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Influence of thermal stress on feed intake and body condition score during early postpartum period of crossbred cows in Kerala*

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Abstract

Increased milk production and environmental alterations caused by climate change makes dairy animals highly vulnerable to Thermal Stress (TS). Cross bred cattle shows some level of adaptation, characterized by reproductive performance of low level, almost uniformly throughout the year. Hence, objective of the present study was to find out the pattern of feed intake and body condition score of cross bred cows in the context of adaptation to TS across seasons prevailing in Kerala.

The study was carried out at Livestock Research Station, Thiruvazhamkunnu, Kerala, in 22 post partum cows between Day 7 and Day 135 of calving. Daily intake of concentrate and weekly body condition score (BCS) were recorded. Blood samples were collected from 10 cows every week for estimation of thermal stress indicators and the climatic variables were recorded daily. Data were analyzed for monthly and seasonal variations and correlations between each other.

Temperature Humidity index (THI) and other climatic variables showed exposure of the animals to TS throughout the year. During summer months, ambient temperature and THI were significantly higher to cause moderate TS. Feed intake, BCS and cortisol levels were significantly high during summer, even though there was no significant correlation with climatic stress factors. HSP 70 was elevated throughout the year and significantly high during the period of moderate THI, indicating adaptation to TS. It is concluded that higher feed intake and BCS during summer months is attributable to TS adaptation because of continuous exposure across many years.

Keywords: *Thermal stress; Adaptation; Climate, Season; Feed intake; BCS*

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Milk production of dairy cows has been increasing over the years, achieved through planned improvements in management as well as genetic potential. The progress in milk production is associated with an increase of feed intake (Cain *et al*., 2006) and high metabolic heat increment, which predisposes the animal to thermal stress (TS). Simultaneously, environmental alterations caused by climate change phenomena seriously affect the animal unless thermoregulatory mechanisms are highly efficient (Schuller *et al.,* 2017).

Thermal stress has been found to reduce the voluntary feed intake as a natural mechanism to reduce the metabolic heat production (Allen *et al.,* 2009), so that dairy cows are in a state of negative energy balance (Guo *et al*., 2018) and this affects lactation and body condition. In this respect, body condition score (BCS) is a simple tool for assessing the energy status of animals especially dairy cattle (Morris *et al.,* 2011; Smijisha, 2012).

In tropical and subtropical regions, high ambient temperature (AT) forms the major reason for TS, and the temperature humidity index (THI) is often used as a composite measure of TS. While high yielding and pure-bred cows are seriously affected, cross bred dairy cattle in Kerala has been found to have varying levels of adaptation against TS (Prasad, 2014), reflected by more or less uniform reproductive performance throughout the year in spite of continuous exposure to TS (Kutty *et al.*, 2019). In this context, present study was carried out to find out the pattern of feed intake and body condition score of cross bred dairy cows reared under mild to moderate levels of TS across various seasons in Kerala.

Materials and methods

The study was carried out at Livestock Research Station, Thiruvazhamkunnu under Kerala Veterinary and Animal Sciences University. The dairy farm of the station was having around 300 heads of cross bred dairy cattle managed intensively as per the standard recommendations (ICAR-NIANP, 2013). The study involved observations on 22 cows between Day 7 and Day 135 postpartum for a period of one year from September 2018 onwards. Every month, 6-8 cows of the study group were replaced with newly calved ones conforming to the study requirements.

The study animals were fed with green grass and concentrate pellets based on feed computation revised every week considering the requirements of maintenance and milk production. Feeding was done in individual troughs to avoid wastage and cross feeding. The quantity of concentrate fed on daily basis and body condition score (BCS) at weekly intervals for each animal was recorded. BCS recording was done subjectively as suggested for cross bred cattle by Smijisha (2012) using 1 to 5 scale with increments of 0.5. The animals were observed from behind and sides of the body focusing changes at seven prominent parts, and a composite score was obtained taking average of all the observations.

Blood samples were collected at weekly intervals from 10 cows of the study group selected randomly, serum was separated and stored frozen for estimation of stress indicators in serum such as HSP 70 and cortisol using ELISA kits (Neogen, USA). Daily ambient conditions were recorded using data logger (HOBO pro V2), installed within the barn and hourly recordings of ambient temperature (AT) and relative humidity (RH) were done. Climatic parameters such as maximum (Mx), mean (Av) and minimum (Mn) of AT and RH were collected and THI values were calculated using the formula (LPHSI, 1990).

$$THI\ (LPHSI) = T - \left[\left(0.55 - \frac{0.55 x RH}{100}\right) \text{x}\ T - 58)\right]$$

Where T - Average temperature (in Degree Fahrenheit)

