Haematological and Hormonal Profile of Various Breeds of Cattle and Buffalo under Varied Seasons and Environmental Conditions

Anjali Aggarwal
Sohan Vir Singh
Khan Farheen Badrealam
Renuka
Anil Kumar

Climate Resilient Livestock Research Centre
ICAR-National Dairy Research Institute
Karnal-132001 (Haryana) India

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भा.कृ.अनु.प.-राष्ट्रीय डेरी अनुसंधान संस्थान
ICAR-NATIONAL DAIRY RESEARCH INSTITUTE
(मान्य विश्वविद्यालय)
(Deemed University)
(भारतीय कृषि अनुसंधान परिषद)
(Indian Council of Agricultural Research)
करनाल-132001, (हरियाणा) भारत
KARNAL- 132001, (Haryana) India

प्रोफेसर (डा.) ए. के. श्रीवास्तव
निदेशक
Prof. (Dr.) A. K. Srivastava
Director

FOREWORD

India has vast resources of livestock. India ranks first in the total buffalo population and second in the population of cattle and goats in the world. These resources are important contributors in the economy of our country. However, the recent trend in climate change is transforming the planet's ecosystem and adversely affecting the livestock population of current and future generations. The animals are affected both directly and indirectly by the climate change. Heamatological and biochemical indices are important indicators of animal health status. Thus, with increase concern for global warming; these indices could act as valuable tool to monitor the health status of the animals. Although reference dataset of the haematological/biochemical values have been reported by different workers in exotic cattle in their home tracks; however, there is no compiled information available on base values for the indigenous cattle and buffaloes under different environmental conditions. In this regards, the present bulletin "Haematological and Hormonal Profile of Various Breeds of Cattle and Buffalo under Varied Seasons and Environmental Conditions" satisfactorily elucidates the haematological and biochemical indices of breeds of cattle and buffaloes under conditions prevailing in our country. The bulletin is an amalgamation of scientific literature and data from practical wet lab experimentations. The improved knowledge of these indices of the indigenous breeds will certainly help the livestock science. Indeed, it will serve as a resource reading material for fraternities working in the field.

I wish them all the best.

Srivastava

(A. K. Srivastava)

दूरभाष/Tel. : 0184-2252800/ 2259002/ 2259004 (O)
0184-2271612/ 2259406 (R)
एक्सचेंज/Exch. : 2250366/ 2250716, ईपीएबीएक्स/EPABX :1002/ 1004 (O)
फैक्स/Fax : 0184-2250042
ई.मेल/e-mail : dir@ndri.res.in
dir.ndri@gmail.com

PREFACE

Blood profile of an individual is an important indicator of an individual's well being. Any deviation from the normal state are certainly reflected through alteration in the blood constituents. Thus, besides performing other functions, the blood constituents serve as valuable tool to monitor health status of an individual. In this context, the present bulletin collates the haematological and biochemical profile of various breeds of cattle and buffalo under varied seasons and environmental conditions so as to generate a reference dataset of the indigenous breeds under native circumstances.

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Anjali Aggarwal
Sohan Vir Singh
Khan Farheen Badrealam
Renuka
Anil Kumar

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1. Introduction

The blood profile of an individual provides an opportunity to clinically investigate the presence of different metabolites and other constituents in the body that concomitantly plays a vital role in the assessment of physiological, nutritional and pathological status of an individual. The knowledge of haematological/biochemical indices is useful in diagnosing various pathological and metabolic disorders, which can adversely affect the productive and reproductive performance of livestock resulting in great economic losses to dairy farmers. Beside these, it also helps in distinguishing the normal state from the state of stress, which can be nutritional, environmental or physical. Since blood indices change during various states, it is imperative to study haematological/biochemical constituents during different physiological states. These changes in the haematological/biochemical constituents are important indicators of the physiological or pathological state of the individuals. Further, it has been reported that the physiological variation in the blood parameters is of great significance for clinical haematology and animal production as blood constituents are indicative of heat tolerance and environmental stress in cattle and buffaloes of tropical regions. It is in general consensus that the reference haematological/biochemical values reported from different workers from abroad in their native environments and conditions cannot be fully applicable to our local climatic conditions. Hence there is a need to develop a haematological and biochemical profile of cattle and buffaloes in our home tracks. Considering these, we have collated a reference dataset of cattle and buffalo during different seasons and environmental conditions.

1.1 Cattle

With the vast bovine genetic resources; India possesses approximately 30 cattle breeds, besides larger proportion of non-descript cattle. Indigenous breeds could be classified under three groups based on utility/purpose: a) Milch breeds/Milk breeds; b) Draught breeds; c) Dual purpose breeds.

a) Milch Breeds / Milk Breeds: The cows of these breeds are high milk yielders and the male animals are slow or poor work animals. The

milk production of milk breeds is on an average more than 1600 kg per lactation. The examples of Indian milch breeds are Sahiwal, Red Sindhi, Gir and Deoni.

b) Draught Breeds: The male animals are good for work and cows are poor milk yielder. They are usually white in color. Their milk yield is on an average less than 500 kg per lactation. The examples of this group are Kangayam, Umblacherry, Amritmahal, Hallikar.

c) Dual Purpose Breeds: The cows in these breeds are average milk yielder and male animals are very useful for work. Their milk production per lactation is 150 kg to 500 kg. The example of this group is Ongole, Hariana, Kankrej, Tharparker, Krishna Valley, Rathi and Goalo Mewathi.

1.1.1 Tharparkar cattle

Origin and Distribution: Umarkot, Naukot, Dhoro Naro, Chhor, Mithi, Islamkot and Khari Ghulam Shah in Pakistan. In India, they are found in Jodhpur, Barmer and Jaisalmer district of Rajasthan and Kach region of Gujarat.

Location and Topography: Tharparkar district of Pakistan lies between 24°13′ and 26°2′ north latitude, and 68°40′ and 71°11′ east longitude. In India, breeding tract lies between 23°15′ and 29°19′ north latitude, between 68°4′ and 74° east longitude.

Climate: Maximum temperature is 48°C to 49°C and nights are cool and comfortable. Average Rainfall is 10 to 15 cm.

Breed Characters

- Heat and drought resistant. The usual colour of the cattle is white or grey.
- The head is of medium size, the forehead is broad and flat or slightly convex above eyes.
- Horns are set well apart curving gradually upwards and outwards in the same line as that of the poll with blunt points inclined inwards.
- The ears are somewhat long, broad and semi-pendulous and face forwards.
- Average milk production is 1,980 kg.

1.1.2 Sahiwal cattle

Origin and Distribution: Original breeding tract lies in Montgomery (now Sahiwal) district Pakistan, Indo-Pak border in Ferozepur, Amritsar district of Punjab and Sri Ganganagar district of Rajasthan. This cattle is related to the cattle of Afghanistan.

Location and Topography: The breeding tract in India lies between 29°10′ and 30°55′ north latitude, and 73°6′ and 74°4′ east longitude.

Climate: Weather in this area is extremely hot during summer (April to August) and extremely cold during winter (December to February).

Breed characters

- Long, fleshy and comparatively lethargic.
- Forehead is medium sized in females but broad and massive in males.
- Horns are short and stumpy.
- Ears are medium sized with black hair on the fringes.
- Dewlap is large and heavy.
- Hump in males is massive and frequently falls on one side.
- Navel flap is loose and hanging.
- Sheath in males is also pendulous.
- Tail is long and fine with a black switch reaching almost to the ground.
- Udder is generally large, bowl shaped, pliable, and firmly suspended from the body. Pendulous udder is also found in high producing females.
- Teats are large and cylindrical in shape.
- Average milk production is 2,326 kg.

1.1.3 Karan Fries cattle

Origin and Distribution: Karan Fries (KF) was developed in India at the National Dairy Research Institute (NDRI) at Karnal by crossing Holstein Friesian with Tharparkar, an Indian milch breed.

Breed characters

- Comparatively heat susceptible.
- Holstein-Friesian cattle are best known for their milk production and are the most established dairy breed worldwide and Tharparkar cows are

average milk yielders but are highly valued for their ability to withstand variable environmental conditions, higher resistance to diseases and capacity to thrive on low feed resources. The cross between these two breed exploited the desirable traits from both the breeds and was named as KF which is very popular amongst dairy farmers of North India.

» Average milk production is 3,585 kg.

1.2 Buffalo

Buffalo is a multipurpose animal. Besides being a better source of milk, they are source of meat as well. Of all the domestic animals, the Asian buffaloes hold the greatest promise and potential for production. The production of buffalo milk in the Asian-Pacific region exceeds 45 million tonnes annually. They are labour intensive, cost-effective and the most versatile of all work animals in the variety of tasks.

1.2.1 Murrah buffalo

Origin and Distribution: Home tract stretches around the southern parts of Haryana comprising the districts of Rohtak, Jind, Hisar, Jhajhar, Fatehabad, Gurgaon and the Union Territory of Delhi.

Location and Topography: The native tract of the breed covers parts of Haryana and lies between 28°15´ and 30°0′ North latitude, and 75°45′ and 70°80′ East longitude.

Climate: The breeding tract has relatively hot and dry climate. Maximum temperature goes as high as 45°C during summer. Minimum temperature may reach near freezing point in winter with frost for a few days.

Breed Characters

» Massive body, neck and head are comparatively long, horns are short and tightly curled.

» Udder is well developed, hip is broad and fore and hind quarters drooping.

» The age at first calving is 45 – 50 months in villages but in well managed herds it is 36 – 40 months. The inter-calving period is 450 – 500 days.

» It performs well in coastal and slightly cold climatic areas.

» The average milk production per lactation is 1,500 to 2,500 kg.

2. Outlines of experimental procedure

Six animals each of growing and adult female of Tharparkar (Zebu), Sahiwal, KF (crossbred) cattle and Murrah buffaloes were selected from the herd maintained at ICAR-NDRI, Karnal. The growing animals were of 8-12 months and adult animals were >2.5 years. All the animals were maintained as per standard practices followed at ICAR-NDRI, Karnal. The animals were fed roughages (green and dry fodder) *ad libitum* during different seasons. Water was available to the animals all round the clock. The concentrate mixture was fed @1-2 kg/animal/day as per the age and body weight for maintenance. Concentrate mixture consisted of mustard cake, maize, wheat bran, rice bran, mineral mixture and salt. The Crude Protein of diet was 12% and total diet nutrient was 60%.

