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Effect of solar eclipse on certain blood biochemicals in goats under intensive and extensive housing systems

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ABSTRACT

During solar eclipse, unusual disturbances in the circadian rhythm affects the metabolism of animals through change in their biological clock. Therefore, the present study was designed to know the effects of solar eclipse on certain serum biochemicals of goats under intensive and extensive housing systems. Experiment was started from 19 July 2009 (control) to study the effects of solar eclipse (22July 2009). Adult goats (24) of both sexes were divided into 4 groups of male and female, viz. group1 (male extensive), group 2 (female extensive), group 3 (male intensive), and group 4 (female intensive). They were provided ration and water *ad lib.* during entire period of investigation. All the experimental goats were housed in extensive (groups 1 and 2) and intensive (groups 3 and 4) housing system to know the protective effect of different housing during solar eclipse. Daily (19–23 July 2009), we collected blood samples for analysis of serum T_3, T_4, thyroid stimulating hormone (TSH), alkaline phosphatase (ALP), alanine aminotransferase (ALT), Ca, and P. After solar eclipse (23 July 2009), TSH level was significantly increased in group 3. Serum ALT activity was significantly low in group1 on day of solar eclipse and end of experiment, whereas low activity of ALT was recorded in group 3 and4 at the end of experiment. Interestingly, high level of Ca in group 3 as well as ALP in group1 and 3 was recorded on solar eclipse day and was persistent till the end of experiment. However, serum T3 was significantly decreased in group 3 on solar eclipse day at the end of experiment. These findings are interesting and noticable in contest of observation on certain serum biochemical profile of goats during solar eclipse under different housing systems, which require further exploration.

Key words: Alanine aminotransferase, Alkaline phosphatase, Goats, Housing systems, Serum biochemicals, Solar eclipse, Thyroid hormone

The earth electromagnetic field, wavelength of light, and incoming solar radiation flux changes during solar eclipse and receive more UV range wavelength light that influence biological clock (Kubinyi *et al.* 1998). Zecca *et al.* (1998) showed significant disturbances in the metabolism of carbohydrate, lipid and protein. Food intake and body condition are seasonally and photoperiodically regulated in many mammals (Mrosovsky and Sherry 1980). We designed our experiment in advance from 19 July 2009 (control) to study the effects of solar eclipse (22 July 2009) on goat's behaviour and possible changes in certain physiological and biochemical profile of blood. The CIRG, Makhdoom, Mathura (India) had witnessed the 88% eclipse for 5 min at 06.15 h. Interestingly, the Krebs cycle is disturbed during solar eclipse as it disturbs electromagnetic fields (Sert *et al.* 2002). Therefore, it is likely that the disturbances lead to adaptive changes, which in turn result in altered metabolic enzymes activity (Picazo *et al.* 1995). We hypothesized the changes in blood biochemical profiles due to alternation in emitted light wavelength and earth electromagnetic field during solar eclipse. The effect of an electromagnetic field on the living organism is a complex phenomenon and the initial mechanism is physico-chemical in nature and afterwards brings biological effects (Bronson and Heideman 1994). Similarly, molecular excitation, biochemical activation, generation of radicals, chemical bond weakening, hydration changes, altered relaxation time of atom vibration, and altered spin of dipoles (Kula 1985 and Bordiushkov *et*

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al. 2000), may also play a role. These physico-chemical changes may influence biochemical processes in the cell, thus changing both biochemical parameters and enzymatic activities of serum. Data on the effects of protective housing systems during solar eclipse on human health and other animals are lacking. Therefore, one of the most important fields of research in this topic is the investigation of the possible biochemical effects of solar eclipse. Hence, present study was undertaken to know the biochemical changes in serum of goats during solar eclipse.

MATERIALS AND METHODS

The Institutional Animal Ethics Committee (IAEC) and Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA) duly approved all the procedures, conducted on the experimental animals. The present study was conducted at Environmental Physiology, Laboratory of Physiology Reproduction and Shelter Management Division, CIRG, Makhdoom, India.

