J. Agric. Sci. Mansoura Univ., 28 (7): 5307 - 5316, 2003

CERTAIN HEMO-BIOCHEMICAL CHANGES DUE TO EXERCISE AND WATER DEPRIVATION STRESSES OF SHEEP AND GOATS UNDER DROUGHT CONDITIONS

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ABSTRACT

Twelve adult females of each of Abou-Delik sheep and Baladi goats raised at Hederba Research Station (in the extreme south of the eastern desert of Egypt), were divided into three equal groups (each 4 sheep ; 4 goats). The first group was standing outdoors just inside wire-fenced pen and watered once every day as control. The second group was enforced to walk 12 km from 09.00 hr. to 15.00 hr. and watered daily. The third group walked the same distance, at the same time, and watered once every 48 hours for consecutive two cycles (each 2 days). After the end of the treatments, animals were left for recovery in their pens for extra two days. This study aimed at studying the adaptive physiological mechanisms that enabled such animals to withstand the walking stress and water deprivation during grazing under hot desert conditions. In this respect, blood samples were collected from all animals to determine some hematological parameters (hematocrit, hemoglobin concentration, red blood cells and white blood cells counts in addition to hemoglobin indices (mean corpuscular volume, mean cell hemoglobin and mean cell hemoglobin concentration). Some blood biochemical measures in terms of plasma proteins, glucose, urea, creatinine, lactate dehydrogenase and transaminase enzymes (aspartate and alanine aminotransaminase) were also determined.

Results revealed that hematocrit % , hemoglobin concentration, red blood cells and white blood cells counts were markedly elevated ($P<0.01$) than their pre-exercised values in both sheep and goat groups suffering either single or combined stress. On the other hand, results of hemoglobin indices revealed a marked reduction in mean corpuscular volume, elevation of mean cell hemoglobin and mean cell hemoglobin concentration coincided with higher elevation in red blood cells count, hematocrit value and hemoglobin concentrations in both sheep and goat groups either under single or combined stress. Muscular activity seemed to accompany with glycogenolysis in the liver cells as indicated by prolonged elevation in glucose concentration and enzymes activity following exercise and rest periods. Following exercise, blood urea and creatinine concentration was markedly elevated either due to single or combined stress in both sheep and goat groups. Plasma enzymes activity as well as lactate dehydrogenase increased ($P<0.01$) in both sheep and goat groups due to single or combined stress. During the rest period, most of these parameters recovered nearly their pre-exercise values. It could be concluded that walking for long distances between grazing areas and water holes is an great problem facing animal flocks in desert areas. The lower metabolic rate reported for walking animals as well as hemo-biochemical changes seemed to be the target physiological mechanisms particularly when suffering combined stresses under desert conditions.

Keywords: Sheep, Goats, Walking stress, Water deprivation, Hematological parameters, Biochemical parameters.

INTRODUCTION

Shalateen – Halaib triangle is located in the southeastern corner of the eastern desert of Egypt. The region has a vital and strategic importance to Egypt. It looks like a triangle with a bottom side of about 300 km parallel to 22° latitude (the Egyptian–Sudanese borders). Since the conventional agricultural activities are not available in such area, sheep, goats and camels form an important segment of animal resources representing the main source of income in the triangle region (EL-Shaer *et al.*, 1997). Abou-Delik sheep and Baladi goats are the most dominant breeds in this region. Badawy (2003) characterized the Abou-Delik sheep breed in details. However, scarcity of palatable natural shrubs and water as well as the extreme harsh climatic conditions are the most striking characteristics of desert lands. Furthermore, during the dry season, natural vegetation was reported to be poor suffering the critical shortage in energy content, some trace elements and vitamins, especially vitamin A which affected adversely the livestock productivity.
Performance of range animals in stressful environments is limited by their physiological and behavioral abilities to cope with such constraints. The present work focused on the certain hematological and biochemical changes of both sheep and goats, from the adaptive point of view, when facing a single stress of forced walking and a combined with 2-day water deprivation during drought season.