RH - Per cent relative humidity

The period of study was divided into four seasons of three months each based on the pattern of rainfall and day length (Kutty *et al.,* 2019) such as North East monsoon (SON), Post monsoon (DJF), Summer (MAM) and South West monsoon (JJA) comprised of months such as September to November, December to February, March to May and June to August

Table 1. Monthly averages of ambient temperature, relative humidity, THI, feed intake and body condition score

Month	Ambient Temperature (°C)	Relative Humidity (%)	THI	Feeding (Kg)	BCS
Sep	28.35	83.84	80.81	6.29	2.84
Oct	28.64	79.08	80.62	6.42	2.90
Nov	29.00	73.78	80.42	6.32	2.90
Dec	28.55	72.39	79.54	6.16	2.99
Jan	26.78	62.85	75.67	8.38	3.03
Feb	29.89	63.43	80.21	7.44	3.19
Mar	31.48	64.45	82.67	8.42	3.10
Apr	32.02	69.22	84.28	7.96	3.16
May	29.86	79.86	82.68	8.48	3.15
Jun	29.12	81.69	81.75	7.92	3.10
Jul	27.35	86.18	79.47	7.53	2.97
Aug	26.89	88.02	78.93	6.75	3.08
Mean	29.00	75.40	80.59	7.34	3.03

Table 2. Quarterly averages of climatic variables and stress indicators in the serum

Quarter	Av. Temp (°C)	Av. RH (%)	THI	MnT (°C)	MxT (°C)	HSP70 (ng/ml)	Cortisol (ng/ml)
SON	28.67±0.19	78.90±2.91	80.62±0.11	24.25±0.34	33.09±0.70	1.97±0.20	7.12±1.46
DJF	28.41±0.90	66.22±3.09	78.47±1.41	22.10±.19	34.72±0.86	2.61±0.07	6.73±1.04
MAM	31.12±0.65	71.18±4.56	83.21±0.53	26.31±0.66	35.93±1.84	6.20±0.44	9.36±1.28
JJA	27.79±0.68	85.30±1.88	80.05±0.87	24.76±0.38	30.82±0.98	3.01±0.19	7.92±1.56
Total	29.00±0.47*	75.40±2.60*	80.59±0.63*	24.35±0.55*	33.64±0.77^{ns}	3.45±0.50**	7.78±0.65**

**. Significant at 5% ** Significant at 1% ns – non significant*

Table 3. Comparison of feed intake (in Kg) during the four seasons of study

Season	Feed intake (Kg)	BCS (Raw)	BCS for Lactation stages
SON	6.34 ± 0.04^{a}	2.87 ± 0.01^{a}	3.10 ± 0.00
DJF	7.32 ± 0.64^{ab}	3.07 ± 0.06^{b}	3.00 ± 0.07
MAM	8.28 ± 0.16^{b}	3.17 ± 0.01^{b}	3.10 ± 0.04
JJA	7.40 ± 0.34^{ab}	3.05 ± 0.04^{b}	3.05 ± 0.03
Overall	7.33 ± 0.26	3.03 ± 0.03	3.06 ± 0.02
F value	4.50*	7.724**;	0.408^{ns};
p- value	0.039	0.010	0.748

**. Significant at 5% ** Significant at 1% ns – non significant*

Values with different superscript varies significantly within column

respectively. The climatic variables, stress indicators and other study parameters were analyzed for descriptive details, monthly and seasonal variations and correlation between study parameters using SPSS software (SPSS V. 24.0.).

Results and discussion

Yearly averages of AT, RH and THI were 29.00ºC, 75.40 per cent and 80.59 respectively indicating moderate climate during the study period. Monthly averages of AT, RH, THI, feed intake and BCS are shown in Table 1. AT ranged from 26.78 ºC in January to 32.02 ºC in April. Since the lowest monthly mean of AT exceeded 26ºC, it can be inferred that climate of the locality cannot be designated as winter in any of the months as opined by Rao (2013). Hence, the quarter comprising lowest monthly

