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INFLUENCE OF TEMPERATURE VARIABILITY ON PHYSIOLOGICAL, HEMATOLOGICAL AND BIO-CHEMICAL PROFILE OF GROWING AND ADULT SAHIWAL CATTLE

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ABSTRACT

In order to observe, the effect of temperature variability on physiological, hematological and biochemical profile, six each of growing and adult Sahiwal cattle were selected from cattle yard of NDRI, Karnal, India. Experiments were conducted during hot humid (32.00±0.30^{0}C and RH 86.30 %), winter (11.0±0.30^{0}C and RH 85.00%), spring (23.00±0.50^{0}C and RH 45.00%) and summer (39.00±0.60^{0}C and RH37.70 %) seasons. The fluctuations were observed in RR and RT of growing and adult Sahiwal cattle during different seasons in morning. The magnitude of increase in RR and ST was found to be higher during hot humid season compared to summer over the spring season. All the physiological parameters showed significantly higher values during afternoon compared to forenoon values in growing and adult Sahiwal cattle. Hematological parameters viz. Packed Cell Volume (PCV) and hemoglobin (Hb) levels were higher during winter season than other seasons, whereas WBC levels were lower during summer as compared to spring season in both groups of animals. Higher ($P<0.05$) levels of cortisol was found during summer (8.91ng/ml) over spring (1.92ng/ml). The plasma enzymes viz ALT, AST, ALP and LDH increased ($P<0.05$) during summer over spring season. Different physiological and biochemical parameters showed positive correlation ($P<0.05$), whereas hematological parameters showed negative correlation ($P<0.05$) with T_{max} and Temperature Humidity Index (THI). Results of the present study indicated significant deviations in different physiological, hematological and biochemical profile different seasons in both growing and adults Sahiwal cattle. But the deviations in these parameters were more pronounced in growing animals than adult cattle during afternoon than morning. Therefore, the growing animals need extra protection from extreme heat.

Key Words : Fluctuations in physiological, Hematological, Biochemical profile, Sahiwal, Temperature variability

INTRODUCTION

Heat is produced in the animal's body by metabolic activities and may also be gained from the environment. Heat is lost from the body by radiation, conduction, convection, evaporation of water from skin and respiratory passages and excretion of faeces and urine. A thermal steady state exists, when the heat gain and the heat loss are balanced. In homeotherms, the various thermoregulatory mechanisms consist of a series of physiological adjustments that serve to establish a thermal steady state at the level of normal body temperature, which consequently struggle to maintain equality in heat gain and heat loss. Activation of such adjustments is highly dependent on the external temperature. The variable insulation, mainly due to circulatory adjustments in the thermoneutral zone of constant metabolism, is sufficient to maintain a thermal steady state. But above and below this thermoneutral zone, circulatory adjustments are no longer enough for maintenance of heat balance. In high and cold temperatures, an increase of evaporative heat loss through skin and respiratory vaporization and an increase in metabolism occur, respectively. Physiological equilibrium is maintained

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mainly by the blood in the body[1] but many physiological conditions may alter this equilibrium. The importance of hemato-biochemical indices in animal husbandry is well acknowledged. The changes in hematological constituents are important indicators of the physiological or pathological state of the animal.[2] The Complete Blood Count (CBC) is an important and powerful diagnostic tool as a component of a minimum database. It can be used to monitor response to therapy to gauge the severity of an illness or as a starting point for formulating a list of differential diagnosis. It is well known that variables such as breed, physiological stage, age, reproductive and lactation stage and environmental cond-itions/season have an influence on physic-obiochemical parameters. Determination of normal values for hematological and blood biochemical values are important for the clinical interpretation of laboratory data.

AIMS AND OBJECTIVES

To develop the data base for various physic-ological, hematological and biochemical parameters during different seasons. The major objectives of the study were to find out the deviations in physiological, hematological and biochemical parameters due to temperature variability from comfortable temperature (spring season) during summer, hot humid and winter season. The study will help in developing the strategies to overcome the adverse impact of temperature variability for sustained productivity.

