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Heat load index vis-à-vis changes in metabolic functions of Sirohi goat from semi-arid tracts of Rajasthan

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Abstract
The effect of heat load index (HLI) on metabolic controllers of *Sirohi* goat from semi-arid tracts of Rajasthan was evaluated. Apparently healthy male and female *Sirohi* goat of different age groups from unorganized sector (Udaipur district, Rajasthan) were assessed. Obtaining of blood samples was carried out during environmental periods (EPs) of the year encompassing intervening EP (October-November); dry-hot EP (April, May and June); humid-hot EP (July, August and September) and cold EP (December and January). The range of average HLI values acquired during intervening or congenial period was 26.00-94.00. Dry-hot and humid-hot periods divulged greater values of HLI. The stress was assessed on the basis of metabolic controllers *viz.* serum Ornithine Carbamoyl Transferase (OCT) and serum Hexokiase (HK) enzymes. The mean values of both the serum enzymes were observed to be significantly ($p \leq 0.05$) greater during dry-hot, humid-hot and cold EPS as compared to intervening or control mean value. OCT enzyme exhibited maximum activities during humid-hot EP and the maximum percent change in the mean value of serum OCT was found to be + 154.52, whereas HK enzyme exhibited maximum activities during cold EP, maximum percent change in the mean value of HK was instituted to be + 25.93 during cold, as compared to equivalent intervening EP values. Outcome has shown bang of extreme environmental periods and their effects on metabolism through the metabolic controllers. This enlightened the change in functions of liver owing to HLI. It is important that pattern of change in liver functions and cellular metabolism coincided that of HLI. It can be concluded that abiotic stressors can impinge stimulation of metabolic controllers and liver activity. It is worth mentioning that *Sirohi* goat of all physiological states were affected with extreme environmental periods.

Keywords: environmental period, HK, OCT, HLI, Sirohi goat

Introduction

The thermal ambience has a sturdy impact on native breeds with environmental temperature coupled with humidity being the peak of adverse stimuli. Environmental periods are known to have in general a husky dangle on production of animals along with managemental and reproductive aspects. Physiological-ecology is the scrutiny of the squat and long- term changes in behavior and physiology of animals making one to keep lively for reproduction profitably in their ever changing ambiences. Explorations concerning native breeds of animals can ease in comprehending the explicit physical condition of the animals. To appreciate the uneasiness of animals to their physical atmosphere is the main point of investigations in the dome of physiological-ecology. Many arid and semi-arid tract animals have to fumble when ambient periods are extremely hot. Metabolic changes during extreme environmental periods can be measured efficiently by using metabolic controllers Carbohydrate pathways are altered by a set of enzymes and blood levels latter can be examined by laboratory tools and tempo of pathways can be appraised. Environmental temperature of higher magnitude can affect nutrient use in sheep [1]. It has been observed that metabolic pathways can be squabbled by the physiological states of the animals, being governed by endocrines mainly thyroid and adrenal glands [2]. An approach to these pathways is vital to observe the physiology of ruminants, who stipulate enormous metabolic whack to thump into ecological confronts in addition to bear their physiological production system. Energy precondition is accomplished by several basic metabolic pathways like gluconeogenesis [3]. They have to encounter water and energy composure. The pursuance of high environmental temperatures can fine-tune the behavior of animals. Stress produces misery and distress. Stress is principally associated to their ambience.

An understanding of stress is vital, hence, use of liver functions becomes an trustworthy contrivance which can help in exposing very low level of fracas in animals along with other facets of stress and responses [4, 5]. In view of above outlook, it can be instituted that heat load index should be measured in native breeds for launching future management gambits. Serum Ornithine Carbamoyl Transferase (OCT) is important enzyme of liver functions. Serum OCT is an imperative enzyme of urea cycle. Looking towards the dearth of work on this aspect in Sirohi goat from Rajasthan, the present investigation was designed for the assessment of heat load index vis-à-vis changes in liver functions of Sirohi goat from semi-arid tracts of Rajasthan.