One set of study was conducted to analyze the haematological parameters (Red blood count (RBC), White blood count (WBC), Packed cell volume (PCV), Hemoglobin (Hb), Mean corpuscular volume (MCV), Mean corpuscular hemoglobin and Mean corpuscular hemoglobin concentration (MCH and MCHC) and biochemical parameters (Alkaline Phosphatase (ALP), Alanine Amino transferase (ALT), Aspartate Amino transferase (AST), Lactate Dehydrogenase (LDH), Acethylcholinesterase (AChE) and Cortisol) of different breeds of cattle and Murrah buffalo during different seasons i.e. winter (10-12^{0}C and RH 75-90%), spring (20-23^{0}C and RH 40-45%), hot humid (32-35^{0}C and RH 75-85%) and summer seasons (38-40^{0}C and RH 35-40%). The blood samples were collected at stipulated time intervals from adult and growing cattle and buffaloes during different seasons and their haematological and biochemical parameters were analyzed as per standard protocols.

Further, another part of the study was conducted in temperature controlled climatic chamber. Basically, the animals (growing female and adult group of cattle and Murrah buffalo) were exposed at 42^{0}C and RH 40-45% and 44^{0}C and RH 40-45% for a time period of 4 hours (Fig. 1 and 2). Finally, all the parameters as mentioned in experiment I were analyzed before and after 4 hour of exposure.

The haematological and biochemical profiles of cattle and buffalo during different seasons (spring, winter, hot humid (HH) and summer) and environmental conditions under temperature controlled climatic chamber (42±1^{0}C and 44±1^{0}C) are depicted in the tables 1-24.

Figure 1: Temperature controlled climatic chamber

Figure 2: Various animals exposed in the climatic chamber. Tharparkar (A); Sahiwal (B); Karan Fries (C); and Murrah (D)

3. Haematological Parameters

Blood fulfills a number of functions in the body and any alteration in the constituents of the blood reflects the functional status of the system. It has been reported that PCV, RBC, WBC count and Hb have a negative correlation with atmospheric temperature. Further, seasonal variation in Hb concentration in Kumauru steers, Sahiwal x Haryana and Deoni x Haryana crossbreds and pure breed cows have also been reported. It has been suggested that Hb concentration decreases during heat stress mainly due to depression of haematopoiesis.

Moreover, the RBC count has been reported to decrease significantly in cattle under heat stress conditions (38°C). Also, the hematocrit percentage (PCV) decreases in heat stressed animals due to red cell destruction and/or hemodilution (Marai et al., 1997). Dinev and Khubenov (1986) reported lower values of Hb and erythrocytes in young animals than adults; whereas with aging, the total count of leukocytes follows a lowering trend; nonetheless, the percent of neutrophils increased. Moreover, a significant decrease in PCV values has been reported in dairy cows exposed to high temperatures (Lee et al., 1976).

Further, exposure of animals at 40, 42 and 45°C lowered Hb content of both Zebu and crossbred cattle, whereas the magnitude of decrease in Hb was highest at 45^0C in Zebu and at 40^0C in crossbred (Kumar, 2010). Similarly, lower levels of Hb has been seen in the heat stressed Murrah buffaloes and cattle exposed to climatic chamber (Thankachan, 2007; Banerjee, 2008).

Considering all these, we collated a haematological profile of different breeds of cattle and Murrah buffalo during different seasons and during temperature controlled chamber exposure at stipulated temperature (42^0C and 44^0C).

Table 1: Red Blood Cell (million/mm^3) of cattle and buffaloes during different seasons

Breed/ Species	Stage	Time	Seasons			
			Spring	Winter	Hot Humid	Summer
Tharparkar	Growing	Morning	8.78±0.20^{ax}	8.93±0.24^{ax}	8.33±0.46^{cx}	8.06±0.16^{dx}
		Afternoon	8.18±0.14^{ay}	8.00±0.36^{by}	7.26±0.28^{cy}	7.67±0.14^{dy}
	Adult	Morning	8.57±0.11^{ax}	8.99±0.07^{bx}	8.14±0.19^{cx}	7.34±0.09^{dx}
		Afternoon	7.76±0.12^{ay}	8.62±0.12^{by}	7.69±0.20^{cy}	7.69±0.12^{cy}
Sahiwal	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^{cx}	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}
Karan Fries	Growing	Morning	8.41±0.00^{ax}	8.41±0.19^{ax}	8.41±0.08^{ax}	9.22±0.09^{dx}
		Afternoon	7.85±0.16^{ay}	7.87±0.22^{ay}	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^{cx}
		Afternoon	7.61±0.14^{ay}	7.59±0.19^{by}	6.96±0.35^{cy}	7.31±0.11^{dy}
Murrah	Growing	Morning	8.29±0.11^{ax}	8.48±0.17^{bx}	8.75±0.17^{cx}	8.33±0.06^{dx}
		Afternoon	7.86±0.13^{ay}	8.12±0.22^{by}	8.37±0.23^{cy}	7.97±0.07^{dy}
	Adult	Morning	8.36±0.18^{ax}	8.41±0.04^{ax}	8.29±0.24^{ax}	7.85±0.16^{dx}
		Afternoon	7.81±0.15^{ay}	8.02±0.15^{by}	7.10±0.39^{cy}	7.23±0.10^{dy}

- *The values are the mean and SEM of six values on six animals*
- *The values with the different superscript in the same row (a, b, c and d) and column (x and y) differed significantly ($P<0.05$). (CD value for seasons = 0.101, Time interval = 0.0715)*

Table 2: White blood cells (cells/µl) of cattle and buffaloes during different seasons

Breed/ Species	Stage	Time	Seasons			
			Spring	Winter	Hot Humid	Summer
Tharparkar	Growing	Morning	11954±492^{ax}	11532±412^{bx}	10786±288^{cx}	11414±495^{bx}
		Afternoon	11446±502^{ay}	10912±347^{by}	10258±312^{cy}	10376±309^{ay}
	Adult	Morning	11255±554^{ax}	11095±397^{ax}	10933±861^{cx}	11920±344^{dx}
		Afternoon	10762±550^{ay}	10805±349^{ay}	10575±791^{cy}	11151±408^{dy}
Sahiwal	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}
Karan Fries	Growing	Morning	12880±584^{ax}	12992±535^{bx}	11126±434^{cx}	13554±287^{dx}
		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}
Murrah	Growing	Morning	13944±547^{ax}	13808±548^{ax}	11517±595^{bx}	13372±207^{cx}
		Afternoon	11558±523^{ay}	11917±423^{by}	10625±545^{cy}	12393±277^{dy}
	Adult	Morning	12774±539^{ax}	11906±301^{bx}	12383±595^{cx}	10253±162^{dx}
		Afternoon	11665±319^{ay}	11343±367^{by}	10223±594^{cy}	10249±31^{cx}

- *The values are the mean and SEM of six values on six animals*
- *The values with the different superscript in the same row (a, b, c and d) and column (x and y) differed significantly ($P<0.05$). (CD value for seasons=282, Time interval =199.68)*

Table 3: Red blood cells (million/mm^3) and White blood cells (cells /µl) of cattle and buffaloes during controlled climatic conditions

Breed/ Species	Stage	Treatment	RBC		WBC	
			Temperature			
			42±1^{0}C	44±1^{0}C	42±1^{0}C	44±1^{0}C
Tharparkar	Growing	Before	8.22±0.10^{ax}	8.01±0.08^{bx}	10900.00±374.61^{ax}	10547.00±282.69^{bx}
		After	7.98±0.13^{ay}	7.75±0.09^{by}	9700.00±174.16^{ay}	9601.33±153.72^{by}
	Adult	Before	7.75±0.14^{ax}	7.40±0.10^{bx}	10333.00±200.28^{ax}	10216.00±187.08^{bx}
		After	7.45±0.13^{ay}	8.09±0.11^{by}	9266.67±184.69^{cy}	9216.33±183.94^{cy}
Sahiwal	Growing	Before	8.36±0.16^{ax}	7.74±0.14^{bx}	10866.00±266.04^{ax}	10637.67±180.42^{bx}
		After	7.91±0.14^{ay}	7.31±0.12^{by}	10000.00±241.06^{ay}	9708.00±134.77^{by}
	Adult	Before	7.38±0.07^{ax}	7.04±0.06^{bx}	9933.00±177.33^{ax}	9852.67±220.81^{bx}
		After	7.13±0.10^{ay}	8.25±0.09^{by}	9316.67±352.43^{ay}	9287.00±171.47^{by}
Karan Fries	Growing	Before	8.43±0.30^{ax}	7.49±0.21^{bx}	12966.67±93.69^{ax}	12447.00±498.53^{bx}
		After	7.80±0.38^{ay}	7.49±0.35^{by}	9983.33±201.94^{ay}	9938.33±337.51^{by}
	Adult	Before	7.60±0.06^{ax}	7.50±0.08^{bx}	9866.67±214.32^{ax}	9593.16±412.78^{bx}
		After	6.84±0.04^{ay}	6.74±0.05^{by}	8683.67±324.23^{ay}	8993.16±272.18^{by}
Murrah	Growing	Before	7.55±0.14^{ax}	7.42±0.12^{bx}	16566.67±241.34^{ax}	15614.33±565.57^{bx}
		After	7.05±0.15^{ay}	6.91±0.17^{by}	14583.33±253.23^{ay}	13767.33±700.31^{by}
	Adult	Before	7.04±0.04^{ax}	6.90±0.06^{bx}	9133.00±234.56^{ax}	9072.67±633.58^{bx}
		After	6.22±0.16^{ay}	6.24±0.04^{by}	7383.33±220.10^{ay}	1540.33±236.46^{by}

