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Effects of Exposure to Solar Radiation on Blood Composition of Sudanese Desert Rams (*Ovis aries*)

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Abstract: This experiment was planned to investigate the effect of exposure to direct solar radiation for three weeks on blood composition of Hamari desert rams in Sudan wet-summer condition. Eight entire rams were divided into two groups, shaded (4 rams) and unshaded (4 rams). Blood samples were collected weekly from each ram in each group and examined for packed cell volume (PCV), total leukocyte count (TLC), differential leukocyte count (DLC), serum total protein concentration (STPC), serum albumin concentration (SAC), serum urea concentration (SUC) and plasma glucose concentration (PLGC). Exposure to solar radiation significantly increased the ratio of neutrophils and lowered the ratio of monocytes in the 1st week compared to the last two weeks and significantly lowered the ratio of eosinophils in the 3rd week compared to the control group. The unshaded rams showed a significantly higher STPC and a significantly lower SAC in the 3rd and 2end week respectively compared to shaded group .Heat stressed rams showed a significantly lower SUC in the 3rd week compared to the 1st two weeks and significantly lower PGC compared to the 1st two weeks and to values reported for the control. It is concluded that exposure of desert Hamari rams to wet-summer solar heat for three weeks was associated with changes in some blood parameters. Providing shade and water supply for sheep raising points will minimize the adverse effects of heat stress.

Key words: Solar · Radiation · Desert rams · Blood · Composition

INTRODUCTION

Thermal stress induced by high intensity of solar radiation could modify blood composition via the neuro-humoral responses. The appetite centre in the hypothalamus is suppressed resulting in low food intake, fewer substrate for enzymatic action,low hormone synthesis [1] and consequently lower metabolic rate [2]. It is reported that, under high ambient temperature the utilization of carbohydrates and nitrogen balance are reduced due to decrease in DM intake [3]. However, the increase in water intake, water turnover and haemodilution are associated with exposure to summer heat [4]. Acute heat exposure of sheep stimulated an increase in cortisol [5], decrease in pituitary [6], insulin and thyroid hormones secretions [7]. More over, an increase in adrenal activity during thermal stress interferes with the immune system [8]. This study was performed to evaluate the effects of exposure to wet- summer heat for three weeks (October-November) on Packed cell volume (PCV), Total leukocyte count (TLC), Differential leukocyte count (DLC), the concentrations of serum total protein (STPC), serum albumin (SAC) serum urea (SUC) and plasma glucose (PGC) of desert Hamari rams.

MATERIALS AND METHODS

Climate and location: Studies were performed at the Department of Physiology, Faculty of Veterinary Medicine at Shambat located at 15°36N 32°35E and an altitude of 390 m. The prevailing climatic conditions during the experimental period were obtained from Shambat Meteorological Centre located about 500 meters from the experimental site and are predicted in Table 1.

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Table 1: The prevailing climatic conditions during the experimental period

Time (weeks)	Temperature (°C) Max.	Min.	Mean	RH (%) (Mean)
1	35.6	19.7	27.7	23
2	38.5	20.6	29.6	25
3	36.5	20.2	28.4	26
Mean±SD	36.87±1.5	20.17±0.45	28.5±0.96	24.67±1.52

Solar radiation: 143 W/m^2

Animals: Eight adult intact Desert rams were randomly assigned to two groups of 4 rams each. One group was kept under shade (shaded) and the other group was exposed to direct solar radiation (Unshaded) .

Experimental Design: Both groups of rams were allowed an adaptive period of 2 weeks for new rearing regimen and housing facilities, followed by an experimental period of 3 weeks. During the experimental period a general management protocol was held, including deworming, clinical examination, claws trimming and sanitary measures were adopted. Rams were examined for general health and breeding soundness. Animals were fed chopped lucerene hay (Medicag Sativa) (CP: 17.5%;ME:8.48MJ/Kg) and were given tap water adlibitum. Blood samples were collected weekly at 9:00-11:00 am.

Collection and Manipulation of Blood Samples: Blood was collected from the rams under aseptic conditions from the jugular vein using plastic disposable syringes. A sample of 5ml was collected and immediately 1 ml was transferred to a test tube with anti-coagulant (Tri-sodium ethylene-diamine-tetra-acetate, EDTA) for the measurements of the erythrocytic and leukocytic indices. 2 ml of blood was also transferred to a test tube with anticoagulants, EDTA and sodium fluoride; these samples of blood were centrifuged for extraction of plasma samples for glucose determination. Sodium fluoride was added to inhibit the enzymatic reactions that influence glucose concentration [9]. The rest of the blood sample was left at room temperature for 2-3 hrs and then centrifuged for extraction of serum samples. Haemolysis free serum samples were stored at -20°C for subsequent measurements of the concentrations of metabolites.

