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ORIGINAL ARTICLE

Ambient Stress Associated Variations in Metabolic Responses of Marwari Goat of Arid Tracts in India

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Ambient stress associated variations in metabolic responses of *Marwari* breed of goat belonging to arid tracts in India were investigated by screening male and female goats of varying age groups during moderate, extreme hot and extreme cold ambiences. Metabolic responses were assessed by analyzing serum urea, creatinine, total proteins, cholesterol, triglycerides and glucose and the mean values were 5.67±0.05 mmol L^{-1}, 120.98±1.44 umol L^{-1}, 69.8±0.10 g L^{-1} , 3.3±0.03 mmol L^{-1} , 1.27±0.01 mmol L^{-1} and 3.63±0.03 mmol L^{-1}, respectively during moderate ambience. The mean values of serum urea and creatinine were significantly ($p \leq 0.05$) higher during hot and cold ambiences, the mean value of total serum proteins and triglycerides were significantly ($p \leq 0.05$) lower during hot and cold ambiences and the mean values of cholesterol and glucose were significantly ($p \leq 0.05$) lower during hot ambience and significantly ($p \leq 0.05$) higher during cold ambience as compared to respective moderate mean value. Significant ($p \leq 0.05$) changes were observed in the value of each parameter according to sex and age. It was concluded that extreme hot and cold ambient temperatures affected the animals of both sexes and all age groups which was evident in the form of variations in the metabolic responses to combat the ambient stress.

Key words: Ambience, cold, hot, Marwari goat, metabolic responses

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Ambient stress, critical illness, severe injury, infection, trauma, and major surgery are serious conditions that may cause profound physiological changes.The term metabolic stress refers to the physiological effects of these conditions which affects the major body systems in different ways. It inhibits the ability of the immune system to protect against outside invaders, slows wound healing, and may diminish muscle strength. Recovery is enhanced when the animals receive adequate medical and nutritional care to prevent sepsis and organ failure. Recent investigations have demonstrated that the response to stress is mediated by complex interactions between the

nervous, endocrine, metabolic, immune, and hematopoietic systems. Recent advances in the field of clinical medicine are linking various metabolic responses with the oxidative stress (Pappolla *et al.,* 2002).

Metabolic response is the name given to metabolic changes which follow some event like stress. These responses to stress have been of interest to scientists for healthy management of animals. Heat stress related variations in the values of total serum proteins are well documented in animals (Healy and Falk, 1974 and Nath, 2006). Ambient stress related variations in metabolic responses are largely because of stress hormone cortisol. Many workers have correlated the serum constituent levels with the oxidative stress (Chena *et al*., 2008). Studies on the effects of heat and cold stress on metabolic responses in goat are lacking, and only preliminary reports are available. The inevitability of exposure of goat to extreme ambiences of arid and semiarid tracts, makes study of metabolic responses associated with extreme ambiences an appropriate area of research to explore adaptive physiological measures of the body and their use in health management and clinical diagnosis. *Marwari* breed of goat constitutes a major portion of the goat population in western part of Rajasthan and plays an important role in the economy of arid and semi arid tract. Therefore, the present investigation was planned to determine serum metabolic responses during extreme ambiences in *Marwari* goat and to set their physiological reference values for future use.

MATERIALS AND METHODS

The study was carried out on six hundred and thirty apparently healthy *Marwari* goat of either sex, between 6 months to 4.5 years of age to determine metabolic responses in the serum during moderate (Mean maximum ambient temperature 28.60 ± 0.32 ^{o}C), hot (Mean maximum ambient temperature 45.5±0.08 ^{o}C) and cold (Mean minimum ambient temperature 2.08±0.10 ^{o}C) ambiences. Blood samples were collected from jugular vein during slaughtering from private slaughter houses (Bikaner, Rajasthan, India) where all the animals were kept in similar conditions of management. In each ambience 210 blood samples were collected to harvest the serum and the animals were categorised sex wise as male (105) and non pregnant goat (105) and age wise as below 1 year (35 male and 35 female); 1-2 years (35 male and 35 female) and 2-4.5 years (35 male and 35 female).

Metabolic responses in the serum included urea, creatinine, total proteins, cholesterol, triglycerides and glucose which were determined by the techniques of Natelson (Varley, 1988), Bonsnes and Taussky (Varley, 1988), Lowry *et al.* (1951), Sackett (Varley, 1988), GPO-PAP method of kit (Wipro) and Folin-Wu (Oser, 1976), respectively. The changes in the means were measured by using multiple mean comparison procedures (Duncan, 1955 and Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Mean ± SEM values of serum urea, creatinine and total proteins are presented in table 1 and of cholesterol, triglycerides and glucose in table 2 during different ambiences, sex and age groups.