- *The values are the mean and SEM of six values on six animals*
- *The values with the different superscript in the same row (a, b, c and d) and column (x and y) differed significantly (P<0.05). CD value for cattle, temperature= 0.0383, Treatment = 0.0383 and for buffaloes, temperature and treatment = 0.110) CD value of WBC for cattle, temperature=153.70, Treatment =153.70 and for buffaloes, temperature and treatment=0.110)*

Table 4: Hemoglobin content (gm %) of cattle and buffaloes during different seasons

Breed/ Species	Stage	Time	Seasons			
			Spring	Winter	Hot Humid	Summer
Tharparkar	Growing	Morning	13.01±0.26^{ax}	14.36±0.22^{bx}	12.50±0.44^{cx}	13.29±0.36^{dx}
		Afternoon	12.18±0.53^{ay}	12.72±0.54^{by}	11.18±0.39^{cy}	12.83±0.29^{dy}
	Adult	Morning	13.09±0.10^{ax}	13.57±0.26^{ax}	11.91±0.39^{cx}	14.41±0.48^{dx}
		Afternoon	11.82±0.47^{ay}	12.54±0.25^{by}	10.97±0.37^{cy}	13.54±0.21^{dy}
Sahiwal	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}
Karan Fries	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}
Murrah	Growing	Morning	13.98±0.27^{ax}	14.42±0.25^{bx}	13.18±0.30^{cx}	11.26±0.67^{dx}
		Afternoon	12.45±0.29^{ay}	13.53±0.24^{by}	11.12±0.28^{cy}	10.68±0.56^{dy}
	Adult	Morning	14.45±0.27^{ax}	13.51±0.13^{bx}	13.47±0.37^{cx}	13.47±0.16^{cx}
		Afternoon	12.85±0.19^{ay}	12.95±0.24^{ay}	12.47±0.46^{cy}	12.07±0.15^{dy}

- *The values are the mean and SEM of six values on six animals*
- *The values with the different superscript in the same row (a, b, c and d) and column (x and y) differed significantly ($P<0.05$) (CD value for seasons=0.217, Time interval =0.153)*

Table 5: Packed cell volume (%) of cattle and buffaloes during different seasons

Breed/ Species	Stage	Time	Seasons			
			Spring	Winter	Hot Humid	Summer
Tharparkar	Growing	Morning	37.16±0.75^{ax}	38.83±1.01^{bx}	33.33±0.49^{cx}	36.16±0.31^{dy}
		Afternoon	35.67±0.49^{ay}	37.50±0.92^{ay}	31.83±0.54^{cy}	34.83±0.17^{dx}
	Adult	Morning	37.83±1.40^{ax}	39.16±0.48^{bx}	34.83±0.48^{cx}	40.16±0.40^{dx}
		Afternoon	33.83±0.95^{ay}	37.33±0.56^{by}	33.33±0.61^{cy}	37.67±0.42^{by}
Sahiwal	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}
Karan Fries	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^{ay}	32.00±0.52^{ay}	35.83±0.60^{dy}
	Adult	Morning	35.16±0.65^{ax}	35.83±1.17^{ax}	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}
Murrah	Growing	Morning	35.50±1.09^{ax}	34.83±0.75^{bx}	36.50±0.62^{cx}	36.00±0.97^{cx}
		Afternoon	34.16±0.60^{ay}	32.16±0.79^{by}	33.83±0.83^{cy}	34.33±0.88^{dy}
	Adult	Morning	35.50±0.92^{ax}	36.00±0.73^{bx}	34.67±0.80^{cx}	36.67±0.61^{dx}
		Afternoon	32.83±0.65^{ay}	32.16±0.70^{ay}	33.00±0.82^{cy}	35.16±0.65^{dy}

- *The values are the mean and SEM of six values on six animals*
- *The values with the different superscript in the same row (a, b, c and d) and column (x and y) differed significantly ($P<0.05$) (CD value for seasons=0.435, Time interval =0.307)*

Table 6: Hemoglobin (gm %) and Packed cell volume (%) of cattle and buffaloes during controlled climatic conditions

Breed/ Species	Stage	Treatment	Hb %		PCV	
			Temperature			
			42±1⁰C	44±1⁰C	42±1⁰C	44±1⁰C
Tharparkar	Growing	Before	14.63±0.13^{ax}	14.63±0.13^{ax}	35.67±1.80^{ax}	37.00±0.97^{bx}
		After	11.11±0.64^{ay}	10.88±0.64^{ay}	32.00±1.67^{ay}	33.33±0.76^{by}
	Adult	Before	13.00±0.20^{ax}	13.00±0.20^{ax}	39.00±0.56^{bx}	39.33±0.56^{bx}
		After	12.09±0.19^{ay}	11.70±0.22^{ay}	38.00±0.21^{ay}	37.00±0.37^{by}
Sahiwal	Growing	Before	13.83±0.22^{ax}	13.84±0.22^{ax}	39.67±0.56^{ax}	39.33±0.56^{ax}
		After	13.84±0.29^{ax}	12.74±0.34^{by}	37.00±0.37^{ay}	36.67±0.56^{ay}
	Adult	Before	13.60±0.77^{ax}	13.60±0.77^{ax}	40.67±1.48^{ax}	38.00±0.63^{bx}
		After	12.90±0.74^{ay}	12.46±0.69^{ay}	39.00±0.97^{ay}	36.67±0.56^{by}
Karan Fries	Growing	Before	11.58±0.36^{ax}	11.58±0.36^{ax}	34.00±0.42^{ax}	35.33±0.21^{bx}
		After	9.76±0.38^{ay}	9.43±0.36^{ay}	27.33±0.56^{ay}	32.33±0.56^{by}
	Adult	Before	13.44±0.81^{ax}	13.44±0.81^{ax}	40.33±0.76^{ax}	39.00±0.37^{bx}
		After	12.84±0.65^{ay}	12.36±0.60^{ay}	38.33±0.92^{ay}	36.33±0.42^{by}
Murrah	Growing	Before	15.14±0.78^{ax}	15.14±0.78^{ax}	36.33±1.12^{ax}	37.00±0.73^{ax}
		After	13.81±0.72^{ay}	13.50±0.56^{ay}	35.00±1.32^{ay}	34.67±0.76^{by}
	Adult	Before	14.54±0.20^{ax}	13.54±0.20^{bx}	38.33±1.28^{ax}	39.33±0.56^{bx}
		After	13.67±0.41^{ay}	13.39±0.33^{ax}	37.33±0.56^{ay}	35.67±0.21^{by}

- *The values are the mean and SEM of six values on six animals*
- *The values with the different superscript in the same row (a, b, c and d) and column (x and y) differed significantly (P<0.05). CD value for cattle, temperature = 0.47, Treatment = 0.47 and for buffaloes, temperature and treatment=0.110)*

Table 7: Mean corpuscular volume (fl/cell) content of cattle and buffaloes during different seasons

Breed/ Species	Stage	Time	Seasons			
			Spring	Winter	Hot Humid	Summer
Tharparkar	Growing	Morning	42.47±1.58^{ax}	43.59±1.37^{bx}	38.13±1.62^{cx}	44.94±1.14^{dx}
		Afternoon	43.65±1.06^{ay}	47.40±2.67^{by}	44.08±1.45^{cy}	45.47±0.88^{dy}
	Adult	Morning	44.19±1.79^{ax}	43.56±0.52^{bx}	42.84±1.06^{cx}	52.26±0.79^{dx}
		Afternoon	43.70±1.75^{ay}	43.29±0.65^{ax}	43.51±1.79^{cy}	51.40±1.16^{dy}
Sahiwal	Growing	Morning	45.65±1.10^{ax}	44.98±1.46^{bx}	50.09±1.53^{cx}	43.34±1.41^{dx}
		Afternoon	43.12±0.87^{ay}	43.70±0.84^{ay}	45.35±2.05^{cy}	41.19±1.43^{dy}
	Adult	Morning	43.67±0.75^{ax}	49.61±1.63^{bx}	43.14±1.95^{cx}	50.88±1.68^{dx}
		Afternoon	44.48±0.92^{ay}	45.79±1.86^{by}	42.28±1.77^{cy}	55.11±2.33^{dy}
Karan Fries	Growing	Morning	42.41±0.85^{ax}	42.21±1.07^{ax}	40.42±0.88^{bx}	40.13±0.74^{bx}
		Afternoon	43.04±0.87^{ay}	42.23±1.34^{bx}	42.02±1.46^{cy}	40.65±0.59^{dx}
	Adult	Morning	42.77±0.80^{ax}	43.54±1.51^{bx}	45.81±2.23^{cx}	45.57±2.30^{cx}
		Afternoon	42.31±0.93^{ax}	43.78±1.57^{bx}	47.39±2.09^{cy}	46.98±2.19^{dy}
Murrah	Growing	Morning	42.78±1.05^{ax}	41.18±1.46^{bx}	43.70±1.16^{cx}	43.21±1.32^{cx}
		Afternoon	43.56±1.32^{ay}	39.71±1.30^{by}	38.71±1.05^{cy}	43.06±1.16^{dx}
	Adult	Morning	42.47±0.79^{ax}	42.76±0.88^{ax}	41.92±1.38^{cx}	46.83±1.44^{dx}
		Afternoon	42.08±0.99^{ax}	40.18±1.44^{by}	47.38±3.68^{cy}	48.63±1.01^{dy}

- *The values are the mean and SEM of six values on six animals*
- *The values with the different superscript in the same row (a, b, c and d) and column (x and y) differed significantly ($P<0.05$). (CD value for seasons = 0.769, Time interval =0.543)*

Table 8: Mean corpuscular hemoglobin (pg) content of cattle and buffaloes during different seasons