Materials and Methods

For the assessment of heat load index on metabolic controllers changes Sirohi goat from semi-arid tracts of Rajasthan, 1280 apparently healthy male and female Sirohi goat of different age groups were explored. Animals belonged to unorganized sector in and around Udaipur district, Rajasthan. Blood sample collection was carried out during the course of slaughtering from the Sirohi goat with the permission of Institutional Animal Ethics Committee (IAEC), Rajasthan University of Veterinary and Animal Sciences, Bikaner, Rajasthan. Blood was collected to harvest serum during various environmental periods (EPs) of the year incorporating intervening EP (October-November); dry-hot EP (April, May and June); humid-hot EP (July, August and September) and cold EP (December and January). In each environmental period (EP), Sirohi goat were grouped as male (160) and female (160). Age wise, animals were classified as 3-7 months (40 male and 40 female); 7- 11months (40 male and 40 female); 11-15 months (40 male and 40 female) and 15-19 months (40 male and 40 female) in each EP. Environmental elements to calculate heat load index [6] were obtained from areas of Udaipur district, Rajasthan. Metabolic controllers *viz*. serum Ornithine Carbamoyl Transferase (OCT) and Hexokinase (HK) enzymes. Serum Ornithine Carbamoyl Transferase was measured by colorimetric method [7] Hexokinase (HK) by technique described in Worthington enzyme manual, Anonymous [8] with modifications Anonymous [9].

Results and Discussions

For the assessment of effect of heat load index on metabolic controllers of Sirohi goat from semi-arid tracts of Rajasthan, computation of HLI values was conducted along with measurement of serum OCT and serum HK enzymes.

Heat load index (HLI)

Heat load index (HLI) values acquired at maximum environmental temperature were 67.82, 81.70, 83.80 and 54.80, respectively at the time of intervening, dry-hot, humid-hot and cold EPs from Udaipur district of Rajasthan. Heat load Index (HLI) values were acquired by computing fundamental environmental elements from Udaipur district of Rajasthan. The basics of heat load index (HLI) were minimum, maximum and average. The values among various EPs mottled significantly ($p \leq 0.05$). Humid-hot EP exhibited maximum values of HLI as compared to corresponding values during intervening, dry-hot and cold EPs. The heat load index (HLI) can be employed as a tool to appraise the environmental heat load which is transferred to sheep. The working out of HLI needs black globe temperature which exhibits radiation influences in addition to air temperature. Therefore, HLI is considered as a marker of physiological stress to the animals. Scientists [10] understand that revelation of animals to tremendously high environmental temperatures and lofty relative humidity for protracted periods can reduce the ability to disperse heat. Hence, gratuitous heat load can give rise to significant reduction in production thereby affecting animal wellbeing. Towering heat loads are generated when animal's heat production and higher environmental temperature combine together considerably influencing decadence of heat from animal. During dry-hot EP, the mean value of maximum HLI substantiated the earlier observations from the Bikaner region, Rajasthan [11].

Serum ornithine carbamoyl transferase (OCT)

Mean± SEM values of serum OCT of male and female Sirohi goat of different age groups are presented in table 1.Significantly ($p \leq 0.05$) higher overall mean value of serum OCT was acquired during dry-hot, humid-hot and cold as compared to intervening EP mean overall value. Utmost level of serum OCT was discerned during humid- hot EP. The percent variation in the value of serum OCT was monitored to be maximum (+ 154.52) during humid- hot. Female sheep divulged significantly ($p \leq 0.05$) higher value in each EP than the corresponding overall mean value of male sheep. Highest mean value was found in humid-hot EP in male and female categories. Comparatively, least value was observed in 3-7 months age group of Sirohi goat and greatest value was observed in 15-19 months age group of sheep in each gender, in each EP. The age wise alterations, irrespective of gender, revealed an enhancing archetype of the mean values which were observed to be least in 3-7 months age group and greatest in 15-19 months age group. In a study, sheep were examined by [12] to measure serum OCT activity. In an exploration, brunt of alterations in ambient temperatures with sex and age on serum OCT values in goat was evaluated [13] and the mean value of OCT was observed to be increased during hot. Results of present study corroborated the earlier work [13]. Observations regarding effect of physiological states also substantiated the earlier research [14].