MATERIAL AND METHODS

Six each of growing (8-12 months) and adult (>2.5 years) Sahiwal female cattle were selected from the herd of NDRI Karnal, India. All the animals were maintained as per standard feeding and management practices followed at farm. The concentrate mixture was fed 1-2 kg/animal/day as per the age and body weight for maintenance. The meteorological parameters viz. dry and wet bulb temperature (°C), relative humidity (%) were recorded during the different seasons and have been presented in in **Table 1.**

Table 1 : Temperature variability during experimental periods in different seasons

Environmental parameters	Spring	Winter	Hot humid	Summer
Dry bulb temperature (^{0}C)	23.0±0.5	11.0 ±0.7	32.0±0.3	39.0±0.6
Temperature variability in relation to Spring season (^{0}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

Physiological parameters viz. Respiration Rate (RR), Pulse Rate (PR), Rectal Temperature (RT) and Skin Temperature (ST) were recorded between 8.00-9.00AM and 2.00-3.00 PM during spring (22±2°C), winter (11±2°C), summer (39±2°C) and hot humid (32±2°C) seasons. Blood samples were also collected from both the groups of animals at the similar interval for haematological parameters viz. Haemoglobin (Hb), Packed Cell Volume (PCV), Red Blood Corpuscles (RBC), White Blood Corpuscles (WBC) and biochemical parameters viz. Aspartate Amino -transferase (AST), Alanine Aminotransferase (ALT), Alkaline Phosphatase (ALP), Lactate Dehydrogenase (LDH) and Cortisol hormone.

Physiological parameters viz. RR, RT and PR were recorded using standard methods i.e flank movement, clinical thermometers and 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, PCV was carried out using Drabkins solution and hematocreit tubes, respectively. The RBC and WBC counts were made using hemocytometer. Plasma enzymes viz. ALP, AST, ALT and Lactate dehydrogenas levels were determined using Span Diagnostic Kits (Kind and Kings Method). The hormone cortisol was estimated in heparinized plasma samples using EIA Kit supplied by Cayman Chemical Co. USA.

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

The results of different physiological, hematological and biochemical parameters and their statistical analysis have been presented in **Table 2** to **Table 4.**

Physiological parameters

Rectal and skin temperature

The mean values of RT and ST during morning varied from 38.27±0.13^{0}C to 38.85±0.07^{0}C and 23.97±0.67^{0}C to 37.71±0.33^{0}C in growing and 38.28±0.24^{0}C to 38.79±0.08^{0}C and 22.70±0.17^{0}C to 35.94±0.02^{0}C in adult Sahiwal cattle, respectively during different seasons **(Table 2)**. The morning mean values of RT and ST during different seasons were found to be higher in growing compared to adult Sahiwal cattle **(Table 2)**. The mean values of RT and ST of growing and adult Sahiwal cattle increased significantly (P<0.01) during afternoon compared to morning values. The magnitude of increase in RT and ST of both groups of Sahiwal cattle during afternoon over forenoon values were significantly (P<0.05) higher during summer (hot dry and hot humid) compared to winter and spring season **(Table 2)**.[3] Also found a circadian rhythm in RT of beef calves exposed to hot and cold stress conditions.[4] Also stated that short horn steers are the least heat tolerant (highest rise in rectal temperature) compared to Brahman cross when exposed to sun exposure at 32-37°C.[5] Reported an increase in skin temperature due to high ambient temperature that leads to increased heat storage in the body of calves.[6] Reported higher skin temperature in buffaloes kept in closed shed compared to open shed during extreme cold environment. Similar pattern of significant increase in skin temperature of buffaloes and cattle with increased environmental temperature has also been reported by.[7] The results of the present investigation are in accordance to those[8, 9]

Table 2 : Mean ±SE of physiological parameters of growing and adult Sahiwal cattle during different seasons