The mean values of serum urea and creatinine were significantly ($p \leq 0.05$) higher during hot and cold ambiences, the mean value of total serum proteins and triglycerides were significantly ($p \leq 0.05$) lower during hot and cold ambiences and

the mean values of cholesterol and glucose were significantly (p≤0.05) lower during hot ambience and significantly (p≤0.05) higher during cold ambience as compared to respective moderate mean value. In each ambience the sex and age effects were significant (p≤0.05) for all the metabolic responses. The mean values were higher in male animals than females significantly (p≤0.05) for all the metabolic responses except for cholesterol and triglycerides where the mean values in all the ambiences were significantly (p≤0.05) higher in female than male animals. Age effect showed a significant (p≤0.05) increase in the mean values being lowest in the animals of below 1 year of age for all the metabolic responses except glucose where age effect showed a significant (p≤0.05) decrease in the mean values being highest in the animals of below 1 year of age. During hot ambience the lowest value of total serum protein was observed in the animal of 1-2 year of age group.

Higher serum urea during extreme ambiences can be related to oxidative stress mediated solute-signaling pathway in tissues because it increases expression of the oxidative stress-responsive transcription factor. Scientists have observed that antioxidant treatment partially inhibit the ability of urea to activate transcription of reporter gene (Zhang *et al.,* 1999). Lower protein catabolism in young animals could be the reason of lower urea concentration in the serum as the status of protein metabolism in the body influences serum urea level (Coles, 1986). Cortisol (Kataria *et al*., 2000a) mediated creatine metabolism in liver could result in higher creatinine formation during hot ambience. Kataria *et al.* (2003) attributed higher serum creatinine in summer to decreased glomerular filtration rate and increased muscle breakdown. Free radical influenced stress mediated oxidative changes in proteins leads to high turnover in blood. Although stress can cause changes in blood proteins (Goswami *et al.,* 2003), but physiological states can also influence the levels (Sharma and Kataria, 2007).

Higher serum cholesterol levels could be attributed to higher thyroid activity in cold ambience as increase in BMR is required with the need for extra production of heat to maintain body temperature (Kataria *et al.,* 2000b) which increases turnover of basic fuel molecules in blood. Lower blood cholesterol in heat stressed animals (Christi,1981) was attributed to lowered thyroid activity (Kataria *et al.,* 2000b) resulting in lower metabolic rate. It has been observed that variations in serum cholesterol can be observed in a variety of conditions other than the thyroid disorders and oxidative stress is one of them (Pappolla *et al.,* 2002). Higher level of cholesterol in females could be due to oestrogen effect which promotes cholesterol synthesis (Singh *et al*., 1994).

The available literature related to the field of triglycerides in goat is rather scarce, and only a few authors have looked into this. Changes in triglyceride level indicated the metabolic status of the animals during extreme ambiences (Karapehlivan *et al.,* 2007). The higher triglyceride values in female animals were due to higher metabolic responses to meet the energy requirements which was related to metabolic stress response (Mazuri *et al.,* 2009). Nazifi *et al*. (2003) observed significantly lower triglyceride levels in sheep during hot and cold stress than in animals kept at optimum temperatures. Various workers have also related triglyceride levels with oxidative stress (Katsuki *et al.*, 2004) and it has been proposed as one of the markers to assess oxidative

stress (Pryor, 1986).

The results of present study regarding variations in glucose concentration due to ambiences ratified the earlier findings (Kataria *et al.,* 2002 and Nazifi *et al.*, 2003). Hot and cold stress induces gluconeogenesis through glucocorticoid secretion with maintenance of blood glucose in stressed animals (Weber *et al*., 1965). However, during heat stress feed consumption decreases, which comparatively lowers the blood glucose (Kataria *et al.,* 2002). The lower blood glucose during hot ambience might also be due to variation in thyroid activity (Nath, 2006).Emerging data from human and animal studies suggest that glucose-derived oxidative stress may play a central role, linking together many of the other physio-pathogenetic mechanisms (Russella *et al.*, 2002).

Results of present study pointed out towards metabolic adjustments to combat stress, however, on the basis of available literature, relationship of variation in metabolic responses with development of oxidative stress can not be overlooked. It was concluded that ambient stress in the form of extreme hot and cold ambient temperatures affected the animals of both sexes and all age groups. This was evident in the form of variations in the metabolic responses which were modified to combat the adverse conditions. Variations in the levels of metabolic responses indirectly reflected towards the modulations of physiological mechanism. The data generated in the present investigation could help in the future research in the field of stress.