MATERIALS AND METHODS

During drought season (April, 2001), twelve adult females of each of Abou-Delik sheep and Baladi goats (aged1.5–2.5 yr., with average body weight of 27.0 ± 1.65 and 17.6 ± 0.85 kg, respectively) were divided randomly into three equal groups (each 4 sheep; 4 goats). The first group was standing outdoors in wire-fenced pen along day and night and watered once every day as control, while the second enforced to walk 12 km from 09.00 to 15.00 hr. and watered once daily for consecutive two cycles (each of 2 days). The third group also walked the same distance at the same time but suffered water deprivation for 48 hours for consecutive two cycles. Following dehydration period (two cycles), all animals rested in their pens for extra two days. In the early morning before feeding and watering, blood samples were withdrawn via the jugular vein using a clinical needle. Samples were collected once before beginning the treatments (0-time) and then twice per cycle (before walking and after return) for the three groups. Blood samples, using EDTA, were used for the red blood cells (RBC's, $x10^6$/ mm^3) and white blood cells (WBC's, $x10^3$/ mm^3) counts by using a hemocytometer (Kolmer *et al.*, 1951). In addition, heparinized blood samples were used for the determination of hematocrit (Ht,%) and hemoglobin concentration (Hb, g/dl) using Wintrob tubes and available kits supplied by the Egyptian-American Company. Heparinized blood samples were centrifuged at 3000 r.p.m. for 15 minutes to obtain clear plasma that stored at –20 °C in glass vials until the assay was performed. Total proteins (TP, g/dl) and albumin (A, g/dl) were determined using available kits

supplied by bioMe'rieux-France company according to Dumas *et al.*, (1971) from which plasma globulin (G, g /dl) and albumin/globulin (A/G) ratio were calculated. Blood glucose (Glu, mg/ dl) was determined according to Somogyi (1945). Also, some serum enzymes especially alanine transaminase (ALT, u/l), aspartate transaminase (AST, u/l) and lactate dehydrogenase (LDH, u/l) as indictors of liver function were determined using a specific kits supplied by bioMe'rieux-France according to Reitman and Frankel (1957) and Scandinavian Society for Clinical Chemistry (1974). Serum urea (Ur) and creatinine (Cr) levels as indicators of kidney functions were determined using available kits supplied by bioMe'rieux-France according to Patton and Crouch, (1977) and Houot (1985), respectively.

Statistical analysis:

Data were analyzed as split plot repeated measurements using SAS (1998) utilizing General Linear Model (GLM) proc. Duncan's Multiple Range Test (DMRT) was used to compare differences between means.

RESULTS AND DISCUSSION

Hematological responses

Hematological parameters (Ht, Hb, RBC's and WBC's) were markedly elevated ($P<0.01$) than their pre-exercised values in both sheep and goat groups suffering either single or combined stress (Table 1). The magnitude percentage of increases due to forced walking (single stress) for sheep were 19, 19.8, 19 and 8.8 % respectively. The corresponding percentages for goats were more limited to be 7.8, 23.7, 7.8 and 5.5 % except for Hb. Similar observations of increased Hb concentration and Ht value after racing were also found in camels (Snow *et al.*, 1988; El-Hassanein and Fawzia., 1996 ; Mohamed and Hussein, 1999) and horses (McKeever *et al.*, 1993). It is well known that, the spleen is an important reservoir of blood cells to be called upon when the body has a greater need for oxygen in the tissues. Thus, the onset of exercise leads primary to splenic contraction and exciting the animal that leads also to releasing of catecholamines. Under such conditions, there will be an increase of erythrocytes count, PCV value and Hb concentration (Martinez *et al.*, 1988). El-Hassanein and Fawzia (1996) attributed such increases in RBC's, Hb and PCV of raced camels to splenic contraction and/ or hemoconcentration. The present results indicated that goats were slightly affected by forced walking as indicated by their relative increases in such hematological parameters when compared with sheep. Based on this finding, goats might be more adapted to grazing for a long distance and time under desert conditions than sheep. In sheep, thirst during exercise (combined stress) was of a pronounced effect than exercise, judging by the higher percentage of increases ($P<0.01$) in Ht (28.5 vs. 19.0 %), RBC's (29.5 vs. 19.0 %), WBC's (16.0 vs. 8.8 %) and Hb value (22.6 vs. 19.8 %). The same trend was also found in goat groups except for WBC's where the rate of increases slightly declined (5.5 vs. 3.1%).