Parameters	Stage	Time	Seasons			
			Spring (23±0.54^{0}C)	Winter (11±0.74^{0}C)	HH (32±0.29^{0}C)	Summer (39±0.56^{0}C)
Rectal Temperature (^{0}C)	Growing	Morning	38.27±0.13^{a}	38.48±0.14^{ax}	38.85±0.07^{bx}	38.37±0.11^{acx}
		Afternoon	38.85±0.07^{a}	38.88±0.04^{ay}	39.15±0.05^{by}	39.03±0.06^{by}
	Adult	Morning	38.41±0.08^{a}	38.28±0.24^{bx}	38.79±0.08^{cx}	38.58±0.09^{dx}
		Afternoon	38.74±0.07^{a}	38.69±0.05^{by}	39.91±0.07^{cy}	39.23±0.04^{dy}
Skin temperature (^{0}C)	Growing	Morning	31.02±0.31^{ax}	23.97±0.67^{bx}	34.24±0.17^{cx}	37.71±0.33^{dx}
		Afternoon	31.69±o.56^{ay}	26.92±0.25^{by}	37.73±0.43^{cy}	39.47±0.17^{dy}
	Adult	Morning	26.93±0.98^{ax}	22.70±0.17^{bx}	35.00±0.11^{cx}	35.94±0.02^{dx}
		Afternoon	32.01±0.56^{ay}	25.50±0.15^{by}	37.25±0.56^{cy}	38.33±0.32^{dy}
Respiratory rate (RR/min)	Growing	Morning	22.50±0.43^{ax}	20.67±0.49^{bx}	23.50±0.76^{cx}	26.16±0.31^{dx}
		Afternoon	25.33±0.49^{ay}	24.50±0.56^{by}	28.83±0.60^{cy}	29.83±0.31^{dy}
	Adult	Morning	16.67±0.49^{ax}	15.83±0.48^{bx}	19.67±0.49^{cx}	21.50±0.43^{dx}
		Afternoon	22.00±0.63^{ay}	19.00±0.26^{by}	22.33±0.67^{cy}	27.67±0.42^{dy}
Pulse Rate (pulse/min)	Growing	Morning	65.50±0.43^{ax}	71.00±0.49^{bx}	72.50±0.76^{cx}	69.50±0.31^{dx}
		Afternoon	70.00±0.49^{ay}	70.16±0.56^{by}	76.16±0.60^{cy}	74.83±0.31^{dy}
	Adult	Morning	53.16±0.49^{ax}	68.83±0.48^{bx}	57.83±0.49^{cx}	56.00±0.43^{dx}
		Afternoon	56.50±0.63^{ay}	61.83±0.26^{by}	62.33±0.67^{cy}	64.50±0.42^{dy}

The values are the mean ± S.E 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 significantly (P<0.05).

who reported almost similar rise in body surface temperature of cattle due to heat exposure. The analysis of variance of RT and ST data indicated significant (P<0.01) difference among seasons, stages, time intervals and the interactions of season X stage (P<0.01). RT showed positive correlation (P<0.05) with physiological parameters (RR and PR), biochemical parameters (ALT, AST, ALP, LDH and Cortisol) and environmental parameters (Tmax and THI).[10,11] Also reported the positive relationship of temperature rise and increase in ST in Sahiwal and Karan fries cattle.[12] showed a positive relationship among THI and physiological parameters.

Respiration and pulse rate

The mean values of RR and PR during morning varied from 20.67±0.49 to 26.16±0.31/ min and 65.50±0.43 to 72.50±0.76/min in growing and from 15.83±0.48 to 21.50±0.43/min and 53.16±0.49 to 68.83±0.48/ min, respectively in adult Sahiwal cattle during different seasons **(Table 2)**. The morning mean values of RR and PR during different seasons were found to be higher in growing compared to adult Sahiwal cattle **(Table 2)**. The mean values of pulse rate of growing and adult Sahiwal cattle during morning increased by 4.00 and 2.83 beats/min whereas during afternoon the pulse rate increased by 4.83 and 8.00 beats/min respectively during summer as compared to spring season.[12, 13] Also reported a significant increase in pulse rate with an increase in ambient temperature and relative humidity.[14] Indicated that panting is thought to be initiated by thermal stimulation of peripheral receptors in buffaloes. The mean values of RR and PR of growing and adult Sahiwal cattle increased significantly (<0.01) during afternoon compared to morning values. The results obtained during the present study are in accordance to those of [15] who reported an increase in respiration and pulse rate in young buffalo calves exposed to solar radiation and recommended protection of buffaloes from direct solar radiation. A similar result of respiration rate was reported by[16] in buffaloes and crossbred cattle i.e. higher RR during summer compared to other seasons.[17] Also reported an increase in respiration rate under heat stress enables the animal to dissipate the excess of body heat by vaporizing more moisture in the expired air, which accounts for about 30 percent of the total dissipation.

The analysis of variance **(Table 2)** of RR and PR data indicated a significant (P<0.01) difference among seasons, stages, time intervals and interaction of season x stage, and stage x time. RR and PR showed positive correlation (P<0.05) with other physiological responses (RT and ST) and biochemical parameters (ALT, AST, ALP, LDH and Cortisol) and THI.[18] Also found similar correlation of RR and PR with ambient temperature in Murrah buffaloes.