Chemicals: The chemicals, glassware and plastic ware were procured as per requirement from different suppliers. All chemicals used in the study were of analytical grade and purchased commercially.

Experimental design: Four groups (6 animals in each group) of adult male and female Barbari goats (weight range 22.0–32.0 kg and the age of the animals ranged from 2.5–3.0 years) were distributed as, group1 (male extensive), group 2 (female extensive), group 3 (male intensive), and group 4 (female intensive). All the experimental goats were housed in extensive (groups 1 and 2) and intensive (groups 3 and 4) housing system to know the protective effect of shelter during solar eclipse (22 July 2009, day 4). They were provided ration and water *ad lib.* during entire period of investigation (19 July 2009, day 1; 20 July, day 2; 21 July, day 3; 22 July, day 4; 23 July 2009, day 5). In this set of experiments the animals tested on July 19, 20, and 21 were considered to be the appropriate controls for those on July 22 as they were treated identically. During entire period of experiment, we collected blood at morning for analysis of certain serum hormones (T_3, T_4, TSH), enzymes (ALP and ALT), and minerals (Ca, P).

Table 1. Distribution of experimental goats to different groups

Groups	Body weight (kg)	Sex	Housing systems
1	36.38 ^{b}±1.96	male	extensive
2	25.83 ^{a}±0.75	female	extensive
3	40.19 ^{b}±2.11	male	intensive
4	25.75 ^{a}±1.18	female	intensive

Values (n=6, means ±SE) in the same column bearing no superscript ($^{a, b}$) common vary significantly (P<0.05).

Biochemical analysis: Serum T_3, T_4, and TSH was estimated by enzyme-immunoassay (EIA) method as per protocol given with kits. Serum calcium, P, ALP, and ALT were analysed by kits.

Statistical analysis: All the statistical analysis of data was performed with the help of computer program. All data were presented as Mean± Standard error (P<0.05 significant level).

RESULTS AND DISCUSSION

The mean values (± SEM) of hormones and enzymes levels for exposed and sham-exposed in goats are shown in Tables 1 and 2. Statistical analysis gives evidence of significant difference between solar eclipse day (day 4) and control (day 1, 2, and 3) in each group. During period of solar eclipse considerable dimness of the light was experienced and environmental temperature drop by 1.6 °C. On day 5, thyroid stimulating hormone (TSH) level was significantly (P<0.05) increased in group 3 as compared to day 1, 2, 3, and 4. However, serum T3 was significantly (P<0.05) decreased in group 3 on day 4 and on day 5. Whereas in group1, T_3 level was significantly low before the solar

Table 2. Changes in serum thyroid stimulating hormone (TSH), T_3, and T_4 of goats in different groups

Group	Days				
	1	2	3	4	5
TSH(µIU/ml)1	0.37 ±0.18	0.42±0.33	0.51±0.34	1.22±0.43	1.04±0.35
2	0.10 ±0.05	0.11±0.03	0.11 ±0.06	0.40±0.19	0.19±0.06
3	0.15 ^{a}±0.20	0.16 ^{a}±0.10	0.22 ^{a}±0.13	0.17 ^{a}±0.14	0.46 ^{b}±0.07
4	0.44 $^{a\,b}$±0.08	0.64 ^{b}±0.20	0.17 ^{a} ±0.20	0.57 $^{a\,b}$±0.25	0.16 $^{a\,b}$±0.08
T_3 (ng/ml)1	1.64 ^{a} ±0.17	1.49 ^{a}±0.39	2.14 ^{b} ±0.13	1.58 ^{a}±0.22	2.59 ^{b}±0.28
2	1.80 ±0.27	1.82±0.79	1.78±0.24	1.98±0.21	1.70±0.22
3	1.11 $^{a\,b}$ ±0.16	0.84 ^{a}±0.25	1.46 ^{b} ±0.18	0.83 ^{a}±0.08	0.78 ^{a}±0.17
4	1.92 ^{b} ±0.27	1.51 $^{a\,b}$±0.16	1.69 $^{a\,b}$ ±0.09	1.29 ^{a}±0.12	1.43 $^{a\,b}$±0.09
T_4 (ng/ml)1	153.50 ^{c} ±10.37	144.00 ^{c} ±15.47	108.80 ^{b} ±18.06	148.40 ^{c}±9.87	69.50 ^{a} ±7.72
2	146.00 ^{b} ±13.64	90.00 ^{a}±6.58	136.40 ^{b} ±7.65	120.00 ^{b}±8.00	79.00 ^{a}±16.46
3	135.00 ^{c} ±13.50	122.00 ^{c}±14.07	72.80 ^{b} ±5.08	126.40 ^{c}±13.26	54.00 ^{a}±5.35
4	125.00 ^{b} ±6.61	85.75 ^{a} ±12.92	102.40 ^{a}±5.23	121.60 $^{a\,b}$±9.89	101.50 $^{a\,b}$±19.80

