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Influence of temperature variability on physiological, hematological and biochemical profiles of growing and adult Karan Fries cattle

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ABSTRACT

Temperature variability impact on physiological, hematological and biochemical parameters of growing and adult Karan Fries cattle was studied during hot humid, winter, spring and summer. During forenoon and afternoon the respiration rate (RR) and rectal temperature (RT) increased by 4.67 and 3.67 breaths/min and 0.87°C and 0.77°C respectively in growing KF cows during summer over spring. The respective values increased in adult KF cows to 2.83 and 6.67 breaths/min and 0.79°C and 0.88°C during forenoon and afternoon during summer over spring. Similar pattern of increase in skin temperature (ST) and pulse rate (PR) was observed during summer and hot humid season over the spring season. The hematological parameters, viz. packed cell volume (PCV) and hemoglobin (Hb) were significantly higher during summer compared to other seasons of the year in both groups of animals. The hematological parameters (RBC, WBC, Hb and PCV) were lower during afternoon compared to forenoon in both groups of cattle during different seasons. The plasma enzymes (ALT, AST, ALP, LDH) activity were significantly higher ($P<0.05$) during summer and hot humid season than spring and winter in both groups. Physiological and biochemical parameters showed positive correlation whereas hematological parameters showed negative correlation with T_{max} and temperature humidity index (THI). Our results indicated significant deviations in different physiological, hematological and biochemical profiles during summer and hot humid season from baseline data (spring). Therefore, these crossbred cattle need to be protected from extreme thermal stress for maintaining the homeothermy/homeostasis specifically during dry and hot humid summer for sustained productivity.

Key words: Physiological, Hematological and Biochemical profiles, Karan Fries, Temperature variability

Animals face thermal challenge for most of the time during the year as India is a tropical country. Heat tolerance of crossbred cattle is poor compared to indigenous cattle mainly due to low sweat gland density and less surface area per unit body weight. Under excess thermal load crossbred animals employ moderate levels of sweating and resort to panting. The adaptive mechanisms under heat stress have been mostly explained by cutaneous characteristics, respiratory frequency, rectal temperature, sweating and panting abilities of the species. For any animal species to adapt to different environmental conditions, a series of physiological, hematological and biochemical responses should be considered. The variation in environmental temperature and relative humidity also causes variation in physiological responses, blood metabolites and hormones. The deviation occurring in physiological, hematological and biochemical parameters due to climatic conditions may help to understand mechanism of physiological function and production losses in the animals and to design strategies to combat stress and minimize production losses. In the present investigation, the fluctuations in different physiological, biochemical and hormonal responses due to temperature variability during different seasons are reported.

MATERIALS AND METHODS

Six each of growing (8–12 months) and adult (>2.5 years) Karan Fries cattle were maintained as per standard feeding and managemental practices followed at the institute farm. The study was carried out during different seasons throughout the year (Table 1). The meteorological parameters viz. dry and wet bulb temperature (°C) and relative humidity (%) were recorded during different months of the year and are presented in the form of climograph (Fig. 1). Temperature variability during different seasons from the baseline temperature (spring) are presented in Table 1. Physiological

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Table 1. Temperature variability during experimental periods in different seasons

Environmental parameters	Spring	Winter	Hot humid	Summer
Dry bulb temperature (°C)	23.0±0.5	11.0±0.7	32.0±0.3	39.0±0.6
Temperature variability in relation to Spring season (°C)	0	–12.00	09.00	17.00
Relative humidity (%)	45.0±2.4	85.00±2.4	86.30±0.4	37.70±2.4
Temperature humidity index (THI)	61.9±0.6	57.1±0.8	80.9±2.1	79.0.±1.9

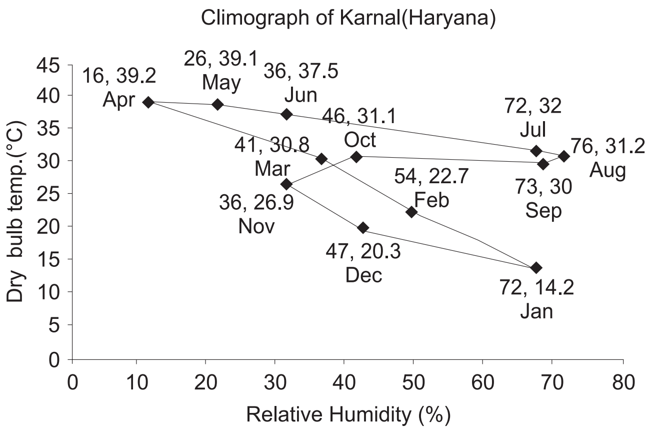

Fig. 1. Climograph of Karnal (Haryana).

parameters viz. respiration rate (RR), pulse rate (PR), rectal temperature (RT) and skin temperature (ST) were recorded between 8.0–9.0AM and 2.0–3.0 PM during spring, winter, summer and hot humid seasons. Blood samples were also collected at the similar interval from all the animals.