Serum hexokinase

The Mean± SEM values of serum hexokinase are presented in table 2. The overall mean values of serum hexokinase were notably ($p \leq 0.05$) higher during extreme EPs i.e. dry-hot, humid- hot and cold as compared to intervening overall mean value. It was observed that percent change in the value of serum HK was maximum (+ 25.93) during cold EP. In each EP, it was observed that overall mean value of female sheep has shown significant ($p \leq 0.05$) rise when compared to corresponding overall mean value of male goat. Again, minimum ($p \leq 0.05$) value was observed in 3-7 months age group whereas, maximum ($p \leq 0.05$) value was observed in 15-19 months age group. These changes revealed an increasing prototype of the mean values which were instituted to be minimum in 3-7 months and maximum in 15-19 months.

Transfer of phosphate from ATP to glucose is catalyzed by hexokinase to produce glucose 6-phosphate. This reaction is considered to be the first rate-limiting step in glucose metabolism. This enzyme also works as the glucose sensor in the beta cell by controlling the tempo of access of glucose into the glycolytic pathway and its consecutive metabolism [15]. It can be proposed that greater values of serum HK pinpointed intonations in metabolic activities. Previous workers have advocated changes in serum HK owing to physiological states [16]. In an investigation [17] revealed atmospheric temperature reliance of glycolytic cycle enzymes in goats. Scientists are of the opinion that serum HK level may rise owing to various metabolic activities. The outcome of present study regarding HK status divulged its function as one of the issues in the expansion of oxidative stress [18].

Upshot of present investigation suggested that force of cold EP was greatest in terms of HK intonations followed by in humid-hot and dry- hot EPs. Among three extreme EPs, it can be opined that cold EP was competent enough to intonate HK activity efficiently as compared to other EPs, perhaps for the requirement of energy to sustain thermoregulation.

Table 1: Mean ± SEM values of serum ornithine carbamoyl transferase (OCT, UL^{-1}) in the Sirohi goat during varying environmental periods (EPs)

S. No.	**Effects**	**Mean ± SEM values during environmental periods**			
		Intervening	**Dry-hot**	**Humid-hot**	**Cold**
1.	Environmental period overall values (320)	3.79^{b}±0.40	81.79^{b}±0.43	101.68^{b}±0.45	51.01^{b}±0.41
2.	**Categorization as male and female (I & II categories)**				
I.	**Male (160), categorization according to gender specific age groups as a, b, c & d**				
	Overall mean values of males (160)	32.80^{bc}±0.10	69.19^{bd}±0.11	81.65^{bd}±0.12	42.82^{bd}±0.10
	3-7 months (40)	28.88^{bd}±0.05	57.41^{bd}±0.06	68.31^{bd}±0.06	38.21^{bd}±0.06
	7-11 months (40)	31.91^{bd}±0.04	63.15^{bd}±0.05	76.20^{bd}±0.05	40.10^{bd}±0.06
	11-15 months (40)	33.21^{bd}±0.05	75.13^{bd}±0.04	86.98^{bd}±0.05	45.00^{bd}±0.05
	15-19 months (40)	37.22^{bd}±0.04	81.07^{bd}±0.05	95.11^{bd}±0.05	47.98^{bd}±0.05
II.	**Female (160), categorization according to gender specific age groups as a, b, c & d**				
	Overall mean values of females (160)	44.78^{bc}±0.10	94.39^{bc}±0.10	121.71^{bc}±0.12	59.19^{bc}±0.10
	3-7 months (40)	40.90^{bd}±0.05	86.17^{bd}±0.06	107.21^{bd}±0.06	56.18^{bd}±0.06
	7-11 months (40)	42.22^{bd}±0.04	91.11^{bd}±0.05	117.31^{bd}±0.05	58.18^{bd}±0.06
	11-15 months (40)	45.88^{bd}±0.05	96.13^{bd}±0.04	125.11^{bd}±0.05	60.12^{bd}±0.05
	15-19 months (40)	50.13^{bd}±0.04	104.14^{bd}±0.05	137.21^{bd}±0.05	62.30^{bd}±0.05
3.	**Categorization according to age as a, b, c & irrespective of gender**				
	3-7 months (80)	34.90^{bd}±0.05	72.17^{bd}±0.06	88.21^{bd}±0.06	46.18^{bd}±0.06
	7-11 months (80)	37.91^{bd}±0.04	77.15^{bd}±0.05	96.20^{bd}±0.05	50.10^{bd}±0.06
	11-15 months (80)	41.88^{bd}±0.05	87.13^{bd}±0.04	105.11^{bd}±0.05	51.12^{bd}±0.05
	15-19 months (80)	43.22^{bd}±0.04	91.60^{bd}±0.05	116.11^{bd}±0.05	54.98^{bd}±0.05