Values (n=6; means ±SE) in the same row bearing no superscript ($^{a, b, c}$) common vary significantly (P<0.05).

Table 3. Changes in serum alkaline phosphatase (ALP) and alanine aminotransferase (ALT) activity of goats in different groups

Group	Days				
	1	2	3	4	5
ALP (KA)1	2.92 ^{a} ±0.41	4.21 ^{a}±0.66	7.72 ^{b}±0.45	7.34 ^{b}±0.42	10.80 ^{c}±0.33
2	6.84 ^{a}±0.62	8.32 ^{b}±0.43	10.13 $^{b\,c}$±0.92	10.55 ^{c}±0.28	9.74 $^{b\,c}$±0.87
4	5.22 ^{a}±0.63	7.63 ^{b}±0.41	6.67 ^{b}±0.65	12.72 ^{d}±0.23	10.77 ^{c}±0.42
4	4.92 ^{a}±0.42	8.78 ^{b}±0.65	9.10 ^{b}±0.41	10.36 ^{b}±0.48	8.92 ^{b}±0.55
ALT (IU/L)1	154.24 ^{c} ±5.46	102.03^{b}±4.69	65.99 ^{a} ±2.35	74.43 ^{a}±3.67	73.39 ^{a}±3.86
2	113.91 ^{d} ±3.13	98.10 ^{c}±6.98	71.02 ^{b}±4.26	59.84 ^{a}±1.85	52.35 ^{a}±5.12
3	87.07 ^{b} ±3.34	76.93 ^{b}±4.84	63.66 ^{a} ±1.59	75.32 ^{b}±2.90	63.25 ^{a}±4.31
4	86.44 ^{b} ±6.12	89.89 ^{b}±5.94	68.18 ^{a} ±3.17	76.70 $^{a\,b}$±5.95	67.40 ^{a}±4.10

Values (n=6, means ±SE) in the same row bearing no superscript ($^{a,\,b,\,c,\,d}$) common vary significantly (P<0.05).

Table 4. Changes in serum calcium (Ca) and phosphorus (P) level of goats in different groups

Group	Days				
	1	2	3	4	5
Ca (mg/dL)1	4.31^{a} ±0.58	6.95 ^{b}±0.29	6.41 ^{b}±0.45	6.66 ^{b}±0.52	6.25 ^{b}±0.55
2	6.25 ^{a} ±0.49	5.94 ^{a}±0.35	6.25 ^{a} ±0.31	6.88 ^{a}±0.42	5.69 ^{a}±0.32
3	5.79 ^{a} ±0.65	6.13 ^{a}±0.56	5.99 ^{a} ±0.36	7.40 ^{b}±0.48	7.28 $^{a\,b}$±0.30
4	5.64 ^{a} ±0.40	6.36 $^{a\,b\,c}$±0.37	6.11 $^{a\,b}$ ±0.28	6.74 $^{b\,c}$±0.28	7.05 ^{c}±0.27
P (mg/dL)1	2.44 ^{a} ±0.16	2.36 ^{a}±0.18	2.74 $^{a\,b}$ ±0.20	2.77 $^{a\,b}$±0.21	3.10 ^{b}±0.26
2	3.59 ^{a} ±0.41	2.96 ^{a}±0.30	3.35 ^{a}±0.19	3.20 ^{a}±0.31	2.72 ^{a}±0.17
3	3.34 ^{a} ±0.18	4.01 ^{b}±0.24	3.19 ^{a} ±0.30	3.15 ^{a}±0.36	3.10 ^{a}±0.35
4	3.77 ^{b} ±0.24	3.72 ^{b}±0.27	3.00 $^{a\,b}$ ±0.28	2.58 ^{a}±0.19	3.32 $^{a\,b}$±0.36