Physiological parameters, viz. RR, RT and PR were recorded by flank movement, clinical thermometers and palpation of coccygeal artery, respectively. The skin temperature was recorded using non contact Tele thermometer, keeping the thermometer 4–6 cm away from the skin.

Hematological parameters, viz. Hb and PCV were studied using Drabkins solution and hematocreit tubes, respectively. The RBC and WBC counts were done using hemocytometer. Plasma enzymes, ALP, AST ALT and lactate dehydrogenase were estimated using kits. The plasma cortisol was estimated using EIA kit.

Statistical analysis of the obtained data were performed using the Systat Software programme by three factor analysis of variance for physiological stage, season, time interval and breed. ANOVA was followed by post-hoc Fisher's LSD test for pair wise comparisons where appropriate.

RESULTS AND DISCUSSION

Physiological parameters

Rectal and skin temperature: The mean morning values of RT and ST during different seasons were higher in growing compared to adult Karan Fries cattle (Table 2). Further mean values of RT and ST of growing and adult Karan Fries cattle were significantly ($P<0.01$) higher during afternoon compared to forenoon. The magnitude of increase in RT and ST of both groups of animals during summer were significantly ($P<0.05$) higher over spring. The higher RT and ST of both groups of KF cattle during higher ambient temperature is mainly due to accumulation of heat in the body beyond their heat losing capacity and therefore the heat balancing mechanism is disturbed. Zhang *et al.* (1994) also found a circadian rhythm in RT of beef calves exposed to hot and cold conditions. Similar increase in the rectal temperature at higher temperature/heat stress was also reported in cattle (Singh and Singh 2006; Banerjee and Ashutosh 2011a). Ashour (1993) reported an increase in skin temperature of calves, when exposed to high ambient temperature. Similar significant increase in skin temperature of buffaloes and cattle with increased environmental temperature was reported by Koga *et al.* (1999).

Our results are in agreement with of those Allen (1962) and Thankachan (2007) who also reported rise in body surface temperature of cattle during heat exposure.

The analysis of variance indicated significant ($P<0.01$) differences in RT and ST among seasons, stages and time intervals. RT showed positive correlation ($P<0.05$) with other physiological parameters, biochemical parameters and environmental parameters (T_{max} and THI). Similar positive relationship of RT and ST with T_{max} was reported by Mayengbam (2008) and Dandage (2009) in Sahiwal and Karan Fries cattle. Singh and Upadhyay (2009) also reported positive relationship among THI and physiological parameters in Sahiwal cattle.

Respiration rate and pulse rate: The mean values of RR and PR in the morning were higher in growing compared to adult Karan Fries cattle in all the seasons (Table 2). The probable reasons for higher RR and PR of growing animals compared to adults are mainly due to their higher metabolic rate. The RR and PR increased significantly ($P<0.01$) during afternoon over morning values in adult and growing cattle. Depending upon environment, the heart frequency is different and varies from animal to animal. Our results are in agreement with those of Das *et al.* (1999) who reported an increase in respiration and pulse rate in young buffalo calves exposed to solar radiation. A similar increase in respiration rate was also reported in adult buffaloes and crossbred cattle i.e. higher RR during summer compared to other seasons (Salam 1980). The increased PR and RR are the measures of heat dissipation

Table 2. Physiological parameters of growing and adult Karan Fries cattle during different seasons