Breed/ Species	Stage	Time	Seasons			
			Spring	Winter	Hot Humid	Summer
Tharparkar	Growing	Morning	14.86±0.55	16.15±0.57	14.27±0.63	16.46±0.16
		Afternoon	14.86±0.52	16.04±0.89	15.57±1.09	16.73±0.30
	Adult	Morning	15.28±0.22	15.09±0.18	14.64±0.52	18.79±0.82
		Afternoon	15.28±0.51	14.53±0.16	14.33±0.79	18.48±0.48
Sahiwal	Growing	Morning	14.98±0.69	15.96±0.51	15.45±0.38	12.77±0.46
		Afternoon	13.98±0.44	14.24±0.61	14.05±0.84	12.25±0.40
	Adult	Morning	14.93±0.80	16.04±0.54	15.18±0.68	17.72±0.70
		Afternoon	14.02±0.75	15.98±0.71	14.84±0.53	18.56±0.90
Karan Fries	Growing	Morning	12.59±0.59	11.88±0.50	12.24±0.31	15.05±0.35
		Afternoon	11.63±0.46	12.05±0.84	11.73±0.76	14.89±0.44
	Adult	Morning	13.94±0.59	15.13±0.48	14.46±0.63	16.07±0.71
		Afternoon	14.94±0.60	14.67±0.56	14.29±0.64	16.42±0.73
Murrah	Growing	Morning	16.88±0.44	17.04±0.55	15.80±0.58	13.53±0.85
		Afternoon	15.88±0.57	16.73±0.60	12.75±0.50	13.38±0.63
	Adult	Morning	17.08±0.45	16.05±0.19	16.35±0.85	17.22±0.57
		Afternoon	16.48±0.40	16.18±0.54	17.95±1.59	16.71±0.41

• *The values are the mean and SEM of six values on six animals*

Table 9: Mean corpuscular volume (fl) and Mean corpuscular hemoglobin (pg) of cattle and buffaloes during controlled climatic conditions

Breed/ Species	Stage	Treatment	Temperature			
			MCV		MCH	
			42±1⁰C	44±1⁰C	42±1⁰C	44±1⁰C
Tharparkar	Growing	Before	43.50±2.60^{ax}	46.23±1.52^{bx}	17.80±0.08^{ax}	18.27±0.02^{bx}
		After	40.16±2.32^{ay}	43.06±1.41^{by}	13.93±0.82^{ay}	14.07±0.91^{ay}
	Adult	Before	50.85±1.30^{ax}	51.77±1.15^{bx}	16.81±0.43^{ax}	17.11±0.38^{ax}
		After	51.48±0.94^{ay}	50.07±1.11^{by}	16.24±0.42^{ax}	15.83±0.42^{by}
Sahiwal	Growing	Before	47.47±0.33^{ax}	48.63±0.31^{bx}	16.57±0.15^{ax}	17.12±0.19^{bx}
		After	46.82±0.65^{ax}	47.33±0.01^{by}	16.62±0.26^{ax}	16.44±0.28^{ay}
	Adult	Before	55.12±2.05^{ax}	51.98±0.99^{bx}	18.41±0.99^{ax}	18.59±1.02^{ax}
		After	54.75±1.75^{ax}	52.10±1.08^{bx}	18.13±1.13^{ax}	17.71±1.04^{by}
Karan Fries	Growing	Before	40.89±1.04^{ax}	42.95±1.30^{bx}	13.76±0.31^{ax}	14.03±0.28^{bx}
		After	35.37±1.63^{ay}	43.77±2.69^{by}	12.54±0.15^{ay}	12.61±0.14^{ay}
	Adult	Before	53.11±1.29^{ax}	52.01±0.81^{bx}	17.68±1.04^{ax}	17.90±1.03^{ax}
		After	56.01±1.04^{ay}	53.85±0.45^{by}	18.75±0.84^{ay}	18.30±0.76^{ay}
Murrah	Growing	Before	48.13±1.29^{ax}	49.83±0.81^{bx}	20.05±0.76^{ax}	20.34±0.79^{ax}
		After	49.58±1.06^{ay}	50.20±0.65^{by}	19.53±0.61^{ay}	19.61±0.32^{ay}
	Adult	Before	54.51±2.15^{ax}	57.02±1.27^{bx}	20.67±0.34^{ax}	21.08±0.38^{bx}
		After	60.09±1.31^{ay}	57.13±0.27^{by}	21.97±0.60^{ay}	21.45±0.53^{ay}

- *The values are the mean and SEM of six values on six animals*
- *The values with the different superscript in the same row (a, b, c and d) and column (x and y) differed significantly (P<0.05). (CD value for cattle, temperature = 0.739,Treatment = 0.739 and for buffaloes, temperature and treatment = 1.106) MCH 0.344. MCH 0.514*

Table 10: Mean corpuscular hemoglobin concentration (%) of cattle and buffaloes during different seasons

Breed/ Species	Stage	Time	Seasons			
			Spring	Winter	Hot Humid	Summer
Tharparkar	Growing	Morning	35.03±0.69	37.15±1.37	37.53±1.34	36.78±1.18
		Afternoon	34.16±1.45	33.89±0.88	35.20±1.54	36.85±0.90
	Adult	Morning	34.85±1.47	34.67±0.59	34.18±0.96	35.92±1.36
		Afternoon	35.22±2.19	33.61±0.65	32.90±0.87	35.98±0.68
Sahiwal	Growing	Morning	32.84±1.36	35.60±1.26	31.02±1.29	30.23±1.03
		Afternoon	32.42±0.87	32.65±1.55	30.90±0.77	29.77±0.47
	Adult	Morning	34.29±2.10	32.37±0.70	35.34±1.45	34.81±0.56
		Afternoon	31.47±1.30	35.06±1.61	35.54±2.46	33.67±0.83
Karan Fries	Growing	Morning	29.74±1.45	28.17±1.44	30.32±0.77	37.56±1.01
		Afternoon	27.11±1.28	28.51±1.60	27.78±0.89	36.65±1.07
	Adult	Morning	32.74±1.81	34.82±0.78	31.77±1.50	25.35±0.48
		Afternoon	35.25±1.98	33.64±1.45	30.18±0.58	35.00±0.47
Murrah	Growing	Morning	39.56±1.35	41.48±1.11	36.20±1.27	31.23±1.42
		Afternoon	36.47±0.71	42.20±1.32	32.98±1.19	31.11±1.45
	Adult	Morning	40.33±1.59	37.62±0.94	38.95±1.25	36.77±0.67
		Afternoon	39.20±0.87	40.34±1.00	37.85±1.28	34.39±0.82

• *The values are the mean and SEM of six values on six animals*

Table 11: Mean corpuscular hemoglobin concentration (%) of cattle and buffaloes during controlled climatic conditions

Breed/ Species	Stage	Treatment	Temperature	
			42±1⁰C	44±1⁰C
Tharparkar	Growing	Before	41.61±2.50	39.73±1.32
		After	34.73±0.94	32.52±1.32
	Adult	Before	33.06±0.05	33.06±0.05
		After	31.56±0.67	31.65±0.82
Sahiwal	Growing	Before	34.91±0.37	35.20±0.19
		After	35.54±0.88	34.73±0.59
	Adult	Before	33.32±0.85	35.67±1.51
		After	32.95±1.12	33.87±1.39
Karan Fries	Growing	Before	33.70±0.64	32.82±1.19
		After	35.80±1.55	29.30±1.58
	Adult	Before	33.24±1.55	34.39±1.76
		After	33.41±0.87	33.99±1.40
Murrah	Growing	Before	41.90±2.59	40.98±2.15
		After	39.37±0.70	39.11±0.98
	Adult	Before	38.11±1.10	37.02±0.81
		After	36.59±0.97	37.53±0.76

- *The values are the mean and SEM of six values on six animals*

Table 12: Haematological parameters of various breeds of buffaloes under normal condition

Parameters	Nili-Ravi (Nabha)	Murrah (Karnal)	Murrah (Hissar)	Surti (Navsari)
WBC ($x10^3$/µl)	16.613±3.96	10.8±2.35	16.05±3.09	9.80±0.54
RBC ($x10^6$/µl)	8.101±2.61	7.930±1.07	8.935±1.27	8.36±0.64
Hb (g/dl)	11.112±3.41	10.911±2.46	11.461±1.10	10.13±0.87
HCT (%)	38.694±11.81	37.96±3.02	41.257±4.31	31.32±3.90
MCV (fl)	45.312±12.91	47.25±5.91	47.35±3.20	35.60±0.90
MCH (pg)	12.956±3.61	13.00±0.42	13.228±.351	13.53±0.74
MCHC (g/dl)	26.9±7.23	30.433±0.74	28.142±1.175	38.35±1.22
RDWC (%)	26.9±7.23	15.087±0.86	21.657±1.01	22.68±0.57
PLT ($x10^3$/µl)	263.87±106.86	242.07±67.80	285.63±156.69	446.67±64.68
MPV (fl)	9.8±2.79	6.50±0.46	10.114±1.16	6.50±0.15

The aforementioned data suggests that RBCs showed higher values in Tharparkar cattle during all seasons; but maximum increase in RBCs was found during winter season among different breeds of cattle. The mean values of RBCs of growing and adult Tharparkar cattle during morning were higher compared to afternoon; further, growing cattle and buffaloes showed higher values of RBCs during all seasons as compared to adults. Moreover, WBCs showed higher values in KF cattle during different seasons; but maximum increase of WBCs was found during winter season among different breeds of cattle. Growing cattle and buffaloes showed higher values of WBCs during different seasons as compared to adults.

PCV was higher in Tharparkar cattle during different seasons but maximum increase in PCV was found during winter season among different breeds of cattle. Hb concentration was higher in Tharparkar cattle during different seasons but maximum increase in Hb was found in winter season among different breeds of cattle. Growing cattle and buffaloes showed higher values of Hb compared to adults during different seasons.

4. Biochemical Parameters

4.1 Alkaline Phosphatase

ALP is an enzyme synthesized in the liver, bone and placenta. It is normally present in higher concentrations in growing bone and bile fluid. It is released into the blood stream during injury and during activities like bone growth and pregnancy. Abnormally high levels of ALP in blood may indicate diseased status of the bone or liver, or bile duct obstruction, or certain malignancies. Infact, a significant reduction in ALP activity with increased rectal temperature in heat exposed calves has been reported (O'kelly, 1973).