EP = Environmental period
'b' = Significant ($p \leq 0.05$) differences among mean values for a row.
'c' = Significant ($p \leq 0.05$) differences between overall mean values of males and females for an EP 'd' = Significant ($p \leq 0.05$) differences among mean values of different gender specific age groups for an EP.
'e' = Significant ($p \leq 0.05$) differences among mean values of different age groups for an EP irrespective of gender.

Table 2: Mean ± SEM values of serum hexokinase (HK, UL^{-1}) in the sirohi goat during varying environmental periods (EPs)

S. No.	Effects	Mean ± SEM values during environmental periods (EPs)			
		Intervening	Dry-hot	Humid-hot	Cold
1.	Environmental period Overall values (320)	46.32b±0.21	51.38b±0.22	54.70b±0.20	60.20b±0.23
2.	**Categorizations male and female (I & II categories)**				
I.	**Male (160), categorization according to gender specific age groups as a, b, c & d**				
	Overall mean values of males (160)	45.60bc±0.020	50.72bd±0.040	54.12bd±0.058	57.56bd±0.030
a.	3-7 months (40)	41.14bd±0.005	46.11bd±0.007	50.11bd±0.006	53.21bd±0.025
b.	7-11 months (40)	43.34bd±0.042	51.38bd±0.038	53.68bd±0.163	55.35bd±0.030
c.	11-15 months(40)	47.31bd±0.029	52.30bd±0.028	55.29bd±0.030	60.26bd±0.026
d.	15-19 months (40)	50.64bd±0.026	53.08bd±0.110	57.41bd±0.033	61.42bd±0.040
II.	**Female (160), categorization according to gender specific age groups as a, b, c & d**				
	Overall mean values of females (160)	47.05bc±0.022	52.05bc±0.021	55.28bc±0.020	62.83bc±0.023
a.	3-7 months (40)	42.32bd±0.022	46.29bd±0.027	50.28bd±0.028	58.30bd±0.029
b.	7-11 months (40)	46.31bd±0.025	50.36bd±0.029	53.28bd±0.014	61.32bd±0.019
c.	11-15months (40)	47.30bd±0.016	53.25bd±0.021	56.27bd±0.024	63.35bd±0.023
d.	15-19 months (40)	52.29bd±0.019	58.30bd±0.018	61.31bd±0.017	68.35bd±0.025
3.	**Categorization according to age as a, b, c & irrespective of gender**				
a.	3-7 months (80)	42.22be±0.121	46.70be±0.048	50.19be±0.017	56.25be±0.231
b.	7-11 months (80)	46.32be±0.113	50.87be±0.062	52.48be±0.084	58.83be±0.280
c.	11-15months (80)	50.34be±0.115	52.77be±0.166	55.28be±0.113	61.31be±0.132
d.	15-19 months (80)	51.47be±0.095	55.19be±0.243	59.36be±0.220	65.38be±0.334

Conclusion

Conclusion can be drawn that dry-hot, humid-hot and cold environmental periods influence the physiological processes including enzymatic reactions at cellular echelon. The force of dry-hot and humid-hot environmental periods was greater as reflected by HLI values and the maximum cadence in different serum enzymes were also observed during different EPs indicating sensitivity of enzymatic reactions towards environmental ambiences. In the present study, influence was observed to be greater on female Sirohi goat and 15-19 months old group. The data obtained through this exploration will assist in producing reference data for future research in the field of Veterinary Clinical Physiology.

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