Hematological parameters

Red and White Blood Corpuscles

The mean values of RBC and WBC during morning varied from 7.45±0.23 to 8.50±0.15 millions/ mm^3 and 12374±739 to 14342±549 cells/ul in growing and from 7.71±0.14 to 8.22±0.19 millions/ mm^3 and 9525±689 to 13567±230 cells/ul, respectively in adult Sahiwal during different seasons **(Table 3)**. The mean values of RBC and WBC of growing and adult Sahiwal cattle during afternoon was significantly (P<0.01) lower compared to morning values.[19] Reported the highest values of erythrocytes count during wet summer compared to values obtained during winter and dry summer. But no such pattern in RBC number was observed during the present study. This difference in number of RBC's in blood of cattle may be due to stage/ age, temperature/ season and managemental conditions. The findings of the present study are in accordance with those of[20] who opinioned after going through the literatures and observed that physiological measurement of stress include neutrophil : lymphocyte ratios and white blood cell count. During the present study, the increase in WBC during winter and decrease during heat stress compared to spring season indicates the variation in WBC with the variability in ambient temperature.

The analysis of variance of RBC and WBC data showed a significant (P<0.01) difference among seasons, stages and time intervals. RBC showed negative correlation (P<0.05) with

physiological responses (RR, RT, PR and ST) and biochemical parameters (ALT, AST, ALP, LDH and Cortisol) and THI.

Hemoglobin and packed cell volume

The mean values of Hb and PCV during morning varied from 10.70±0.40 to 13.54±0.30 g % and 35.50±1.34 to 38.16±0.87% in growing and from 12.06±0.51 to 13.63±0.38 g% and 34.16±0.87 to 40.67±0.56% respectively in adult Sahiwal cattle during different seasons **(Table 3)**. The mean values of Hb and PCV of growing and adult Sahiwal cattle during afternoon was significantly ($P<0.01$) lower compared to morning values. Similar results have been shown by [19] who reported significantly ($P<0.001$) lower Hb during heat compared to cold temperature**.** Contradictory reports have also been documented by[21] who reported a reduction in hemoglobin, PCV, MCV and MCH during summer season. Whereas[22] did not find any significant difference in PCV and hemoglobin concentration during hot and cool weather. Even in another study[23, 24] reported contradictory report i.e.an increase in hematocrit values and hemoglobin concentration during summer. These differences in the values may be due to breed/ species differences, season and management of animals.

Table 3 : Mean ±SE of hematological values of Sahiwal cattle during different seasons

Parameters	Stage	Time	Seasons			
			Spring (23±0.54^{0}C)	Winter (11±0.74^{0}C)	HH (32±0.29^{0}C)	Summer (39±0.56^{0}C)
Red Blood Cell (million/mm^3)	Growing	Morning	8.18±0.10^{ax}	8.50±0.15^{bx}	7.45±0.23^{cx}	8.37±0.05^{dx}
		Afternoon	7.89±0.12^{ay}	8.32±0.15^{by}	7.42±0.21^{cy}	8.00±0.09^{dy}
	Adult	Morning	8.17±0.13^{ax}	8.22±0.19^{ax}	7.97±0.32^{cx}	7.71±0.14^{dx}
		Afternoon	7.62±0.21^{ay}	7.79±0.23^{by}	7.56±0.18^{cy}	6.90±0.22^{dy}
White blood cells (cells/µl)	Growing	Morning	14296±534^{ax}	14342±549^{ax}	12374±739^{bx}	13596±545^{cx}
		Afternoon	11804±422^{ay}	12917±147^{by}	12242±288^{cy}	12486±504^{cy}
	Adult	Morning	11225±234^{ax}	13567±230^{bx}	9525±689^{cx}	11598±459^{dx}
		Afternoon	9835±344^{ay}	12058±432^{by}	8945±515^{cy}	9722±657^{ay}
Hemoglobin content (gm %)	Growing	Morning	12.24±0.50^{ax}	13.54±0.30^{bx}	11.52±0.46^{cx}	10.70±0.40^{dx}
		Afternoon	11.02±0.35^{ay}	11.85±0.52^{by}	10.36±0.45^{cy}	9.81±0.39^{dy}
	Adult	Morning	12.17±0.57^{ax}	13.15±0.25^{bx}	12.06±0.51^{cx}	13.63±0.38^{dx}
		Afternoon	10.62±0.38^{ay}	12.40±0.46^{by}	11.24±0.58^{cy}	12.72±0.28^{dy}
Packed cell volume (%)	Growing	Morning	37.33±0.88^{ax}	38.16±0.87^{bx}	37.16±0.48^{ax}	35.50±1.34^{dx}
		Afternoon	34.00±0.58^{ay}	36.33±0.49^{by}	33.50±0.89^{cy}	33.00±1.37^{dy}
	Adult	Morning	35.67±0.67^{ax}	40.67±0.56^{bx}	34.16±0.87^{cx}	39.16±0.83^{dx}
		Afternoon	33.83±0.65^{ay}	35.50±0.81^{by}	31.83±0.79^{cy}	37.83±0.83^{dy}