4.2 Aspartate Aminotransferase and Alanine Aminotransferase

Aspartate Aminotransferase (AST) formally known as Glutamic Oxaloacetic Transaminase (GOT) basically transfers the amino group from aspartate to α-ketoglutaric acid forming glutamate and oxaloacetate. In ruminants, AST enzymes are present in many tissues, particularly liver, striated and cardiac muscle, thus making it a good marker of soft tissue damage (Otto et al., 2000). Jenkins et al. (1982) reported normal levels of this enzyme in calves and mature bovines. Alanine Aminotransferase (ALT) also known as Glutamate-Pyruvate Transaminase or Glutamic Pyruvic Transaminase (GPT) basically catalyzes the two parts of the alanine cycle. It is found in the liver, plasma and various body tissues, with most common abundance in the liver. Serum ALT level, or serum AST level, and/or their ratio (AST/ALT ratio) are commonly measured clinically as biomarkers for liver health. Piccioni et al. (2010) reported a significant effect of days of life on GOT levels but not on GPT during the first week or first month of life.

During artificial heat stress or during summer season, an increment in the levels of transaminase enzyme activities has been observed; albeit, water sprinkling restores their levels (Marai et al., 1995). High ambient temperatures significantly enhanced AST and ALT activities (Boots et al., 1970) even in exotic crosses (Singh and Bhattacharyya, 1984). On the contrary, Ronchi et al. (1999) and Srikandalkumar and Johnson (2004) reported decline in hepatic enzyme activities during heat exposition. This decrease in enzyme activities is suggested due to the slowdown of the function and not due to damage of liver.

In Avikalin sheep, higher values of AST has been reported compared to Malpura, this could be attributed to greater influence of heat stress in different breeds (Naqvi et al., 1991). The increase in the activities of AST and ALT in serum/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 functions (Shakoori et al., 1994).

Although AST activity was not significantly affected by the season, however the AST/ALT ratio was significantly ($P<0.01$) increased during summer compared to spring. This ratio indicates the state of aspartate to alanine synthesis in the liver as reported by Okab et al. (2008). The AST and ALT are dependent on the amino acid groups of alanine and glutamine taken up by the liver and reflect the changes in the liver metabolism associated with glucose synthesis (El-Maghawry et al., 2000).

4.3 Lactate Dehydrogenase

LDH is a cytoplasmic enzyme that converts pyruvic acid into lactic acid. The activity of this enzyme has been correlated with cellular damage (Cavallina et al., 2003).

LDH is a terminal enzyme of anaerobic glycolysis, therefore, being of crucial importance to the muscular physiology, particularly in conditions of chemical stress, when high levels of energy may be required in a short period of time (De Coen et al., 2001). Biochemical and molecular parameters that are specific and sensitive may be useful for identifying doses below which increase in biomarkers are not statistically significant (Andersen and Barton, 1998). Interspecies differences in the activity of LDH have been reported which may be due to physiological factors, such as age, sex, etc.

4.4 Acetylcholinesterase

AChE is an enzyme that degrades (through its hydrolytic activity) the neurotransmitter acetylcholine, producing choline and an acetate group. It is mainly found at neuromuscular junctions and cholinergic nervous system, where its activity serves to terminate synaptic transmission. AChE has a very high catalytic activity i.e. each molecule of AChE degrades about 25000 molecules of acetylcholine per second. The choline produced by the action of AChE is recycled, it is transported through reuptake and back into nerve terminals where it is used to synthesize new acetylcholine molecules. AChE is also found in the

RBCs membrane, where it constitutes the blood group antigen. AChE exists in multiple molecular forms, which possess similar catalytic properties, but differ in their oligomeric assembly and mode of attachment to the cell surface.

Cholinesterase activity is varied among species of animals, and even within the same species, depending on the differences in the age, gender, reproductive status, climate and seasonal status of the individual (Munro et al., 1991). The level of AChE and pseudocholinesterase in animal blood can be used to determine exposure and risk of toxicity. Less literatures are available on AChE on large domestic animals, therefore, the information gathered on various breeds of cattle and buffalo species are presented in this bulletin. Lewandowski, (1988) reported AChE activity in mouse brain stem reticular formation at four different times of the year under normal (LD 12/12) and constant light regime. Under both illumination regimes, a significant ultradian rhythm of AChE activity was observed. In the investigated seasons of the year, changes in AChE behaviour were limited to mean activity of the enzyme (median) as well as to the amplitude and acrophase of the rhythm. Lewandowski also reported annual course of AChE and locomotor activity in the mouse brain and concluded that locomotor activity and AChE activity are changed by the time of the year. Amongst biochemical markers, the measurement of fish cholinesterase activities has become a classical tool for biomonitoring pollution in marine and continental waters. Other factors like pollutants and stress can alter AChE activity as well, whereas an 8-fold increase in AChE mRNA levels under exposure to anticholinesterasic compounds and a 2-fold increase by psychological stress were reported in brain of animal.

4.5 Cortisol

Plasma cortisol concentrations have been used as a physiological marker of stress. In most animals, cortisol is the primary glucocorticoid secreted by the zona fasciculata of the adrenal cortex and is released within minutes after the exposure to some stressful situations. The main function of cortisol is to mobilize energy reserves to promote hyperglycemia by stimulating hepatic gluconeogenesis and reducing cellular glucose uptake. Under acute stress situations, cortisol allows an individual to respond to stressors by supporting energy mobilization; Christinson and Johnson (1972) observed that moderate heat stress (35^0C) increases the plasma cortisol levels. During heat acclimation, there is reduction of plasma cortisol that helps the animals in reducing the heat production (Yousef and Johnson 1967, Stott and Wiersma 1971). There

is an initial increment in cortisol hormone due to acute heat stress which is followed by a decline after prolonged exposure to stressors. Neuwirth et al. (1979) observed that male HF calves responded with increased cortisol level only about at 32.2^{0}C and 60% RH. According to Purchas et al. (1980) there was positive correlation between plasma cortisol level and growth rate in Angus steers, but in case of Hereford steers, the correlation was negative signifying breed effect. A negative correlation of cortisol with body weight in growing KF cattle has been reported. Further, it has also been reported that plasma cortisol levels during afternoon (2 PM) tended to be lower than that during morning (8 AM) in spite of the increased RT and RR during afternoon (2 PM) showing that heat load on the buffaloes was high enough to cause stress (Gudev et al., 2004). A significant increase in cortisol levels at 42^{0}C compared to 23^{0}C in Zebu cattle has been reported, however, in crossbred cattle the increment was not significant.

Table 13: Plasma Alkaline Phosphatase (KA unit) of cattle and buffaloes during different seasons

Breed/ Species	Stage	Time	Seasons			
			Spring	Winter	Hot Humid	Summer
Tharparkar	Growing	Morning	9.68±0.50^{ax}	10.39±0.41^{bx}	23.70±2.96^{cx}	29.02±1.61^{dx}
		Afternoon	11.28±0.64^{ay}	13.95±1.51^{by}	32.01±3.48^{cy}	29.58±0.50^{dy}
	Adult	Morning	7.00±0.37^{ax}	13.36±0.54^{bx}	23.98±0.76^{cx}	28.65±0.77^{dx}
		Afternoon	11.33±0.71^{ay}	13.70±0.64^{bx}	28.77±0.51^{cy}	29.68±1.02^{dy}
Sahiwal	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^{ax}	21.89±0.54^{cx}	24.68±0.21^{dx}
		Afternoon	13.11±1.25^{ay}	13.95±1.51^{ay}	27.83±0.46^{cy}	27.61±0.23^{cy}
Karan Fries	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^{cy}
	Adult	Morning	8.55±0.51^{ax}	8.57±0.08^{ax}	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}
Murrah	Growing	Morning	10.56±0.74^{ax}	9.31±0.54^{bx}	28.33±0.91^{cx}	25.91±0.20^{dx}
		Afternoon	11.85±0.89^{ay}	11.50±0.50^{ay}	30.05±0.61^{cy}	28.52±0.34^{dy}
	Adult	Morning	8.90±0.64^{ax}	10.42±0.11^{bx}	26.32±0.59^{cx}	24.42±0.21^{dx}
		Afternoon	10.93±0.53^{ay}	12.09±0.73^{by}	28.79±0.55^{cy}	26.86±0.37^{dy}

- *The values are the mean and SEM of six values on six animals*
- *The values with the different superscript in the same row (a, b, c and d) and column (x and y) differed significantly ($P<0.05$). (CD value for seasons = 0.513, Time interval =0.363)*

Table 14: Plasma Alkaline Phosphatase (KA unit) of cattle and buffaloes during controlled climatic conditions

Breed/ Species	Stage	Treatment	Temperature	
			42±1^{0}C	44±1^{0}C
Tharparkar	Growing	Before	29.02±1.61^{ax}	27.21±0.30^{bx}
		After	29.58±0.50^{ax}	32.69±0.53^{by}
	Adult	Before	29.68±0.77^{ax}	30.00±0.27^{ax}
		After	28.65±1.02^{ay}	32.67±0.50^{by}
Sahiwal	Growing	Before	25.69±0.21^{ax}	25.69±0.21^{ax}
		After	28.95±0.21^{ay}	32.15±0.26^{by}
	Adult	Before	24.68±0.21^{ax}	24.68±0.21^{ax}
		After	27.61±0.23^{ay}	30.56±0.29^{by}
Karan Fries	Growing	Before	23.26±0.64^{ax}	23.26±0.64^{ax}
		After	25.42±0.39^{ay}	28.75±0.59^{by}
	Adult	Before	23.27±0.14^{ax}	23.27±0.14^{ax}
		After	26.21±0.15^{ay}	28.97±0.60^{by}
Murrah	Growing	Before	25.91±0.20^{ax}	25.91±0.20^{ax}
		After	28.52±0.34^{ay}	31.63±0.49^{by}
	Adult	Before	24.42±0.21^{ax}	24.42±0.21^{ax}
		After	26.86±0.37^{ay}	29.61±0.37^{by}