Blood Analysis: The analyses of blood samples were carried out according to the standard methods described in Schalm's Veterinary Haematology [10]. The serum concentrations of total protein (STPC), albumin (SAC) and urea (SUC) were determined. The optical densities were measured at 637nm. SUC was determined using diacetyl monoxime (DAM) and thiosemicarbazide reagents (TSC) [11]. The optical densities were measured at a wave length of 520 nm. Plasma glucose concentration (PGC) was determined by the colorimetric method using a commercial kit (Aromex-Amman, Jordon) [12]. The optical densities were measured at a wave length of 540nm.

Statistical Analyses: The effect of exposure to solar radiation on blood composition and duration was evaluated by two way ANOVA using the statistical software [13]. The data obtained were presented as means ± S.E.

RESULTS AND DISCUSSION

Table 1 shows the prevailing ambient temperature during which this experiment was conducted.

In the present study, the unshaded rams maintained progressively higher total leukocyte count (TLC) during the experimental period (Table 2). This increase could be associated with modulation in the responses of the rams to thermal stress. Exposure to heat stress stimulates the release of glucocorticoids which usually increase the leukocytes in blood from lymphoid tissue and bone marrow [14]. The increase in TLC in heat stressed animals could be due to thyromolymphatic involution [15]. The significant ($p<0.05$) increase in neutrophils ratio in the 1st week compared to the last two weeks (Table 3) could be associated with high levels of cortisol secreted during acute heat stress. Higher number of neutrophils were reported in heat stressed Tasmania ewes [16]. The remarkable eosinopenia observed in unshaded rams ($p<0.05$) in the 3rd week (Table3) compared to the control, could be associated with increases in adrenocorticoids levels. During heat stress adrenocorticoids increase the sequestration of eosinophils in the spleen and lungs [14, 17]. However, the ratio of monocytes (Table3) significantly ($p< 0.05$) decreased in the 1st week compared to the other two weeks. This response could be accounted for by the inhibition of migration of monocytes from spleen and bone marrow and reduction in their circulating number in response to short-term rise of blood cortisol. Blood cortisol level increases in response to acute heat exposure [18, 19]. The general effect of cortisol usually subsides during chronic heat stress and adaptation to hot environment [20].

The exposure to solar radiation significantly ($p< 0.05$) increased serum total protein concentration (Table2) in third week of the experimental period compared to the respective value obtained for the shaded rams.

Table 2: Effects of exposure to solar radiation on some blood parameters of Sudanese desert Hamari rams (n = 12)

	Blood parameters											
	PVC%		Total leukocyte count ($x10^3/\mu l$)		Glucose conc. (mg/dl)		Total protein con. (g/dl)		Albumin conc. (g/dl)		Urea conc. (mg/dl)	
Week	Shaded	Unshaded	Shaded	Unshaded	Shaded	Unshaded	Shaded	Unshaded	Shaded	Unshaded	Shaded	Unshaded
1	26.8±1.3	26.8±1.3	5.9±0.3	5.9±0.7	81.6±5.0^{Aa}	81.8±6.0^{Aa}	7.6±0.4^{Aa}	7.3±0.1^{Aa}	3.9±0.4^{Aa}	3.6±0.1^{Aa}	24.2±1.9^{Ba}	28.5±2.2^{Aa}
2	24.0±0.7	22.3±1.7	6.2±0. 5	7.5±0.6	85.6±2.0^{Aa}	85.1±2.7^{Aa}	7.5±0.2^{Aa}	7.8±0.4^{Aa}	3.8±0.1^{Aa}	3.5±0.1^{Ab}	30.1±2.4^{Aa}	24.1±2.6^{Aa}
3	27.0±1.6	23.0±2.3	8.1±0.2	7.6±0.9	74.2±3.6^{Ba}	56.8±3.4^{Bb}	6.6±0.3^{Bb}	7.7±0.3^{Aa}	3.7±0.1^{Aa}	3.48±0.1^{Aa}	18.5±1.9^{Ba}	17.80±2.4^{Ba}

