 4 Hot and humid was observed in modified sheds. During a particular season, no effect of shed was observed for production of semen volume. Similar findings were observed by Barros *et al.* (2015). Some reports indicated significant effect (Goswami *et al*., 1991) while others (Helbig *et al*., 2007) found non-significant effect of different seasons on semen quality parameters in crossbred bulls. Mean spermatozoa per ejaculate did not show any pattern in bulls during different seasons kept in sheds of different designs.

As far as quality of semen is concerned sperm motility is one of the important parameters for accepting semen samples for freezing. Significantly ($P<0.05$) higher initial motility was observed in bulls of modified sheds than in the traditional sheds except during comfortable season. Lowest initial sperm motility was observed during hot and humid period in group TGW and MGE. Similar to our findings, Bhakat *et al.* (2014) found significant effect of season on initial motility of spermatozoa in crossbred bulls. The influence of season was not seen on sperm motility in Group TGN and MGW. Sirohi *et al.* (2017) reported positive influence of shower on initial motility of spermatozoa in bulls of modified sheds than in traditional sheds during summer season.

CONCLUSION

Open sided modified sheds with higher ceiling height had significantly lower THI value in the afternoon period than traditional sheds with covered sides and lower ceiling height during hot and humid season. The breeding bulls managed in these sheds had comparatively better physiological responses and initial progressive sperm motility.

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