Table 1: Hematological responses of experimental sheep and goat groups during walking period.

Experi-mental period		Hematological parameters							
		Sheep				Goats			
		Ht %	Hb g/dl	RBC's $X10^6/\mu l$	WBC's $X10^3/\mu l$	Ht %	Hb g/dl	RBC's $X10^6/\mu l$	WBC's $X10^3/\mu l$
	0-time	25.2	16.8	7.5	12.5	25.5	18.0	7.7	12.8
	T1	26.3^a	17.7^a	7.8^a	12.5^a	25.8^a	19.0^a	7.7^a	12.8^a
Tr	T2	31.3^b	21.2^b	9.3^b	13.6^b	27.8^a	23.5b	8.3^b	13.5^b
	↑(%)	19.0	19.8	19.0	8.8	7.8	23.7	7.8	5.5
	T3	33.8^c	21.7^c	$10.^c$	14.5^c	32.3^b	24.3^c	9.6^c	13.2^c
	↑(%)	28.5	22.6	29.5	16.0	25.2	27.9	24.7	3.1
	T1	28.8^a	17.3^a	7.3^a	12.2^a	26.3^a	18.4^a	7.5^a	12.5^a
	T2	30.0^a	19.2^a	8.5^b	13.0^b	27.0^a	20.8^a	7.8^a	12.6^a
RP	T3	31.3^a	19.3^a	8.3^b	13.1^b	29.0^a	21.8^a	8.6^b	12.6^a
	Overall mean	28.7	18.6	8.0	12.8	27.4	20.3	8.0	12.6

Tr; Treatments . RP; recovery period. T1, control group. T2; walked group.T3; walked and water deprived group. Ht, hematocrit. Hb; hemoglobin. RBC's; red blood cells. WBC's; white blood cells.
Means having different superscript within the same column differed significantly ($P<0.01$).

The present results partially agreed with those of El-Hassanein and Fawzia (1996) on raced camels. They reported an increase of WBC's by 33-34% and remained higher than their normal values within the rest period. However, in the present study, values recovered rapidly at the end of 2-day rest period. The contrasted results might be due to the differences in species and period of racing. The present results agreed with those of MaCarthy *et al.* (1987) and Mohamed and Hussein (1999). They suggested that the delayed increases of leucocytes (up to 235% increase at 5 hours post exercise) might be related to a gradually release of leucocytes from bone marrow. Under drought conditions, results reflected the higher adaptability of goats to maintain constant blood volume during stress to conserve water that will be used in evaporative cooling and also reflect the higher need for oxygen uptake to cover their activity. On the other hand, results of hemoglobin indices (Table 2) revealed a marked reduction in MCV and an elevation of MCH and MCHC coincided with higher elevation in RBC's count, Ht % and Hb concentration in both sheep and goat groups either under single or combined stress. These results might reflect the ability of these animals to compensate for red cells shrinkage by increasing these cells number to achieve a Ht value higher than that of the control because of hemoconcentration that accompanied the loss of water due to walking or water deprivation. These variations in hemoglobin parameters might indicate the higher need for oxygen consumption to meet the requirements of higher activity. Blood Hb increased as a result of an increase in values of mean cell hemoglobin concentration (MCHC) which indicated an adaptive physiological control on Hb against stressfull conditions (El-Sherif et al., 1996). During the rest period, most of these parameters returned to their pre-exercised values (Table 2).