Parameters	Stage	Interval	Seasons			
			Spring (23±0.54°C)	Winter (11±0.74°C)	Hot humid (32±0.29°C)	Summer (39±0.56°C)
Rectal temperature (°C)	Growing	Morning	$38.42±0.15^{ax}$	$38.62±0.11^{bx}$	$38.42±0.13^{acx}$	$39.29±0.04^{dx}$
		Afternoon	$38.96±0.06^{ay}$	$38.88±0.06^{ay}$	$38.89±09^{ay}$	$39.73±0.04^{dy}$
	Adult	Morning	$38.25±0.10^{ax}$	$37.79±0.10^{bx}$	$38.35±0.07^{cx}$	$39.04±.0.15^{dx}$
		Afternoon	$38.67±0.08^{ay}$	$38.67±0.05^{ay}$	$38.88±0.05^{cy}$	$39.55±0.12^{dy}$
Skin temperature (°C)	Growing	Morning	$33.93±0.61^{ax}$	$23.81±0.45^{bx}$	$35.82±0.44^{cx}$	$37.74±0.38^{dx}$
		Afternoon	$34.83±0.20^{ay}$	$25.98±0.45^{by}$	$35.40±0.39^{cy}$	$39.65±0.18^{dy}$
	Adult	Morning	$32.98±0.21^{ax}$	$22.21±0.16^{bx}$	$35.40±0.15^{cx}$	$35.91±0.11^{dx}$
		Afternoon	$33.43±0.18^{ay}$	$25.27±0.31^{by}$	$37.52±0.18^{cy}$	$38.35±0.43^{dy}$
Respiratory rate (RR/min)	Growing	Morning	$23.83±0.31^{ax}$	$21.50±0.43^{bx}$	$24.67±0.42^{cx}$	$28.50±0.50^{dx}$
		Afternoon	$27.16±0.60^{ay}$	$25.50±0.43^{by}$	$30.16±0.48^{cy}$	$30.83±0.40^{dy}$
	Adult	Morning	$20.00±0.58^{ax}$	$15.16±0.40^{bx}$	$20.50±0.22^{cx}$	$22.83±0.79^{dx}$
		Afternoon	$22.00±0.63^{ay}$	$18.00±0.45^{by}$	$25.83±0.31^{cy}$	$28.67±0.21^{dy}$
Pulse Rate (pulse/min)	Growing	Morning	$72.67±0.31^{ax}$	$71.00±0.43^{bx}$	$74.33±0.42^{cx}$	$71.00±0.50^{dx}$
		Afternoon	$78.16±0.61^{ay}$	$61.67±0.43^{by}$	$76.67±0.48^{cy}$	$75.83±0.40^{dy}$
	Adult	Morning	$56.00±0.58^{ax}$	$70.33±0.40^{bx}$	$56.67±0.22^{cx}$	$60.67±0.79^{dx}$
		Afternoon	$59.16±0.63^{ay}$	$62.83±0.45^{by}$	$59.00±0.31^{cy}$	$65.00±0.21^{dy}$

The values are the mean±SE of 6 values on 6 animals. The values with the different superscript in the same row (a, b, c and d) and column (x, y) differed (P<0.05).

in livestock by evaporative heat loss through skin surface and respiratory passage (Mc Lean 1963, Nonaka *et al.* 2008). The analysis of variance of data indicated a significant (P<0.01) difference in RR and PR among seasons, stages, time intervals. RR and PR showed positive correlation (P<0.05) with biochemical parameters and THI. Shibu *et al.* (2008) also observed positive correlation of RR and PR with ambient temperature in Murrah buffaloes.

Hematological parameters

The mean values of hematological parameters are presented in Table 3. The mean concentration of RBC and WBC of growing and adult cattle was significantly (P<0.01) lower during afternoon compared to morning during different seasons. Abdelatif *et al.* (2009) reported higher erythrocytes count during wet summer compared to winter and dry summer. But no such pattern in RBC content was observed during the present study. This difference in number of RBC's in blood of cattle may occur due to physiological stage/age, temperature/season and managemental conditions (Mirzadeh *et al.* 2010). During the present study, the overall average of WBC in cattle (growing and adult) was higher during winter compared to summer (Table 3). Mirzadeh *et al.* (2010) also reported lower levels of WBC in different breeds of cattle during summer than spring. The analysis of variance of data of RBC and WBC showed a significant (P<0.01) difference among seasons, stages and time intervals. RBC showed negative correlation (P<0.05) with physiological responses and biochemical parameters and THI.