Values (n=6, means ±SE) in the same row bearing no superscript ($^{a,\,b,\,c}$) common vary significantly (P<0.05).

eclipse and simultaneously decreased on day 4 and increased on day 5. We observed significant (P<0.05) high level of serum Ca in group 3 and alkaline phosphatase (ALP) in group1 and 3 on day 4 and it was persistent up to day 5 (at the end of experiment). However, alanine aminotransferase (ALT) activity was significantly (P<0.05) low in group1 on day 4 and day 5, whereas decreased activity of ALT was recorded in group 3 and 4 on day 5. However, we did not observe any changes in level of TSH, T_3, T_4, ALP, Ca, and P in group 2 and 4 (Tables 2, 3, 4). Similarly, there was no variation in TSH, T_4, Ca, P level in group1 and P, T_4 in group 3 due to solar eclipse (Table 2, 3).

Solar eclipse-induced physico-chemical changes may affect the biochemical parameters of serum. Previous studies on effect of electromagnetic fields upon living organisms showed that the initial effect of an electromagnetic field is the triggering of key biochemical processes in various metabolic pathways (Kubinyi *et al.* 1998). In our study, the thyroid hormone profile and enzymes in group1 was similar before and after end of solar eclipse indicating the less or no effect of partial solar eclipse on metabolic hormones and enzymes. However, the slight increase in the minerals in group 3 and 4 animals might be due to the variation in feed intake and neuroendocrine interaction. An increase in solar radiation during solar eclipse increases the electromagnetic activity in mitochondria of living cells and there will be a marked increase in endocrine function (Kubinyi *et al.* 1998).

In present study, the increase in ALP and Ca was recorded in group 1 and 3 animals on solar eclipse day. This increase might be due to change in thyroid hormone level and liver metabolism. Since, endocrine, metabolic, cardiovascular and biochemical changes in living cells are influenced by the changes in the electromagnetic properties of the cell and their environment. The serum ALT activity was greatly reduced on day 5 in group1, 3, and 4, which might be due to poor metabolism and rest of the animals during solar eclipse. Biochemical and neurological studies have established the relationship between mammalian pineal gland and change in photoperiod. They act as a neuroendocrine transducer, converting neural signals specific to the parameters of environmental lighting into an endocrine message that leads to synthesis and release of melatonin (Reiter 1991 and Bharti and Srivastava 2009). Therefore, changes in biochemical parameters during period of solar eclipse might be influenced by varied melatonin secretion.

The activity of serum catabolic enzymes and their metabolism are triggered by the metabolic action in liver and kidney. The observations made on serum minerals (Ca,

P) and T_3 with respect to different housing were similar for entire period of experiments. Changes in emitted light wavelength, earth electromagnetic field and biological clock influence biochemical processes in the cell, thus changing both biochemical parameters and enzyme activities of serum (Loudon 1994 and Forgacs *et al.* 1998). It appears that the above effects may be due to disturbance in some radiations and interaction with pineal function on the eclipse day (Singh *et al.* 2009).

Present findings indicated the inter-relationship between solar eclipse and change in serum thyroid hormones and certain enzymes and minerals under different housing systems, which require further exploration. The results also provide evidence of an encouraging role of protective micro-environment and managemental practices in the prevention of solar radiation stress. These observations, however, prompt further investigations to clarify the subcellular action of solar eclipse, as well as to establish the biological and production significance of this effect in animals.

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