- *The values are the mean and SEM of six values on six animals*
- *The values with the different superscript in the same row (a, b, c and d) and column (x and y) differed significantly (P<0.05). (CD value for cattle, temperature=0.289, Treatment = 0.289 and for buffaloes, temperature and treatment=0.287)*

Table 15: Plasma Alanine amino transferase (IU/L) of cattle and buffaloes during different seasons

Breed/ Species	Stage	Time	Seasons			
			Spring	Winter	Hot Humid	Summer
Tharparkar	Growing	Morning	26.05±0.09^{ax}	30.42±0.34^{bx}	46.48±2.70^{cx}	58.77±1.02^{dx}
		Afternoon	29.42±0.17^{ay}	34.23±0.33^{by}	46.44±1.32^{cx}	68.68±0.27^{dy}
	Adult	Morning	27.42±0.17^{ax}	33.86±0.73^{bx}	48.20±1.24^{cx}	54.63±0.88^{dx}
		Afternoon	29.52±0.38^{ay}	37.42±0.78^{by}	61.64±1.91^{cy}	64.26±0.83^{dy}
Sahiwal	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}
Karan Fries	Growing	Morning	22.55±0.24^{ax}	28.56±0.38^{bx}	53.58±1.77^{cx}	53.37±0.67^{cx}
		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}
Murrah	Growing	Morning	25.10±0.28^{ax}	33.65±0.29^{bx}	55.02±2.75^{cx}	60.01±0.65^{dx}
		Afternoon	27.97±0.22^{ay}	36.90±0.30^{by}	65.04±3.51^{cy}	68.18±0.30^{dy}
	Adult	Morning	24.32±0.14^{ax}	34.82±0.16^{bx}	50.85±3.56^{cx}	54.31±0.69^{dx}
		Afternoon	27.83±0.18^{ay}	37.16±0.11^{by}	60.77±3.31^{cy}	62.52±1.00^{dy}

- *The values are the mean and SEM of six values on six animals*
- *The values with the different superscript in the same row (a, b, c and d) and column (x and y) differed significantly (P<0.05). (CD value for seasons=0.917, Time interval =0.648)*

Table 16: Plasma Alanine Amino Transferase (IU/L) of cattle and buffaloes during controlled climatic conditions

Breed/ Species	Stage	Treatment	Temperature	
			42±1^{0}C	44±1^{0}C
Tharparkar	Growing	Before	51.86±1.29^{ax}	49.77±1.29^{bx}
		After	44.4±1.29^{ay}	51.86±0.93^{by}
	Adult	Before	40.37±1.42^{ax}	36.51±1.42^{bx}
		After	28.26±2.27^{ay}	40.37±2.22^{by}
Sahiwal	Growing	Before	62.11±1.42^{ax}	62.11±1.42^{ax}
		After	54.34±1.37^{ay}	61.34±1.04^{by}
	Adult	Before	41.61±1.09^{ax}	41.61±1.09^{ax}
		After	35.71±0.52^{ay}	42.37±0.90^{by}
Karan Fries	Growing	Before	68.32±4.25^{ax}	48.64±2.77^{bx}
		After	47.82±2.08^{ay}	52.93±2.23^{by}
	Adult	Before	36.95±2.46^{ax}	34.65±1.01^{bx}
		After	32.29±0.71^{ay}	37.67±0.56^{by}
Murrah	Growing	Before	62.42±1.80^{ax}	48.76±3.46^{bx}
		After	53.72±1.04^{ay}	50.09±3.72^{by}
	Adult	Before	30.43±0.20^{ax}	30.43±0.20^{ax}
		After	23.91±0.71^{ay}	36.31±0.38^{by}

- *The values are the mean and SEM of six values on six animals*
- *The values with the different superscript in the same row (a, b, c and d) and column (x and y) differed significantly (P<0.05). (CD value for cattle, temperature = 0.915, Treatment = 0.915 and for buffaloes, temperature and treatment = 1.78)*

Table 17: Plasma Aspartate amino transferase level (IU/L) of cattle and buffaloes during different seasons

Breed/ Species	Stage	Time	Seasons			
			Spring	Winter	Hot Humid	Summer
Tharparkar	Growing	Morning	43.83±1.80^{ax}	63.69±3.88^{bx}	107.58±2.65^{cx}	154.14±7.23^{dx}
		Afternoon	52.42±1.97^{ay}	69.40±4.42^{by}	101.95±12.56^{cy}	166.25±7.62^{dy}
	Adult	Morning	35.33±1.38^{ax}	55.75±1.37^{bx}	77.65±2.42^{cx}	138.64±7.73^{dx}
		Afternoon	43.26±1.24^{ay}	62.06±1.82^{by}	86.23±1.67^{cy}	167.68±2.70^{dy}
Sahiwal	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}
Karan Fries	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}
Murrah	Growing	Morning	51.18±2.40^{ax}	43.29±1.82^{bx}	112.99±3.33^{cx}	218.50±8.48^{dx}
		Afternoon	61.57±0.90^{ay}	54.01±2.10^{by}	129.73±5.46^{cy}	256.79±10.17^{dy}
	Adult	Morning	53.06±0.61^{ax}	47.52±2.05^{bx}	118.36±4.75^{cx}	200.98±7.67^{dx}
		Afternoon	64.28±1.63^{ay}	60.46±1.89^{by}	138.39±3.12^{cy}	252.34±1.60^{dy}

- *The values are the mean and SEM of six values on six animals*
- *The values with the different superscript in the same row (a, b, c and d) and column (x and y) differed significantly ($P<0.05$). (CD value for seasons = 2.47, Time interval =1.74)*

Table 18: Plasma Aspartate Amino Transferase (IU/L) of cattle and buffaloes during controlled climatic conditions

Breed/ Species	Stage	Treatment	Temperature	
			42±1⁰C	44±1⁰C
Tharparkar	Growing	Before	126.15±3.15^{ax}	121.55±2.39^{bx}
		After	143.68±1.85^{ay}	142.55±1.99^{ay}
	Adult	Before	127.15±3.91^{ax}	129.25±2.13^{ax}
		After	163.43±9.24^{ay}	164.63±9.55^{ay}
Sahiwal	Growing	Before	81.04±7.89^{ax}	81.04±7.89^{ax}
		After	132.13±7.51^{ay}	142.96±3.62^{by}
	Adult	Before	83.42±2.77^{ax}	83.42±2.77^{ax}
		After	98.26±4.89^{ay}	116.87±0.96^{by}
Karan Fries	Growing	Before	40.59±6.27^{ax}	67.74±3.01^{by}
		After	136.64±2.36^{ay}	141.21±2.58^{by}
	Adult	Before	76.59±4.27^{ax}	76.59±4.27^{ax}
		After	124.09±9.90^{ay}	131.59±8.10^{by}
Murrah	Growing	Before	97.77±11.17^{ax}	82.72±2.27^{bx}
		After	211.78±17.90^{ay}	173.07±9.27^{by}
	Adult	Before	151.70±17.74^{ax}	91.15±9.15^{bx}
		After	190.89±12.61^{ay}	148.92±14.51^{by}

- *The values are the mean and SEM of six values on six animals*
- *The values with the different superscript in the same row (a, b, c and d) and column (x and y) differed significantly ($P<0.05$). (CD value for cattle, temperature = 2.763, Treatment = 2.763 and for buffalo, temperature and treatment = 11.57)*

Table 19: Plasma Lactate dehydrogenase level (IU/L) of cattle and buffaloes during controlled climatic conditions

Breed/ Species	Stage	Time	Seasons			
			Spring	Winter	Hot Humid	Summer
Tharparkar	Growing	Morning	235.00±8.69^{ax}	344.86±32.29^{bx}	339.67±10.13^{cx}	412.93±19.12^{dx}
		Afternoon	295.55±4.40^{ay}	389.97±45.32^{by}	371.93±6.99^{cy}	474.60±7.4^{9dy}
	Adult	Morning	210.76±13.00^{ax}	209.31±23.72^{ax}	294.53±14.01^{cx}	408.67±16.42^{dx}
		Afternoon	250.97±1.98^{ay}	294.12±36.57^{by}	342.46±26.38^{cy}	451.00±14.99^{dy}
Sahiwal	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}
Karan Fries	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}
Murrah	Growing	Morning	238.88±9.16^{ax}	412.98±24.91^{bx}	303.05±19.12^{cx}	423.13±21.55^{dx}
		Afternoon	307.98±2.56^{ay}	389.37±13.44^{by}	394.60±7.49^{cy}	417.20±9.90^{dy}
	Adult	Morning	217.84±9.23^{ax}	418.88±32.59^{bx}	302.00±16.42^{cx}	383.52±9.49^{dx}
		Afternoon	236.52±18.58^{ay}	278.01±10.37^{by}	344.40±14.99^{cy}	474.46±19.53^{dy}

- *The values are the mean and SEM of six values on six animals*
- *The values with the different superscript in the same row (a, b, c and d) and column (x and y) differed significantly ($P<0.05$). (CD value for seasons = 11.55, Time interval = 8.16)*

Table 20: Plasma Lactate dehydrogenase level (IU/L) of cattle and buffaloes during controlled climatic conditions

Breed/ Species	Stage	Treatment	Temperature	
			42±1^{0}C	44±1^{0}C
Tharparkar	Growing	Before	394.65±19.23^{ax}	394.65±19.23^{ax}
		After	459.30±20.74^{ay}	473.57±16.25^{by}
	Adult	Before	171.97±21.79^{ax}	248.24±5.81^{bx}
		After	388.81±6.95^{ay}	450.71±19.53^{by}
Sahiwal	Growing	Before	356.94±10.04^{ax}	356.94±10.04^{ax}
		After	387.39±4.02^{ay}	402.45±6.78^{by}
	Adult	Before	285.71±48.69^{ax}	268.01±52.01^{bx}
		After	397.50±13.54^{ay}	404.38±15.72^{ay}
Karan Fries	Growing	Before	368.47±8.39^{ax}	368.47±8.39^{ax}
		After	400.97±4.93^{ay}	425.88±2.91^{by}
	Adult	Before	417.15±2.23^{ax}	417.15±2.23^{ax}
		After	501.52±18.34^{ay}	520.27±15.14^{by}
Murrah	Growing	Before	404.58±14.52^{ax}	404.58±14.52^{ax}
		After	441.31±12.49^{ay}	460.69±10.95^{by}
	Adult	Before	194.32±28.26^{ax}	229.69±4.06^{bx}
		After	372.15±11.70^{ay}	404.61±10.57^{by}