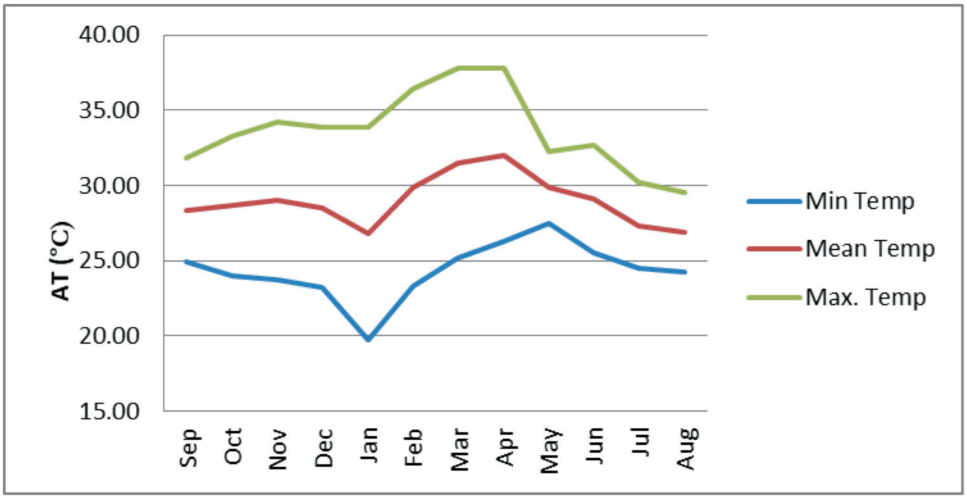

Fig. 1. Monthly trends of daily mean, minimum and maximum ambient temperatures

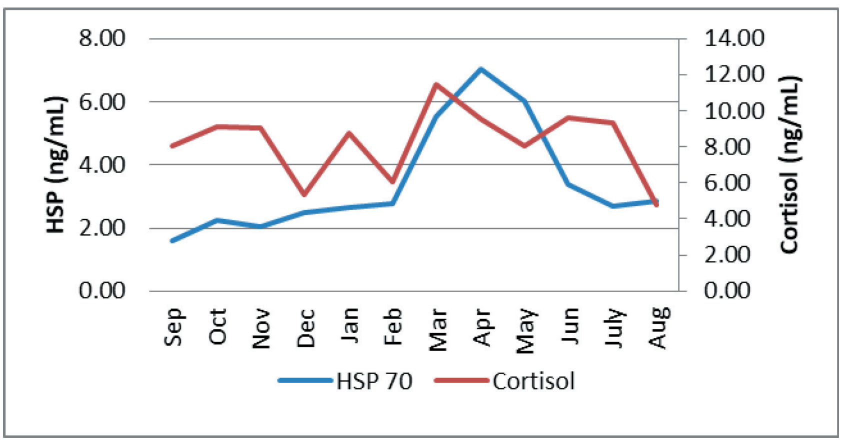

Fig.2. Monthly trends of HSP 70 and Cortisol during the study period

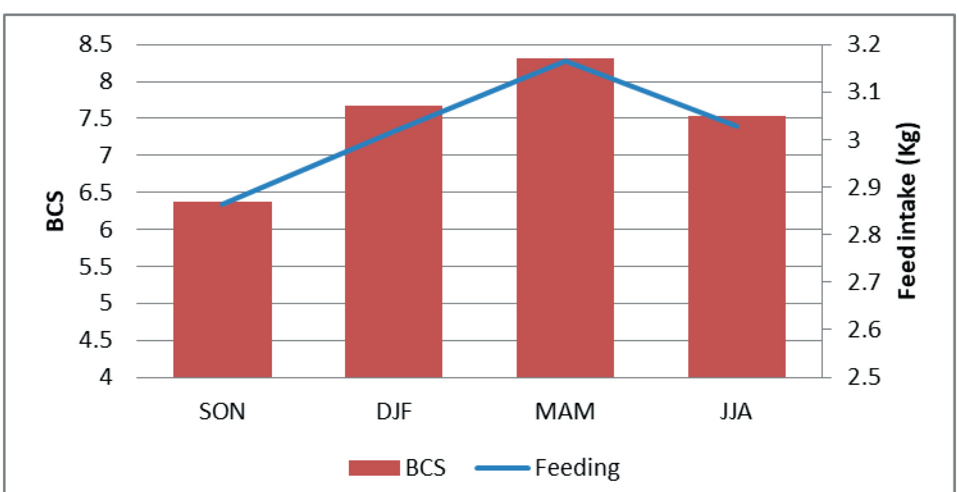

Fig. 3. Comparison of BCS and feed intake across the four seasons

mean of AT is designated as post monsoon in the study.

Annual trends based on monthly averages of Mn, Av and Mx AT of the study locality are shown in Fig. 1. Corresponding to the lowest monthly value for daily mean AT in January, MnT and MxT lines showed a depression in January, while the highest monthly means of MnT and MxT varied slightly from that of daily AvT. The variations of Mn AT, Av AT and Mx AT between months were highly significant indicating considerable variation of climate between months causing more stress to the animals (Krishnan *et al*., 2017).