The values are the mean ± S.E 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 significantly ($P<0.05$).

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 (RR, RT, PR and ST), biochemical parameters (ALT, AST, ALP, LDH Cortisol) and THI. The results of the present are in accordance with[22, 25] who reported a decrease in level of hemoglobin in the stressed and dairy cattle exposed to higher temperature.

Biochemical parameters

Plasma alkaline phosphatase and alanine animo transferase levels

The mean values of plasma ALP and ALT during morning varied from 10.08±0.57 to 25.69±0.21 KA units and 27.53±0.47 to 55.92±0.54 IU/L in growing and from 11.46±0.46 to 24.68±0.21 KA units and 28.54±0.24 to 52.65±0.41 IU/L in adult Sahiwal cattle respectively during different seasons **(Table 4)**. The mean values of plasma ALP and ALT in growing and adult Sahiwal cattle was significantly (<0.01) higher during afternoon compared to morning values. Our results are in accordance with[26] who reported that Enzyme activity of ALP has been indicated to be a quick and reliable blood marker for heat stress in animals**.** The results observed in present study are contrary to[27] who observed a significant (p<0.01) reduction in alkaline phosphatase activity with increased rectal temperature in heat exposed calves. The probable reasons for difference in the results may be due to breed/ species difference and managemental practices followed at the farm. The analysis of variance of data indicated that ALP and ALT differed significantly (P<0.01) among seasons, time interval and the interaction of season x time. ALP and ALT showed positive correlation (P<0.05) with other physiological responses (RR, PR and ST), biochemical parameters (AST, ALP, LDH and Cortisol) and THI.

Table 4 : Mean ±SE of biochemical profile of growing and adult Sahiwal cattle during different seasons