- *The values are the mean and SEM of six values on six animals*
- *The values with the different superscript in the same row (a, b, c and d) and column (x and y) differed significantly (P<0.05). (CD value for cattle, temperature = 10.07, Treatment = 10.07 and for buffaloes, temperature and treatment = 13.45)*

Table 21: Plasma Acetylcholine esterase level (IU/L) of cattle and buffaloes during different seasons

Breed/ Species	Stage	Time	Seasons			
			Spring	Winter	Hot Humid	Summer
Tharparkar	Growing	Morning	537.97±13.02^{ax}	625.62±26.30^{bx}	425.73±29.64^{cx}	759.29±2.18^{dx}
		Afternoon	673.97±6.58^{ay}	662.06±30.04^{by}	451.39±11.62^{cy}	770.56±4.22^{dy}
	Adult	Morning	458.51±3.14^{ax}	718.84±31.29^{bx}	208.26±30.43^{cx}	724.44±2.88^{dx}
		Afternoon	513.29±16.36^{ay}	799.84±46.51^{by}	266.35±27.88^{cy}	738.06±2.08^{dy}
Sahiwal	Growing	Morning	456.50±46.44^{ax}	687.00±28.26^{bx}	361.11±39.04^{cx}	737.78±2.64^{dx}
		Afternoon	561.77±40.04^{ay}	723.76±28.89^{by}	409.72±51.78^{cy}	753.73±3.73^{dy}
	Adult	Morning	529.20±12.38^{ax}	693.67±22.21^{bx}	277.77±11.62^{cx}	709.14±4.97^{dx}
		Afternoon	613.67±13.00^{ay}	809.11±50.22^{by}	325.31±12.55^{cy}	723.23±4.73^{dy}
Karan Fries	Growing	Morning	468.04±46.80^{ax}	675.55±46.94^{bx}	416.67±7.61^{cx}	704.14±3.53^{dx}
		Afternoon	681.21±48.35^{ay}	807.72±49.52^{by}	462.58±24.29^{cy}	716.18±1.28^{dy}
	Adult	Morning	567.42±48.85^{ax}	486.65±27.44^{bx}	238.21±7.45^{cx}	686.35±6.38^{dx}
		Afternoon	637.96±60.74^{ay}	593.96±21.58^{by}	279.25±16.79^{cy}	702.02±3.21^{dy}
Murrah	Growing	Morning	547.37±35.14^{ax}	687.00±31.11^{bx}	472.22±56.07^{cx}	749.56±2.54^{dx}
		Afternoon	573.43±57.31^{ay}	816.91±21.54^{by}	546.96±44.37^{cy}	769.48±4.81^{dy}
	Adult	Morning	502.65±28.67^{ax}	633.33±30.61^{bx}	346.40±38.92^{cx}	722.43±0.39^{dx}
		Afternoon	568.30±12.09^{ay}	673.82±26.49^{by}	428.68±44.18^{cy}	734.77±1.62^{dy}

- *The values are the mean and SEM of six values on six animal*
- *The values with the different superscript in the same row (a, b, c and d) and column (x and y) differed significantly ($P<0.05$). (CD value for seasons=14.88, Time interval =10.52)*

Table 22: Plasma Acetylecholinesterase level (IU/L) of cattle and buffaloes during controlled climatic conditions

Breed/ Species	Stage	Treatment	Temperature	
			42±1^{0}C	44±1^{0}C
Tharparkar	Growing	Before	343.50±17.96^{ax}	376.00±30.04^{bx}
		After	457.45±31.16^{ay}	539.09±45.82^{by}
	Adult	Before	420.11±36.07^{ax}	267.36±14.40^{bx}
		After	458.45±44.92^{ay}	527.91±11.57^{by}
Sahiwal	Growing	Before	424.29±29.37^{ax}	424.29±29.37^{ax}
		After	523.27±15.39^{ay}	553.05±13.22^{by}
	Adult	Before	405.49±14.48^{ax}	421.31±20.44^{bx}
		After	473.40±10.48^{ay}	523.19±15.57^{by}
Karan Fries	Growing	Before	236.52±46.44^{ax}	317.74±35.99^{bx}
		After	440.31±22.29^{ay}	510.12±23.97^{by}
	Adult	Before	500.75±71.34^{ax}	422.20±18.43^{bx}
		After	518.39±23.43^{ay}	529.68±24.38^{ay}
Murrah	Growing	Before	405.69±18.40^{ax}	471.19±3.90^{bx}
		After	473.44±11.25^{ay}	605.55±19.44^{by}
	Adult	Before	395.16±7.61^{ax}	432.09±6.63^{bx}
		After	503.22±20.80^{ay}	561.77±15.84^{by}

- *The values are the mean and SEM of six values on six animals*
- *The values with the different superscript in the same row (a, b, c and d) and column (x and y) differed significantly (P<0.05). (CD value for cattle, temperature=15.91, Treatment = 15.91 and for buffaloes, temperature and treatment=12.99)*

Table 23: Plasma Cortisol level (ng/ml) of cattle and buffaloes during different seasons

Breed/ Species	Stage	Time	Seasons			
			Spring	Winter	Hot Humid	Summer
Tharparkar	Growing	Morning	1.14 ± 0.04^{ax}	1.88 ± 0.08^{bx}	4.43 ± 0.18^{cx}	11.20 ± 0.54^{dx}
		Afternoon	1.30 ± 0.04^{ay}	2.06 ± 0.05^{by}	4.53 ± 0.18^{cx}	11.42 ± 0.67^{dx}
	Adult	Morning	1.75 ± 0.03^{ax}	2.15 ± 0.05^{bx}	3.89 ± 0.10^{cx}	9.62 ± 0.29^{dx}
		Afternoon	2.18 ± 0.04^{ay}	3.04 ± 0.19^{by}	4.42 ± 0.05^{cy}	12.91 ± 0.07^{dy}
Sahiwal	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^{cx}	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^{ax}	2.89 ± 0.12^{bx}	4.58 ± 0.18^{cx}	12.70 ± 0.28^{dx}
Karan Fries	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^{cx}	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^{cx}	12.74 ± 1.14^{dy}
Murrah	Growing	Morning	1.42 ± 0.07^{ax}	2.06 ± 0.07^{bx}	3.76 ± 0.18^{cx}	10.58 ± 0.24^{dx}
		Afternoon	1.78 ± 0.12^{ay}	2.77 ± 0.02^{bx}	4.23 ± 0.21^{cy}	13.81 ± 0.21^{dy}
	Adult	Morning	1.92 ± 0.13^{ax}	3.10 ± 0.15^{bx}	4.11 ± 0.48^{cx}	11.23 ± 0.53^{dx}
		Afternoon	2.26 ± 0.10^{ay}	2.62 ± 0.30^{by}	4.71 ± 0.08^{cy}	11.90 ± 0.36^{dy}

- *The values are the mean and SEM of six values on six animals*
- *The values with the different superscript in the same row (a, b, c and d) and column (x and y) differed significantly ($P<0.05$). (CD value for seasons = 0.199, Time interval = 0.110)*

Table 24: Plasma Cortisol level (ng/ml) of cattle and buffaloes during controlled climatic conditions

Breed/ Species	Stage	Treatment	Temperature	
			42±1^{0}C	44±1^{0}C
Tharparkar	Growing	Before	12.36±0.89^{ax}	11.49±0.23^{bx}
		After	12.80±0.64^{ax}	13.16±0.45^{by}
	Adult	Before	11.98±0.20^{ax}	11.09±0.24^{ax}
		After	12.45±0.28^{ay}	12.65±0.35^{ay}
Sahiwal	Growing	Before	11.93±0.21^{ax}	10.27±0.39^{bx}
		After	13.48±0.28^{ay}	13.49±0.28^{ay}
	Adult	Before	12.15±0.25^{ax}	9.77±0.15^{bx}
		After	13.48±0.06^{ay}	13.48±0.06^{ay}
Karan Fries	Growing	Before	11.37±0.35^{ax}	10.61±0.17^{bx}
		After	13.06±0.41^{ay}	13.49±0.42^{ay}
	Adult	Before	11.39±0.19^{ax}	11.39±0.19^{ax}
		After	13.29±0.16^{ay}	16.29±0.74^{by}
Murrah	Growing	Before	10.56±0.11^{ax}	10.56±0.11^{ax}
		After	11.33±0.28^{ay}	13.95±0.12^{by}
	Adult	Before	11.54±0.26^{ax}	11.31±0.18^{ax}
		After	13.04±0.40^{ay}	14.31±0.14^{by}

- *The values are the mean and SEM of six values on six animals*
- *The values with the different superscript in the same row (a, b, c and d) and column (x and y) differed significantly (P<0.05). (CD value for cattle, temperature = 0.196, Treatment = 0.196 and for buffaloes, temperature and treatment = 0.203)*

Thus, it could be suggested that ALP showed higher values in Tharparkar during different seasons but the magnitude of increase in ALP was during summer season among different breeds of cattle and Murrah buffaloes.

Further, ALT showed higher value in Sahiwal during different seasons but the magnitude of increase in ALT was higher during summer season among different breeds of cattle and Murrah buffaloes. ALT was found significantly higher in afternoon compared to morning in both the species during different seasons and controlled climatic conditions exposures for four hours at 42^0C and 44^0C. Highest levels of ALT (34.95 IU/L) was observed in Murrah buffaloes during summer season as compared to spring (26.3 IU/L) season; whereas lower values (4.41 IU/L) were observed in Sahiwal during winter as compared to spring (29.35 IU/L) season. Whereas, AST showed higher values in Tharparkar during different seasons but the magnitude of increase in AST was higher during summer season among different breeds of cattle and buffaloes. AST was found to be significantly higher in afternoon compared to morning in both groups of cattle and buffaloes; whereas, AST was found significantly higher in growing compared to adult animals. Maximum deviation in AST was observed in Murrah buffaloes in summer season (174.63 IU/L) as compared to spring season (57.52 IU/L) among both the species.