Table 2: Hemoglobin indices of sheep and goats during the experimental period

	Experim-ental period	Blood biochemical analyses							
		Sheep				Goats			
		MCV µ3	MCH Pg	MCHC g/dl	Glu mg/dl	MCV µ3	MCH Pg	MCHC g/dl	Glu mg/dl
	0-time	33.6	22.2	67.0	115.9	33.4	24.1[a]	71.5	110.2
	T1	33.9[a]	22.8[a]	67.2[a]	121.7[a]	33.6[a]	24.8[a]	73.9[a]	111.0[a]
	T2	33.5[a]	24.8[a]	78.0[b]	166.4[b]	33.0[a]	28.4[a]	84.8[b]	151.2[b]
Tr	↑(%)	-1.2	8.8	16.1	36.7	-1.8	14.5	14.7	36.2
	T3	33.6[a]	25.6[b]	78.5[b]	176.6[c]	33.0[a]	28.3[a]	87.2[b]	151.8[c]
	↑(%)	-0.9	15.3	16.8	45.1	-1.8	14.1	18.0	36.8
	T1	33.3[a]	22.8[a]	67.1[a]	110.0[a]	33.4[a]	24.6[a]	72.3[a]	109.3[a]
RP	T2	33.8[a]	23.8[a]	68.8[a]	122.9[b]	33.5[a]	28.4[a]	74.5[a]	125.7[b]
	T3	33.5[a]	23.0[a]	67.0[a]	128.9[b]	33.5[a]	25.6[a]	73.1[a]	119.4[b]
	Overallmean	33.5	23.2	67.6	120.6	33.5	26.2	73.3	118.1

MCV; mean corpuscular volume. MCH; mean cell hemoglobin. MCHC; mean cell hemoglobin concentration. Glu; glucose.
Means having different superscripts within the same column differed significantly (P<0.01).

Biochemical responses:

It is well known that the maintenance of exercise requires production of sufficient energy to meet the demands necessary for the muscular movement. Metabolic demand is met by the conversion of chemical fuel substrates, normally carbohydrates and fats into adenosine triphosphate (ATP) which is the energy currency of the muscular contractile process (Hodgeson, 1994). Exercised animals showed a marked elevation in the blood glucose concentration. It is curious that glucose elevation after exercise, in sheep group, reached about 36.7, 45.1 % of their pre-exercise values under single and combined stress, respectively. The corresponding values in goats group were 36.2 and 36.8 % (Table 2). These findings might reflect that the onset of exercise rapidly enhanced the glycogenolysis process in the liver, which resulted in high elevation in the glucose concentration that was much more than that needed during rest. Muscular activity is found to accompany with glycogenolysis in the liver cells that causes some cellular impairment as indicated by prolonged elevation in glucose concentration and enzymes activity following exercise and during the rest period. Similar results were also reported in raced camels by snow *et al* (1988), Evans *et al.* (1992), El-Hassanein and Fawzia (1996) and Mohamed and Hussein (1999). On the other hand, the output of adrenocorticotrophic hormone, glucocorticoid and adrenaline are increased for breakdown of liver glycogen (Bell *et al.*, 1961). The adrenocorticotrophic hormone acts especially in mobilizing amino acids from body proteins, which is associated with an increase in the rate of hepatic deamination and conversion of certain of the resultant J ketoacids to glucose (Allen, 1977). Blood plasma proteins and albumin were elevated significantly (P<0.01) as well as globulin for both sheep and goat groups suffered either single or combined stress (Table 3). Increased TP concentrations in exercised animals may be an indicator of the incidence of hemoconcentration (Khalifa *et al.*, 2000) which may be due to the loss of considerable amount of body water through sweating.