Enzyme	Stage	Time	Seasons			
			Spring (23±0.54^{0}C)	Winter (11±0.74^{0}C)	HH (32±0.29^{0}C)	Summer (39±0.56^{0}C)
Alkaline Phosphatase (KA unit)	Growing	Morning	10.08±0.57^{ax}	13.48±0.99^{bx}	23.52±0.77^{cx}	25.69±0.21^{dx}
		Afternoon	11.63±0.69^{ay}	15.77±0.81^{by}	26.39±0.57^{cy}	28.95±0.21^{dy}
	Adult	Morning	11.64±0.43^{ax}	11.46±0.46^{bx}	21.89±0.54^{cx}	24.68±0.21^{dx}
		Afternoon	13.11±1.25^{ay}	13.95±1.51^{by}	27.83±0.46^{cy}	27.61±0.23^{dy}
Alanineamino transferase (IU/L)	Growing	Morning	27.53±0.47^{ax}	31.39±0.50^{bx}	48.28±4.80^{cx}	55.92±0.54^{dx}
		Afternoon	30.19±0.43^{ay}	34.24±0.49^{by}	50.59±4.24^{cy}	67.20±0.29^{dy}
	Adult	Morning	28.54±0.24^{ax}	33.10±0.89^{bx}	52.53±2.35^{cx}	52.65±0.41^{dx}
		Afternoon	31.14±0.29^{ay}	36.31±0.19^{by}	58.64±3.48^{cy}	60.99±0.64^{dy}
Aspartate amino transferase level (IU/L)	Growing	Morning	41.31±2.19^{ax}	61.82±2,44x	80.96±11.58^{cx}	99.15±1.96^{dx}
		Afternoon	53.84±2.14^{ay}	73.57±2.69^{by}	90.73±12.12^{cy}	130.62±3.27^{dy}
	Adult	Morning	47.06±2.29^{ax}	48.89±1.04^{bx}	71.36±3.99^{cx}	93.51±3.40^{dx}
		Afternoon	58.01±2.54^{ay}	56.92±0.93^{by}	80.01±5.57^{cy}	125.57±11.08^{dy}
Lactate dehydrogenase level (IU/L)	Growing	Morning	284.51±9.19^{ax}	356.07±13.07^{bx}	376.00±21.94^{cx}	278.01±10.37^{dx}
		Afternoon	290.06±19.27^{ay}	416.42±32.64^{by}	440.06±7.76^{cy}	444.00±17.77^{dy}
	Adult	Morning	199.16±10.56^{ax}	393.18±30.84^{bx}	280.00±22.81^{cx}	390.06±17.36^{dx}
		Afternoon	232.63±2.61^{ay}	307.52±41.31^{by}	337.20±7.24^{cy}	442.73±11.12^{dy}
Cortisol (ng/ml)	Growing	Morning	1.60±0.10^{ax}	1.72±0.22^{bx}	3.26±0.22^{cx}	12.23±0.52^{dx}
		Afternoon	2.20±0.20^{ay}	2.12±0.05^{ay}	3.79±0.16^{cy}	15.28±0.53^{dy}
	Adult	Morning	2.04±0.38^{ax}	2.35±0.11^{bx}	4.09±0.12^{cx}	12.37±0.19^{dx}
		Afternoon	2.54±0.10^{ay}	2.89±0.12^{by}	4.58±0.18^{cy}	12.70±0.28^{dy}

The values are the mean ± S.E 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 significantly (P<0.05)

Plasma aspartate aminotransferase and lactate dehydrogenase

The mean plasma values of AST and LDH during morning varied from 41.31±2.19 to 99.15±1.96 IU/L and 278.01±10.37 to 376.00±21.94 IU/L in growing and from 47.06±2.29 to 93.51±3.40 IU/L and 199.16±10.56 to 393.18±30.84 IU/L respectively in adult Sahiwal cattle during different seasons **(Table 4)**. The mean values of AST of growing and adult Sahiwal Cattle was significantly (P<0.01) higher during afternoon compared to morning values. Except adults in winter season LDH also showed higher values during afternoon compared to morning values. Similar results have been reported in sheep by[28] that, lactate dehydrogenase level increased significantly in native Patanwadi sheep and its crosses with Merino and Rambouillet when 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 activities 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.[29]

An increase in AST of cattle due to heat exposure has been observed by.[30-35] In contrary observed decreased plasma AST in Merino and Omni sheep.

The analysis of variance of data indicated that AST and LDH differed significantly (P<0.01) among seasons, stage, time interval and the interaction of season x stage. AST and LDH showed positive correlation (P<0.05) with other physiological responses (RR, PR and ST), biochemical parameters (ALP, ALT and Cortisol) and THI and negative correlation with hematological parameters (RBC, PCV, WBC and Hb).

Plasma cortisol

The mean values of cortisol of growing Sahiwal cattle during morning and afternoon were 1.60±0.10 and 2.20±0.20 ng/ml whereas in adult the values were 2.04±0.38 and 2.54±0.10 ng/ml respectively during spring season. During afternoon of winter, hot humid and summer season the mean values of cortisol increased by 23.26, 16.88 and 24.93 percent respectively over morning values in growing Sahiwal cattle **(Table 4)**. The respective increase in adult Sahiwal cattle were 22.97, 11.49 and 2.66 percent during afternoon compared to forenoon values.

The magnitude of increase in cortisol was more during summer season in both groups of Sahiwal cattle. Cortisol was found significantly higher during afternoon as compared to morning in both groups of Sahiwal cattle.

CONCLUSION

The analysis of variance data indicated that cortisol differed significantly (P<0.01) among seasons, stage and time interval and the interaction of season x time and season x stage x time (P<0.01). Cortisol showed positive correlation (P<0.05) with other physiological responses (RR, RT, ST and PR), biochemical parameters (AST, ALP. ALT and LDH) and THI and negative correlation with RBC and WBC. Based on the results of the present study it can be stated that growing animals needs extra protection during the extreme climatic conditions.

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