LDH showed higher values in KF cows during different seasons but the magnitude of increase in LDH was higher during summer season among different breeds of cattle and buffaloes. LDH was found significantly higher in afternoon as compared to morning in both the species. The LDH was significantly higher in growing animals compared to adults. Maximum and minimum deviation in LDH was observed in Tharparkar cattle during summer (188 IU/L) and winter (248 IU/L) seasons over spring season.

AChE showed higher value in Sahiwal during different seasons but the magnitude of increase in AchE was highest during summer season among different breeds of cattle and buffalo. Maximum deviation was observed in Tharparkar cattle during summer season 222.12 IU/L compared to spring season 537.43 IU/L among both the species. Lowered deviations in AchE were observed in KF during winter season (325.30 IU/L) compared to spring season (632.23 IU/L).

Plasma cortisol concentration was higher in KF compared to Zebu cattle during different seasons. Further, higher level of cortisol was observed when animals were exposed to temperature of 44^0C in climatic chamber among

different breeds of cattle and buffaloes. Cortisol was found to be significantly higher ($P<0.05$) during afternoon compared to morning in both species. Cortisol was also found significantly higher ($P<0.05$) in adult groups of animals compared to growing awards in both species during different seasons and during controlled climatic chamber at 42^0C and 44^0C, respectively.

5. Conclusion

Seemingly, it could be suggested that

- The haematological parameters (RBC, WBC, PCV, Hb, MCV, MCH and MCHC) were higher during winter season as compared to other season and at 42^0C as compared to 44^0C in all categories of cattle and Murrah buffaloes. The haematological parameters (RBC, WBC, PCV, Hb, MCV, MCH and MCHC) did not show any remarkable difference among forenoon and afternoon values.
- Temperature rise during summer, HH and on exposure to high temperatures (42^0C and 44^0C) in controlled climatic chamber increased activity of ALP, AST, ALT, LDH and cortisol in different breeds of cattle and buffaloes. Compared to spring season, the values were higher during summer and at 44^0C compared to 42^0C. The magnitude of AChE was found to be lower during hot humid season compared to other seasons. The temperature exposure caused a rise in plasma cortisol in zebu, crossbred and buffaloes to different levels, whereas the maximum cortisol level were observed in KF during both climatic exposure conditions and summer season compared to spring season.

It is in general consensus that a complete haematological and biochemical parameters are an important and powerful tools to monitor response to therapy, to gauge the severity of illness, or as a starting point for formulating a list of differential diagnosis which will help in developing the suitable housing system for different breeds of cattle and Murrah buffaloes for sustained productivity by preventing the adverse effects due to temperature variability during different seasons and projected temperature rise due to climate change in future. The study conducted is likely to help as a diagnostic tool, a component of minimum database.

6. References

Andersen, M. E. and Barton, H. A. 1998. The use of biochemical and molecular parameters to estimate dose response relationships at low levels of exposure. Environ. Health Perspect. 106 suppl. 1: 349-355.

Banerjee, D. 2008. Circadian rhythms and oscillations in physiological parameters of Tharparkar and crossbred heifers. M.V.Sc. Thesis submitted to National Dairy Research Institute, Karnal (Haryana), India.

Boots, L. R., Ludwick, T. M. and Rader, E. R. 1970. Plasma glutamic-oxaloacetic and glutamic-pyruvic transaminase activities in lactating Holstein cattle. II. Some effect of environmental temperature, season, body weight and age. J. Dairy Sci. 53: 1587-1591.

Cavallina, R., Alfieri, L. and Lai, O. 2003. Metabolic, endocrine and immune profile in buffalo calves from birth to weaning. Atti Secondo Congresso Nazionale sull' Allevamento del Buffalo. Monterotondo, Roma: 279-283.

Christison, G. I. and Johnson, H. D. 1972. Cortisol turnover in heat stressed cows. J. Anim. Sci. 35: 1005-1010.

De Coen, W. M., Jansen, C. R. and Segner, H. 2001. The use of biomarkers in Daphnia magna toxicity testing V. *In vivo* alternations in the carbohydrate metabolism of Daphnia magna exposed to sublethal concentrations of mercury and lindane. Ecotoxicol. Environ. Saf. 48: 223-234.

Dinev, D. and Khubenov, K. D. 1986. Normal values of the hematological, biochemical and enzymological indices of the donkey. Vet. Med. Nauki. 23: 69-75.

El-Maghawry, A. M., Soliman, M. M., El-Sayiad, G. H. A. and Mahrose, K. H. M. 2000. Effects of breed, season of kindling and pregnancy status on some blood measurements of doe rabbits raised in Egypt. Egypt. J. Rab. Sci. 10: 295-306.

Gudev, D., Ralcheva, S., Moneva, P. and Johnson, H.D. 2004. Endocrine changes in two behavioural types of cows exposed to heat. Bulg. J. Agric. Sci. 10: 629-636.

Jenkins, S. J., Green, S. A. and Clark, P. A. 1982. Clinical chemistry reference values of normal domestic animals in various age groups as determined on the ABA-100. Cornell Vet. 72: 403-415.

Kumar, N. 2010. Studies on temperature threshold for HSP-72 induction in Zebu and crossbred cattle. M.V.Sc. Thesis submitted to National Dairy Research Institute, Karnal (Haryana), India.

Lee, J. A., Roussel, J. D. and Beatty, J. F. 1976. Effect of temperature-season on bovine adrenal cortical function, blood cell profile and milk production. J. Dairy Sci. 59: 104-108

Lewandowski, M. H. 1988. Seasonal variations in the circadian activity of AChE in the brain stem reticular formation of mice under normal and constant light regimens. Chronobiol. Int. 5: 121-25.

Marai, I. F. M., Daader, A. M., Abdel-Samee, A. M. and Ibrahim, H. 1997. Winter and summer effects and their amelioration on lactating Friesian and Holstein cows maintained under Egyptian conditions. Proceedings of the International Conference on Animal, Poultry, Rabbits and Fish Production and Health, Cairo, Egypt.

Marai, I. F. M., Habeeb, A. A., Daader, A. H. and Yousef, H. M. 1995. Effects of Egyptian subtropical summer conditions and the heat-stress alleviation technique of water spray and a diaphoretic on the growth and physiological functions of Friesian calves. J. Arid. Environ. 30: 219–225.

Munro, N. B., Shugart, L. R., Watson, A. P. and Halbrook, R. S. 1991. Cholinesterase activity in domestic animals as a potential biomonitor for nerve agent and other organophosphate exposure. JAVMA. 199: 103-115.

Naqvi, S.M.K., Hooda, O.K., Saxena, P. 1991. Some plasma enzymes of sheep under thermal, nutritional and exercise stress. Ind. Vet. J. 68: 1045-1047.

Neuwirth, J.J., Norton, J.K., Rawling, C.A., Thompson, F.N. and Ware, G.O. 1979. Physiological responses of dairy calves to environmental heat stress. Int. J. Biometerol. 23: 243-254.

Okelly, J. C. 1973. Plasma lipid changes in genetically different types of cattle during hyperthermia. Comp. Biochem. Physiol. A Physiol. 44: 313-320.

Okab, A. B., El-Banna, S. G. and Koriem, A. A. 2008. Influence of environmental temperatures on some physiological and biochemical parameters of New-Zealand rabbit males. Slovak J. Anim. Sci. 41: 12-19.

Otto, F., Baggasse, P., Bogin, E., Harun, M. and Vilela, F. 2000. Biochemical blood profile of Angoni cattle in Mozambique. Israel Vet. Med. Assoc. 55: 1-9.

Piccione, G., Casella, S., Pennisi, P., Giannetto, C., Costa, A. and Caola, G. 2010. Monitoring of physiological and blood parameters during perinatal and neonatal period in calves. Arq. Bras. Med. Vet. Zootec. 62: 1-12.

Purchas, R.W., Barton, R.A. and Kirton A.H. 1980 Relationship of circulating cortisol levels with growth rate and meat tenderness of cattle and sheep. Australian J. of Agri. Res. 31: 221-252.

Ronchi, B., Bernabucci, U., Lacetera, N. G., Supplizi, A. V. and Nardone, A. 1999. Distinct and common effects of heat stress and restricted feeding on metabolic status of Holstein heifers. Zoot. Nutr. Anim. 25: 11–20.

Shakoori, A., Butt, G., Riffat, R. and Aziz, F. 1994. Hematological and biochemical effects of danitol administrated for two months on the blood and liver rabbits. Zeitchrift Fuer Angewandte. Zool. 80: 156-180.

Singh, K. and Bhattacharyya N. K. 1984. Serum enzyme activity during hypertermia in Hariana cattle and their exotic crosses. Ind. J. Anim. Sci. 54: 1028–1031.

Srikandalkumar A. and Johnson, E. H. 2004. Effect of heat stress on milk production, rectal temperature, respiratory rate and blood chemistry in Holstein, Jersey and Australia milking Zebu cows. Trop. Anim. Health Prod. 36: 685-692.

Stott, G.H. and Wiersma, F. 1971. Plasma corticoids as an index of acute and chronic environmental stress. Presented at Ist Conference on Biometeorology and 10th conference on Agricultural Meteorology, Columbia.

Thankachan, S. 2007. Effect of thermal exposure on heat balance and erythrocyte oxidative status in growing cattle and buffaloes. M.V. Sc. Thesis submitted to National Dairy Research Institute, Karnal (Haryana), India.

Yousef, M.K. and Johnson, H.D. 1967. Calorigenesis of cattle as induced by hydrocortisone and environmental temperature. J. Anim. Sci. 26: 1087-1093.