Table 3: Plasma proteins of sheep and goats during the experimental period

Experimental period		Blood biochemical analyses							
		Sheep				Goats			
		TP g/dl	A g/dl	G g/dl	A/G ratio	TP g/dl	A g/dl	G g/dl	A/G ratio
	0-time	7.4	3.6	3.8	0.95	7.4	3.6	3.8	0.95
	T1	7.5^{a}	3.6^{a}	3.9^{a}	0.92^{a}	7.3^{a}	3.7^{a}	4.1^{a}	0.90^{a}
	T2	9.9^{b}	4.8^{b}	5.1^{b}	0.94^{a}	9.3^{b}	4.6^{a}	4.7^{a}	0.98^{a}
Tr	↑(%)	32.0	33.3	30.8	2.2	27.4	24.3	14.6	8.9
	T3	9.5^{b}	4.4^{b}	5.1^{b}	0.86^{b}	9.4^{b}	4.4^{a}	5.0^{a}	0.88^{b}
	↓(%)	26.7	22.2	30.8	- 6.5	28.8	18.9	22.0	-2.2
	T1	7.7^{a}	3.3^{a}	3.4^{a}	0.97^{a}	7.8^{a}	3.8^{a}	4.0^{a}	0.95^{a}
	T2	8.6^{a}	4.2^{b}	4.4^{b}	0.94^{a}	7.2^{a}	3.3^{a}	3.9^{a}	0.87^{a}
	T3	8.8^{a}	4.2^{b}	4.6^{b}	0.91^{a}	8.1^{a}	3.8^{a}	4.3^{a}	0.89^{a}
RP	Overall mean	8.4	3.9	4.1	0.94	7.7	3.6	4.1	0.90

TP: total protein. AL: albumin G: globulin A/G; albumin/ globulin ratio.
Means having different superscripts within the same column differed significantly (P<0.01).

The same trend was also reported in camels by Evans *et al.* (1992), El-Anwer *et al.* (1993) and El-Hassanein and Fawzia (1996). On the other hand, in acclimatized animals; the body can manufacture the proteins rapidly to restore blood osmotic pressure as reported by Nijland and Baker (1992).

The present results were in harmony with those of El-Sherif *et al.* (1996) who reported that sun exposed animals had higher TP values when dehydrated than hydrated ones due to the increase in globulin portion and as a result A/G ratio was significantly lower for dehydrated groups than their counterparts. After rest period, values tended to decline slowly but still above their pre-exercised values reflect the exhaustion state.

The levels of serum urea and creatinine are used to reflect the state of glomerular filtration rate and kidney function. The reference of blood urea nitrogen for sheep and goats ranged from 8-40 mg/dl serum (Kaneko, 1989). In the present study, blood urea concentration was markedly elevated by 9.1 % (26.4 vs. 28.8 mg/dl) and by 19.1 % (17.8 vs. 21.2 mg/dl) in both sheep and goats group after enforced exercise. The corresponding increases due to combined stress were 26.1 and 46.1 % for both sheep and goats, respectively. In addition, mean urea concentration was steadily recovered its pre-exercise value during rest period. The same trend was also noticed for creatinine, where an increase of 17.9 and 25.0% were found in both sheep and goat groups suffering single stress. The corresponding percentage increases during combined stress were 28.6 and 37.5 %. Similar results were reported in camels (Evans *et al.*, 1992 ; El-Hassanin and Fawzia, 1996), sheep (Lerg *et al.*, 1987) and rabbits (Szabo *et al.*, 2002). The elevation of blood urea of exercised animals might be due to the combined prerenal effects of reduced infusion with lower glomuler filtration and greatest load from increased metabolic activity (Snow et al., 1988).

Lactate dehydrogenase also increased by 8.8 and 27.7% in sheep group suffered either single or combined stress, respectively (Table 4). Likewise,

LDH increased by 6.3 and 14.1% in goats group, respectively. The present results agree with those of Szabo *et al.* (2002) on rabbits and Estrella *et al.* (2000) on bulls during bullfighting.

The present results also revealed that combined stress was of more pronounced effects on liver function. Lactate dehydrogenase catalyzes the interconversion of pyruvate and lactate. So, exercised muscles convert glucose to lactate which released into the blood and uptake by the liver, which converts lactate back to glucose that released into the blood. This glucose is taken up by resting muscles, red blood cells and other tissues (Wahiefeid, 1983). After rest period, animals were rapidly recovered their pre-exercised values.