Changes in RH corresponded to the amount of rainfall received with highest during August and lowest during January in the study year. THI was beyond 75 throughout the year, indicating mild to moderate stress exposure throughout the year and the yearly average was more than 80, which forms the threshold level for moderate TS (Das *et al*., 2016). Similarly, the highest THI was during April (84.28) indicating that none of months had THI level leading to severe stress. Even though RH also contributes to TS by affecting heat dissipation from the animal body, monthly means of THI showed almost similar pattern as that of AT across months, which indicates that elevation of temperature is the major contributor of TS.

Quarterly averages of daily mean AT, RH, THI, Mn AT and Mx AT and stress indicators such as HSP70 and cortisol are shown in Table 2. Corresponding to the highest value of AT and THI during summer, both HSP 70 and cortisol levels were also highest during the period with highly significant variation between quarters, which indicated that the study animals were affected by TS. While HSP 70 had the same pattern of variation across seasons comparable to that of AT and THI, the pattern of variation was different for cortisol. This indicated that HSP 70 was more specific for TS, whereas cortisol indicated combined influence of other stress factors as well affecting the animal.

Monthly trends of HSP 70 and cortisol are shown in Fig. 2. Overall mean value of HSP 70 throughout the study period (3.45 ng/ml) exceeded the level (1.5 to 2.0 ng/ml) prescribed for animals not exposed to TS (Archana *et al*., 2017), indicating that the animals were under TS during most part of the year. While, levels of HSP 70 showed consistent variation between months, levels of cortisol was highly variable, indicating involvement of different factors in the regulation of these stress indicators (Rajoriya *et al.,*2014).

Monthly average of feed intake is also shown in Table 1. The intake was more from January to July, with the highest values during March to May – the period of maximum TS. Since the animals were not fed *ad libitum*, and the feed intake represents the quantity offered based on computation for the milk yield as well, it can be inferred that the yield of animals in summer was more, necessitating increased feed allocation during summer months. Thus, highest feed intake coincided ($P<0.05$) with the highest AT and THI of summer, which is contrary to many reports that TS causes reduction of feed intake as a biological measure to reduce metabolic heat increment (Rhoads *et al.,*2009; Settivari *et al.,* 2007).

Feed intake and BCS of the study animals are compared across seasons in Table 3. BCS was significantly low during SON compared to other three seasons. The periods of highest and lowest, and the pattern of variations were similar for feed intake and BCS as shown in Fig. 3; so that BCS variations across seasons can be attributed to the feed intake. At the same time, feed intake did not show significant correlation with major climatic variables indicating lesser influence of TS, concurring to the report of Sonmez *et al.* (2005).

Since increased milk production affects body condition, mean BCS across seasons for each stage of lactation are also shown in Table 3. While raw BCS was significantly low during SON, BCS adjusted for lactation did not show significant variation between lactation stages or seasons. This implies that whatever difference in BCS noticed between seasons was due to change in feed intake. However, indirect influence of lactation on BCS was evident since feed allocation was primarily based on milk yield, even though variation of BCS between lactation groups was non-significant (F-value= 0.22, p-value=0.344).

There was significant positive correlation between feed intake and BCS ($P<0.05$) as reported by Gaughan *et al.* (2013). HSP 70 also had the same pattern of variation across seasons with major elevation from February to June corresponding to the elevation of THI beyond 81. There was significant positive correlation ($P<0.01$) of HSP 70 with major climatic stress factors such as THI and AT. Since HSP 70 functions as molecular chaperones facilitating repair of cellular damage caused by TS, higher level of HSP 70 in the study forms an indication of adaptation to TS as reported by Archana *et al.* (2017).

The higher intake of feed and better BCS during summer and similar pattern of HSP 70 having significant correlation between each other indicated increased feed intake as against a decrease reported in many studies (Settivari *et al.,* 2007; Rhoads *et al.,* 2009), and was made possible by the adaptation to TS. Thus, significantly higher ($P<0.05$) feed intake during summer could be attributed to the tolerance of the animals against moderate TS. An increase of 7 to 25 per cent in maintenance requirement of cows during summer has been reported by Allen *et al.* (2009), even though severe TS was found to cause lactating cows to enter a period of negative energy balance (Rhoads *et al.,* 2009; Settivari *et al.,* 2007).

To conclude, the study animals were exposed continuously to TS indicated by THI value exceeding 75 throughout the year. During summer months, climatic variables were high enough to cause moderate TS, also reflected by elevation of HSP 70 and cortisol. However, feed intake and BCS were high during summer and no significant correlation was evident with major climatic stress factors. Hence, better feed intake and BCS during summer months was attributed to adaptation of these animals developed through continuous exposure to TS across many years and was reflected by the increased level of HSP 70 throughout the year and significantly higher levels during the period of moderately high THI.

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