Table 1. Mean ± SEM values of serum urea, creatinine and total proteins in *Marwari* goat

Ambiences	Serum metabolites		
	Urea, mmol L^{-1}	Creatinine, umol L^{-1}	Total proteins, g L^{-1}
Moderate (210)	**5.67±0.05 [b]**	**120.98±1.44 [b]**	**69.8±0.10 [b]**
Sex			
Male (105)	6.53±0.07 [d]	136.32±1.84 [d]	79.04±0.10 [d]
Female (105)	4.81±0.03 [d]	105.64±1.11 [d]	60.57±0.11 [d]
Age			
Below 1 Year (70)	4.20±0.05 [f]	102.75±1.01 [f]	63.2±0.10 [f]
1-2 Years (70)	5.48±0.04 [f]	120.91±1.22 [f]	69.2±0.12 [f]
2-4.5 Years (70)	7.33±0.06 [f]	139.28±2.11 [f]	76.8±0.08 [f]
Hot (210)	**7.79±0.08 [b]**	**213.75±3.9 [b]**	**60.92±0.20 [b]**
Sex			
Male (105)	8.3±0.09 [d]	238.8±4.5 [d]	66.13±0.22 [d]
Female (105)	7.21±0.07 [d]	188.70±3.4 [d]	55.71±0.18 [d]
Age			
Below 1 Year (70)	6.02±0.09 [f]	173.85±3.89 [f]	60.21±0.25 [f]
1-2 Years (70)	7.59±0.09 [f]	206.13±3.11 [f]	56.37±0.14 [f]
2-4.5 Years (70)	8.75±0.07 [f]	261.28±4.7 [f]	66.18±0.23 [f]
Cold (210)	**6.06±0.09 [b]**	**209.74±2.44 [b]**	**65.16±0.07 [b]**
Sex			
Male (105)	6.63±0.09 [d]	230.03±2.82 [d]	70.1±0.10 [d]
Female (105)	5.49±0.10 [d]	189.42±2.53 [d]	60.1±0.05 [d]
Age			
Below 1 Year (70)	4.20±0.10 [f]	182.10 ±3.32 [f]	59.1±0.10 [f]
1-2 Years (70)	6.01±0.08 [f]	209.34±2.0 [f]	65.3±0.10 [f]
2-4.5 Years (70)	8.01±0.09 [f]	237.82±2.0 [f]	71.1±0.03 [f]

i.Figures in the parenthesis indicate number of goats.
ii. 'b' marks significant (p≤0.05) differences among ambience mean values of a parameter.
iii. 'd' marks significant (p≤0.05) differences between male and female mean values of a parameter within an ambience.
iv. 'f' marks significant (p≤0.05) differences among mean values of different age groups of a parameter within an ambience

Table2. Mean ± SEM values of serum cholesterol, triglycerides and glucose in *Marwari* goat

Ambiences	Serum metabolites, m mol L^{-1}		
	Cholesterol	Triglycerides	Glucose
Moderate (210)	**3.3±0.03** [b]	**1.27±0.01** [b]	**3.63±0.03** [b]
Sex			
Male (105)	2.7±0.03 [d]	0.82±0.01 [d]	3.79±0.01 [d]
Female (105)	3.9±0.03 [d]	1.73±0.01 [d]	3.47±0.01 [d]
Age			
Below 1 Year (70)	2.5±0.07 [f]	0.71±0.01 [f]	3.78±0.02 [f]
1-2 Years (70)	3.4±0.06 [f]	1.12±0.01 [f]	3.61±0.02 [f]
2.5-4.5 Years (70)	4.1±0.07 [f]	1.98±0.01 [f]	3.50±0.04 [f]
Hot (210)	**2.7±0.02** [b]	**0.44±0.01** [b]	**3.15±0.01** [b]
Sex			
Male (105)	2.2±0.03 [d]	0.16±0.01 [d]	3.35±0.02 [d]
Female (105)	3.2±0.03 [d]	0.72±0.01 [d]	2.95±0.01 [d]
Age			
Below 1 Year (70)	1.9±0.04 [f]	0.27±0.01 [f]	3.53±0.01 [f]
1-2 Years (70)	2.5±0.01 [f]	0.41±0.02 [f]	3.07±0.02 [f]
2.5-4.5 Years (70)	3.3±0.03 [f]	0.64±0.01 [f]	2.85±0.01 [f]
Cold (210)	**4. 9±0.03** [b]	**1.1±0.01** [b]	**3.89±0.01** [b]
Sex			
Male (105)	4.2±0.04 [d]	0.9±0.01 [d]	4.24±0.02 [d]
Female (105)	5.6±0.02 [d]	1.3±0.02 [d]	3.53±0.01 [d]
Age			
Below 1 Year (70)	3.7±0.02 [f]	0.8±0.02 [f]	4.23±0.01 [f]
1-2 Years (70)	5.0±0.03 [f]	1.1±0.01 [f]	3.84±0.01 [f]
2.5-4.5 Years (70)	6.0±0.04 [f]	1.4±0.01 [f]	3.65±0.01 [f]

i. Figures in the parenthesis indicate number of goats.
ii. 'b' marks significant (p≤0.05) differences among ambience mean values of a parameter.
iii. 'd' marks significant (p≤0.05) differences between male and female mean values of a parameter within an ambience.
iv. 'f' marks significant (p≤0.05) differences among mean values of different age groups of a parameter within an ambience.

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