Transaminases are widely distributed in plasma, bile, cerebrospinal fluid and saliva but none is found in urine unless a kidney lesion is present (Norbert, 1987). Serum alanine aminotransaminase (ALT) is particularly useful in measuring hepatic necrosis and increased in serum when cellular degeneration or destruction occurs. On the other hand, aspartate aminotransaminase (AST) is present in extrahepatic tissues including myocardium and kidney and can be used as a good indicator of hepatic injury

Table 4: Some liver and kidney functions of sheep and goats during the experimental period

		Blood biochemical analyses									
		Sheep					Goats				
Experim-ental period		ALT U/l	AST U/l	LDH U/l	Ur mg/l	Cre mg/l	ALT U/l	AST U/l	LDH U/l	Ur mg/l	Cre mg/l
0- time		5.1	32.5	15.7	26.0	2.9	4.8	32.1	17.6	18.0	1.6
	T1	5.1^{a}	32.2^{a}	15.9^{a}	26.	2.8^{a}	4.8^{a}	34	19.1^{a}	17.	1.6^{a}
	T2	6.1^{b}	34.9^{a}	17.3^{b}	28.	3.3^{b}	5.2^{b}	36.	20.3^{a}	21.2	2.0^{b}
	›(%)	19.6	8.4	8.8	9.	17.9	8.3	6.1	6.3	19.	25
Tr	T3	5.9^{b}	38.5^{b}	20.3^{c}	33	3.6^{b}	5.3^{b}	41	21.8^{b}	26.	2.2^{b}
	›(%)	15.7	19.6	27.7	26	28.6	10.4	20.5	14.1	46.	37.5
	T1	4.9^{a}	32.1^{a}	16.1^{a}	26.	2.8^{a}	4.7^{a}	29	17.2^{a}	17.3	1.8^{a}
	T2	5.2^{a}	31.5^{a}	16.2^{a}	27.	2.9^{a}	5.1^{a}	29	17.3^{a}	20.6	1.8^{a}
	T3	5.4^{a}	30.8^{a}	16.5^{a}	23.	2.8^{a}	4.6^{a}	31	16.6^{a}	20.8	2.0^{a}
RP	Overall mean	5.2	31.5	16.3	25.9	2.8	4.8	30.0	17.0	19.6	1.9

ALT; alanine aminotransaminase. AST; aspartate aminotransaminase. LDH; lactate dehydrogenase. Ur; urea. Cr;creatinine .

Means having different superscripts within the same column differed significantly (P<0.01).

(Lessard *et al.*, 1986). The increased hepatic enzymes activity due to single or combined stresses was observed in both sheep and goat groups. In sheep group, the percentage of increases in ALT and AST due to single stress was 19.6 and 8.4%, respectively. While, it amounted to 8.3 and 6.1 % in goats group. Higher elevations of the previous liver parameters(ALT and AST) in response to combined stress were found to be 15.7 and 19.6 % for sheep and 10.4 and 20.5 % for goats group, respectively. El-Anwer et al. (1993) and El-Hassanein and Fawzia (1996) found similar observations in transaminases activity in raced camels. In the present study, the increased hepatic enzymes activity might be an indicative parameters for liver cellular impairment due to rapid glycogenolysis as a response to the intense of stresses upon animals.

In conclusion, the onset of exercise is followed by rapid glycogenolysis in the liver cells that causes some cellular impairment as indicated by prolonged elevations in enzymes activity. In addition, splenic contraction following exercise stress resulted in high elevations of RBC's count and Hb concentration to meet the demand of oxygen for muscular activities. On the other hand, WBC's increased as a result of stress stimulation on bone marrow. In general, most parameters returned to their normal state after the rest period indicating the adaptability of both grazing sheep and goats under drought conditions due to good utilizing of their physiological mechanisms to cope with these desert constrains. On the other hand, the lower metabolic rate reported of walking in desert animals (Yousef, 1999) allows them to graze long distances searching for water sources and thus contribute to their thriving deserts using limited amounts of food and water. The low energy cost of locomotion suggests that selection for locomotion efficiency may have occurred as an adaptive mechanism for survival in harsh conditions and still need more research to develop a practical and easy method for measuring energy cost of locomotion for free-ranging animals.