Hemoglobin and packed cell volume: The mean values of Hb and PCV during morning in growing and in adult Karan Fries cattle varied during different seasons (Table 3).The mean values of Hb and PCV of growing and adult Karan Fries cattle were significantly (P<0.01) lower during afternoon compared to morning. The Hb and PCV were lower in adults compared to growing KF calves. Our results are in accordance to those of Steinhardt *et al.* (1994) who reported a decrease in Hb and PCV with advancing lactation and pregnancy which increased at parturient stage. Abdelatif *et al.* (2009) reported significantly (P<0.001) lower Hb concentration during hot environment compared to cold. Whereas Toharmat and Kume (1997) did not find any significant difference in PCV and hemoglobin concentration during hot and cool weather. The results of the present study are in accordance to those of Koubkova *et al.* (2002), who reported an increase in hematocrit and hemoglobin concentration during summer. It is recognized that normal values for the various blood cell parameters not only differed from species to species but can vary between breeds within a species (Claxton and Ortiz 1996). The analysis of variance of Hb and PCV data indicated a significant (P<0.01) difference among seasons. PCV showed negative correlation (P<0.05) with physiological responses, biochemical parameters and THI. The results of the present study are in accordance with Thankachan (2007) and Banerjee and Ashutosh (2011a) who reported lower levels of hemoglobin

Table 3. Hematological parameters of growing and adult Karan Fries cattle during different seasons

Parameters	Stage	Interval	Seasons			
			Spring (23±0.54°C)	Winter (11±0.74°C)	Hot humid (32±0.29°C)	Summer (39±0.56°C)
Red blood cell (million cells/mm^3)	Growing	Morning	8.41±0.00^{ax}	8.41±0.19^{bx}	8.41±0.08^{cx}	9.22±0.09^{dx}
		Afternoon	7.85±0.16^{ay}	7.87±0.22^{by}	7.65±0.25^{cy}	8.82±0.15^{dy}
	Adult	Morning	8.23±0.18^{ax}	8.23±0.16^{ax}	7.67±0.32^{cx}	7.75±0.12^{dx}
		Afternoon	7.61±0.14^{ay}	7.59±0.19^{by}	6.96±0.35^{cy}	7.31±0.11^{dy}
White blood cells (cells/µl)	Growing	Morning	12880±584^{ax}	12992±535^{ax}	11126±434^{bx}	13554±287^{cx}
		Afternoon	11953±392^{ay}	12123±229^{by}	10881±463^{cy}	12479±421^{dy}
	Adult	Morning	12992±309^{ax}	12667±213^{bx}	12583±564^{bx}	11969±294^{cx}
		Afternoon	10703±347^{ay}	12124±296^{by}	10725±702^{ay}	10354±143^{cy}
Hemoglobin content (gm%)	Growing	Morning	10.59±0.49^{ax}	9.99±0.49^{bx}	10.30±0.25^{cx}	13.87±0.21^{dx}
		Afternoon	9.11±0.25^{ay}	9.41±0.46^{by}	8.89±0.33^{cy}	13.10±0.20^{dy}
	Adult	Morning	11.48±0.56^{ax}	12.47±0.46^{bx}	11.04±0.50^{cx}	12.45±0.55^{dx}
		Afternoon	11.30±0.54^{ay}	11.16±0.62^{by}	9.85±0.21^{cy}	12.00±0.52^{dy}
Packed cell volume (%)	Growing	Morning	35.67±0.71^{ax}	35.50±0.50^{ax}	34.00±0.52^{cx}	37.00±0.58^{dx}
		Afternoon	33.83±1.05^{ay}	33.16±0.75^{by}	32.00±0.52^{cy}	35.83±0.60^{dy}
	Adult	Morning	35.16±0.65^{ax}	35.83±1.17^{bx}	34.83±0.87^{cx}	35.33±1.86^{ax}
		Afternoon	32.16±0.60^{ay}	33.16±0.98^{by}	32.67±0.67^{cy}	34.33±1.65^{dy}

The values are the mean±SE of six values on six animals.The values with the different superscript in the same row (a, b, c and d) and column (x, y) differed (P<0.05).

in cattle exposed to heat stress.