Values (mean±SE), for each parameter, with different lower case letters in the same row and with different upper case letters in the same Column differ significantly (P < 0.05)

Table 3: Effect of exposure to solar radiation on differential leukocyte count of Sudanese desert Hamari rams (n = 12)

		Treatment	
WBC Type	Time (weeks)	Shaded	Unshaded
Lymphocytes	1	56.25±4.21	52.75±5.39
	2	64.50±2.02	55.75±6.61
	3	61.75±0.63	63.75±1.38
Neutrophils	1	37.00±4.45^{Aa}	41.05±5.73^{Aa}
	2	28.75±1.97^{Aa}	29.76±0.63^{Ba}
	3	28.75±1.25^{Aa}	29.00±1.47^{Ba}
Eosinophils	1	3.25±0.48^{Aa}	3.50±0.65^{Aa}
	2	2.25±0.63^{Aa}	3.00±0.01^{Aa}
	3	5.50±1.55^{Aa}	2.25±0.25^{Ab}
Monocytes	1	3.50±0.50^{Aa}	2.75±0.48^{Ba}
	2	4.75±0.25^{Aa}	4.50±0.50^{Aa}
	3	3.75±0.75^{Aa}	4.50±0.50^{Aa}

Values (mean±SE), for each WBC type, with different lower case letters in the same row and with different upper case letters in the same Column differ significantly (P < 0.05)

The increase in serum total protein concentration could be attributed to increased urinary nitrogen retention. This response is associated with depression in feed consumption and increased tissue protein catabolism [21]. Acute heat exposure decreases serum total protein due to increased plasma volume [22]; however nitrogen retention increases with prolonged heat exposure for protein building [15]. Similar results were reported [23] on exposure of Lettle wethers to heat stress due to increased nitrogen retention. However, in Sudanese desert rams fed lucerne hay and exposed to direct solar radiation, the plasma total protein level increased insignificantly [24].

In the second week, the serum albumin concentration was significantly (p< 0.05) lower in unshaded rams (Table2) compared to the value obtained for the shaded group. This response is clearly associated with high ambient temperature and increased cortisol level, as the blood albumin concentration is inversely related to blood cortisol level. It was reported [25] that the decrease in the binding capacity of albumin in blood was associated with high free blood cortisol level. This result could be also related to the decline in food intake which results in low amount of amino acids available for albumin synthesis in the liver [26, 27]. Similar findings were reported [22, 28]. Abdelatif and Ahmed [24] reported that exposure of Sudanese desert rams fed lucerne hay to solar radiation did not influence the plasma albumin concentration.

The significant (p< 0.05) decrease in serum urea concentration in the last week of exposure to solar radiation (Table 2) could be associated with the decrease in food intake and increased panting .Payne and Payne [26] indicated that lowering the amount of protein required for formation of NH_3, which is converted to urea in the liver, is usually responsible for decrease in blood urea concentration. Also this reduction is attributed to higher rate of water consumption and the increase in urine volume excretion in response to vasopressin and aldosterone hormones [15]. Also the low values of serum urea could be accounted for by increased secretion of catabolic hormones of the adrenal cortex in heat stressed rams. Authors [29] reported that in ruminants exposed to heat stress with low dietary protein, the secretion of the catabolic hormones of the adrenal cortex is elevated, which resulted in nitrogen losses and the nitrogen balance becomes negative. Also this response could be related to the reabsorption of the urea- N from the blood to the rumen in response to decrease in ruminal ammonia due to lowered food intake [30] The present finding contradicts the results reported [24] in Sudanese desert rams exposed to solar radiation.

The plasma glucose concentration of the unshaded rams (Table 2) was significantly (p<0.01) (p<0.05) lower in the 3rd week compared to the 1st two weeks and to the value reported for the control rams respectively .This response could be related to the high respiration rate and consequently high utilization of glucose by the respiratory muscle and decrease in feed intake [15]. The significantly lower plasma glucose level reported in the unshaded rams compared to the control, could be

related to low food intake in the radiant environment and to the decline of adrenocortical activity in response to prolonged heat stress [15]. A decrease in plasma glucose level of Egyptian Suffolk rams in response to chronic heat stress was attributed to low cortisol level [31].

In conclusion, the different parameters of blood of Sudanese desert rams are influenced by heat stress. Under tropical conditions, the necessity for shade and water supply in different rearing systems of sheep became high to maintain their production. Further studies are required to correlate between the effect of heat stress on the immune system and diseases susceptibility.

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