ACKNOWLEDGEMENT

This work is a part of a Project to Improve Animal Production in Shalteen-Halaib triangle, which financially support by the National Academic of science. The authors wish to express their gratitude to Prof. Dr. H. M. El-Shaer; Vice President of the Desert Research Center and the main investigator of the project for his continuous interest, encouragement and facilitate the research materials.

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بعض التغيرات الهيماتولوجية والبيوكميائية فى دم الأغنام والماعز نتيجة تعرضها لاجهادات المشى والتعطيش تحت ظروف الجفاف

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قسم فسيولوجيا الحيوان والدواجن- شعبة الإنتاج الحيواني والدواجن - مركز بحوث الصحراء- المطرية- القاهرة

أجريت التجربة بمحطة بحوث حدربة التابعة لمركز بحوث الصحراء والتي تقع فى أقصى الجنوب من الصحراء الشرقية واستخدم فى هذه التجربة اثنتا عشرة أنثى من كل من أغنام ابودليك والماعز البلدي قسمت إلى ثلاث مجا ميع (كل مجموعة ٤ نعاج ، ٤ إناث ماعز). تركت المجموعة الأولى حبيسة فى حظائر سلك طوال اليوم (كنترول) فى حين تعرضت المجموعة الثانية للمشى مسافة ١٢ كيلومتر من الساعة التاسعة صباحا وحتى الثالثة ظهرا يوميا ولمدة أربعة أيام بينما تعرضت المجموعة الثالثة للسير نفس المسافة بجانب حرمانها من الشرب لمدة ٤٨ ساعة وعلى مدار ٤ أيام (دورتين تعطيش) ثم تركت المجاميع الثلاثة للراحة لمدة يومين بهدف دراسة بعض التغيرات الهيماتولوجية والبيوكميائية فى دم الأغنام والماعز عند تعرضها لاجهاد المشي أثناء النهار مع التعطيش لمدة ٤٨ ساعة .

أوضحت النتائج زيادة معنوية فى قيم الهيماتوكريت والهيموجلوبين وكرات الدم الحمراء والبيضاء فى مجا ميع الأغنام والماعز المعرضة لاجهاد المشي عن مثيلاتها قبل بداية التجربة وارتفعت معدلات الزيادة فى حالة التعرض للمشى مع التعطيش و كانت معدلات الزيادة فى الماعز اقل من الأغنام مما يعكس مدى تأقلم الأولى بدرجة اكبر تحت ظروف السير فى الصحراء. أوضحت النتائج أيضا حدوث انكماش بسيط فى حجم كريات الدم و تزامن هذا مع زيادة متوسط هيموجلوبين الخلية ومتوسط تركيز الهيموجلوبين فى الخلية مع زيادة عدد كرات الدم الحمراء كنتيجة لفقد الماء أثناء السير تحت أشعة الشمس وخاصة مع التعطيش مما أدى إلى زيادة قيم الهيموجلوبين و الهيماتوكريت. أدى التعرض للمشى فقط أو مع التعطيش إلى زيادة مستوى الجلوكوز فى الدم كنتيجة لتحلل جليكوجين الكبد وزيادة نشاط إنزيمات الترانس امينيز واللكتات دى هيدروجينيز والتي استمرت فى الزيادة بعد فترة الراحة. لوحظ أيضا استمرار الزيادة فى مستوى اليوريا والكرياتينين نتيجة للتعرض لاجهاد المشي فقط وخاصة مع وجود التعطيش. أكدت النتائج على قدرة هذه الحيوانات على التأقلم فسيولوجيا لظروف الإجهاد سواء كان منفردا أو متداخل مع عوامل أخري وربما كان لذلك تأثير على كفاءتها الإنتاجية.