Biochemical parameters

Plasma aspartate aminotransferase (AST) and alanine animo transferase (ALT) levels: The mean values of plasma AST and ALT in growing and adult Karan Fries cattle was significantly (P<0.01) higher during afternoon compared to morning values (Table 4). Contrary to our results, Okab *et al.* (2008) and Ronchi *et al.* (1999) observed significantly (P<0.01) lower ALT activity during summer (65.7±2.63 IU/L) season compared to spring (84.3±2.94 IU/L) season. An increase in plasma AST activity in cattle due to heat exposure was observed by Shaffer *et al.* (1981). The higher ALT levels observed during summer and hot humid season compared to spring and winter may be due to increase in gluconeogensis and corticoid activity during higher temperature for metabolic adaptation. Higher enzymes activities during summer and hot humid season compared to spring season suggested damage in the liver functions due to heat stress. Similarly higher ALT activity was also reported by Yokus and Cakir (2006) in cattle. Contrary to our results, Srikandakumar *et al.* (2003) observed lower plasma AST activity in Merino and Omni sheep during heat exposure. This difference in levels of these enzymes may be due to breed/species differences, temperature conditions and health of animals. The analysis of variance of AST and ALT data indicated significantly (P<0.01) difference between seasons and time interval. AST and ALT showed positive correlation (P<0.05) with physiological responses, other biochemical parameters and THI. Chander Bhan *et al.* (2012) also found the similar correlation among plasma enzymes and physiological parameters in Murrah buffaloes exposed at different environmental conditions.

Plasma alkaline phosphatase levels: The mean values of plasma ALP during morning varied from 8.90±0.78 to 23.26±0.64 KA units in growing and from 8.55±0.51 to 23.27±0.14 KA units in adult Karan Fries cattle respectively during different seasons (Table 4). The levels of ALP were higher during summer and hot humid season than winter and spring season. The levels were also higher during afternoon than forenoon during different seasons and in both groups of cattle. These results are in accordance to those of Marai *et al.* (1995 1997) who reported higher ALP during summer season compared to cooler temperature. The analysis of variance of data indicated that ALP differed significantly (P<0.01) among seasons, time interval and the interaction of season×time. ALP showed positive correlation (P<0.05) with other physiological responses (RR, PR and ST), biochemical parameters and THI.

Lactate dehydrogenase (LDH): The mean plasma values of LDH during morning varied from 294.33±41.58 to 399.65±8.75 IU/L in growing and from 202.43±18.97 to 505.27±24.70 IU/L in adult Karan Fries cattle during different seasons (Table 4). Similar significantly higher lactate dehydrogenase level in native Patanwadi sheep and its crosses with Merino and Rambouillet was reported by Patel *et*

Table 4. Biochemical parameters of growing and adult Karan Fries cattle during different seasons

Enzyme	Stage	Interval	Seasons			
			Spring (23±0.54°C)	Winter (11±0.74°C)	Hot humid (32±0.29°C)	Summer (39±0.56°C)
Alkaline phosphatase (KA unit)	Growing	Morning	10.07 ± 0.68^{ax}	8.90 ± 0.78^{bx}	22.27 ± 1.07^{cx}	23.26 ± 0.64^{dx}
		Afternoon	12.48 ± 0.67^{ay}	11.84 ± 0.48^{by}	25.47 ± 0.84^{cy}	25.43 ± 0.39^{dy}
	Adult	Morning	8.55 ± 0.51^{ax}	8.57 ± 0.08^{bx}	19.97 ± 0.84^{cx}	23.27 ± 0.14^{dx}
		Afternoon	10.92 ± 0.87^{ay}	12.14 ± 0.39^{by}	24.64 ± 1.05^{cy}	26.21 ± 0.15^{dy}
Alanineamino transferase (IU/L)	Growing	Morning	22.55 ± 0.24^{ax}	28.56 ± 0.38^{bx}	53.58 ± 1.77^{cx}	53.37 ± 0.67^{dx}
		Afternoon	25.42 ± 0.26^{ay}	31.78 ± 0.25^{by}	57.64 ± 1.38^{cy}	62.67 ± 0.51^{dy}
	Adult	Morning	19.50 ± 0.42^{ax}	31.53 ± 0.40^{bx}	51.33 ± 1.81^{cx}	49.88 ± 0.58^{dx}
		Afternoon	22.97 ± 0.42^{ay}	34.58 ± 0.34^{by}	56.69 ± 1.95^{cy}	56.34 ± 0.80^{dy}
Aspartate amino transferase level (IU/L)	Growing	Morning	37.59 ± 2.35^{ax}	54.30 ± 2.15^{bx}	85.11 ± 2.33^{cx}	88.17 ± 3.75^{dx}
		Afternoon	48.93 ± 1.83^{ay}	61.21 ± 2.00^{by}	90.71 ± 3.24^{cy}	103.60 ± 3.12^{dy}
	Adult	Morning	48.56 ± 1.80^{ax}	47.24 ± 2.43^{bx}	76.07 ± 4.00^{cx}	94.96 ± 7.22^{dx}
		Afternoon	59.71 ± 2.63^{ay}	56.58 ± 2.76^{by}	87.07 ± 2.59^{cy}	128.38 ± 1.69^{dy}
Lactate dehydrogenase level (IU/L)	Growing	Morning	302.26 ± 3.74^{ax}	399.65 ± 8.75^{bx}	294.33 ± 41.58^{cx}	370.67 ± 7.14^{dx}
		Afternoon	334.09 ± 5.95^{ay}	329.30 ± 42.51^{by}	352.20 ± 29.89^{cy}	420.26 ± 13.59^{dy}
	Adult	Morning	202.43 ± 18.97^{ax}	505.27 ± 24.70^{bx}	231.00 ± 29.19^{cx}	377.33 ± 26.01^{dx}
		Afternoon	283.19 ± 13.97^{ay}	321.14 ± 37.14^{by}	307.93 ± 19.19^{cy}	430.46 ± 19.57^{dy}
Cortisol (ng/ml)	Growing	Morning	1.74 ± 0.05^{ax}	2.01 ± 0.13^{bx}	4.01 ± 0.10^{cx}	9.11 ± 0.30^{dx}
		Afternoon	2.25 ± 0.11^{ay}	2.23 ± 0.09^{ay}	4.45 ± 0.16^{cy}	10.50 ± 0.39^{dy}
	Adult	Morning	1.62 ± 0.04^{ax}	$2.30\pm=0.13^{bx}$	4.33 ± 0.19^{cx}	10.89 ± 0.69^{dx}
		Afternoon	2.09 ± 0.10^{ay}	3.04 ± 0.09^{by}	4.47 ± 0.20^{cy}	12.74 ± 1.14^{dy}

The values are the mean±SE of 6 values on 6 animals.The values with the different superscript in the same row (a, b, c and d) and column (x, y) differed ($P<0.05$).

al.(1991) when sheep were exposed to direct sunlight from 8.30 (32.3°C) to 14.30 h (38.7°C) for 3 consecutive days in the last week of May. The increase in the activity of ALT, AST, ALP and LDH in plasma is mainly due to the leakage of these enzymes from the liver cytosol into the blood stream, which reflects liver damage and disruption of normal liver function (Shakoori *et al.* 1994).The analysis of variance of data indicated that LDH differed significantly ($P<0.01$) among seasons, stage, time interval and the interaction of season × stage. LDH showed positive correlation ($P<0.05$) with other physiological responses (RR, PR and ST), biochemical parameters and THI and negative correlation with hematological parameters.

Plasma cortisol: Acute stressors activates hypothalamo-pituitary-adrenal axis, resulting in increased cortisol levels (Dantzer and Mormede 1983) and involved in adaptation to short and long term heat stress (Beraidinell *et al.* 1992). During present study, the mean levels of cortisol were higher at higher temperature during summer and during afternoon compared to spring season and forenoon values, respectively. The mean values of cortisol of growing Karan Fries cattle during morning and afternoon were 1.74±0.05 and 2.25±0.11 ng/ml, whereas in adult the values were 1.62±0.04 and 2.09±0.10 ng/ml respectively during spring season (Table 4). During afternoon of winter, hot humid and summer season, the mean values of cortisol increased by 10.95, 10.97 and 15.25% respectively over morning values in growing Karan Fries cattle (Table 4). The respective increases in adult Karan Fries cattle were 32.17, 3.23 and 16.99% during afternoon compared to forenoon values. Similarly Yousef *et al.* (1977) and Habeeb *et al.* (2001) also reported an increase in plasma cortisol in cattle when exposed to high environmental temperature. The analysis of variance of data indicated that cortisol differed significantly ($P<0.01$) among seasons, stage and time interval. Cortisol showed positive correlation ($P<0.05$) with physiological responses, biochemical parameters and THI. Chander Bhan *et al.* (2012) also found similar correlation among cortisol hormone and physiological, enzymatic parameters and THI in Murrah buffaloes exposed to different environmental conditions.

Our results showed significant deviations in different physiological, hematological and biochemical profiles due to temperature variability during summer, hot humid and winter season from baseline data (spring season). The physiological, hematological and biochemical profiles obtained under the investigation can be used as reference values for correct interpretation of normal physiology of Karan Fries cattle. Changes in these parameters due to climatic variability may help in designing strategies for combating stress and maximizing production.

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