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Effects of Season and Water Deprivation on Blood Cellular and Non-Cellular Components of the Aardi Goat

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ABSTRACT. In an attempt to evaluate the adpatability of Aardi goats to arid environment, 6 Aardi bucks were used to assess the effects of spring and summer seasons and 4-days of water deprivation during each season on some blood cellular and non-cellular constituents. High ambient temperature during summer caused significant rise in blood haemoglobin (Hb), packed cell volume (PCV), red blood cell counts (RBC), mean cell haemoglobin concentration (MCHC), serum total protein (TP) and albumin (A) and a significant decline in mean cell volume (MCV), mean cell haemoglobin (MCH) and white blood cell counts (WBC) compared with their levels during moderate ambient temperature of spring.

Water deprivation for 4-days caused 17% and 18% loss in body weight during spring and summer, respectively. This was accompanied by significant elevation in blood Hb, PCV and RBC to almost similar extent during spring and summer seasons. TP also rose during water deprivation especially in summer as a result of the increase in both albumin (A) and globulin (G) concentrations, but the increase in the former was less than that in the latter, resulting in a lower A/G ratio.

The similarity in body weight losses and in blood haematological changes during spring (24.8 C) and summer (35.8 C) in association with water deprivation may indicate that Aardi goats are well adapted to the arid environment.

Goats are of considerable interest to the agricultural development in arid regions, where extreme heat or cold prevails for most of the year. These high and low environmental temperatures along with shortage in water and sparse desert pasture are the main stressfull conditions that make the hot desert a hostile environment to animal productivity (Hassan *et al.* 1986; Jindal 1980). These stressors are known to evoke a gamut of changes-which vary in magnitude from species to species-in the biological processes of homeotherms. Among various domestic animals, goats are probably privileged to be able to withstand arid environment and continue to eat and produce milk (Maltz *et al.* 1984).

Aardi goats, a desert-evolved breed, inhabit the central region of Saudi Arabia. They are black, hairy, long legged with wide long ears and their mature body weight reach 40-60 kg. It is expected that these goats have acquired great adaptability that enable them to thrive under a wide range of environmental conditions. Therefore, this study was conducted to examine the effects of season (summer *vs* spring), water deprivation and length of deprivation (2 *vs* 4 ays) on some blood cellular and non-cellular components of black Aardi goats.

Materials and Methods

Six Aardi bucks 1-2 years of age, belonging to the Animal Production Department Experimental Station, College of Agriculture, King Saud University were used in an attempt to evaluate their adaptability to seasonal variations in air temperatures and water deprivation. Animals were individually housed in a confinement barn and fed on hay *ad libitum* along with 0.5 kg/day of commercially formulated concentrates (12% crude protein) given at 9.00 hr. Water was available at all times except during the deprivation period.

The experiments started on March 1986 (spring season) and lasted for three weeks. Daily maximum and minimum ambient air temperatures were recorded. Dry and wet bulb temperatures were also recorded twice a day at 9.00 and 16.00 hr. The first week was considered as a preliminary period. During the second week (control period), initial body weight (Bwt.) was recorded and three blood samples were collected at 0, 2 and 4 days from the initiation of the control period. Blood samples were collected at 9 a.m. from the external jugular vein using EDTA vacutainer tubes and were immediately placed on ice until used. Sample was also collected in plain tubes for obtaining serum. Plasma or serum was obtained by centrifugation of blood at 860 xg for 20 min, and were stored at −20°C till analysed. Then water was withheld during the third week for 4 days (deprivation period). Animals were weighed and blood samples were collected at 0, 2 and 4 days from the beginning of deprivation.

Whole blood were analysed shortly after collection for haemoglobin (Hb), packed cell volume (PCV) and red blood cell (RBC) and white blood cell (WBC) counts by the conventional methods of Hepler (1966). Mean cell volume (MCV), mean cell haemoglobin (MCH) and mean cell haemoglobin concentration (MCHC) were calculated as described by Hepler (1966). Total serum protein (TP) was determined by the method of Armstrong and Carr (1964). Albumin (A) concentrations were assayed utilizing the method of Doumas *et al.* (1971) and globulin (G) concentrations were obtained by subtraction. The above experimental protocol was repeated again during September 1986 (Summer season).

Data were subjected to statistical analyses at King Saud University Computer

Center according to Goodnight *et al.* (1986). The least squares analyses of variance program was applied to the data. The following model was used:

$$Y_{ijkl} = U + S_i + T_j + L_k + (ST)_{ij} + (SL)_{ik} + (TL)_{jk} + (STL)_{ijk} + e_{ijkl}$$

where, Y_{ijkl} is the 1st observation of the ith season, jth treatment and kth length of deprivation. U is the general mean and e_{ijkl} is the random error associated with the Y_{ijkl} observation.

Results and Discussion

Average maximum ambient temperature recorded during the experimental period was 24.8°C during Spring and 35.8°C during Summer with corresponding minimum values of 21.8°C and 31.6°C. Average a.m. relative humidity and vapour pressure were 68% and 13.6 mmHg during Spring and 40% and 15.1 mmHg during Summer. The corresponding p.m. values were 65% and 13.3 mmHg during Spring and 41% and 17.2 mmHg during Summer.

The effects of season, water deprivation, length of deprivation and their various interactions on Bwt, blood Hb, PCV, RBC, MCV, MCH and MCHC of Aardi bucks are presented in table 1 and on WBC and serum proteins in table 2. The percent changes due to water deprivation in the above parameters from the control are presented in table 3. Feeding regime was constant throughout the experimental periods, therefore, the rise in Bwt from spring to summer can be ascribed mostly to the advancement of age. Four days of water deprivation resulted in a significant loss ($p < 0.01$) in Bwt (Table 1) that was slightly higher in summer compared with spring (18.3% *vs* 17.0%, Table 3) but the difference was not significant. The significant effect of length of deprivation and its interaction with treatment ($p < 0.01$) indicated that most of the losses in Bwt occurred during the first two days (Table 1 and 3). Sudanese desert goats subjected to water deprivation during hot summer lost 18% of their initial weight after 3 days only of water deprivation (Hadi 1986). Under the condition of hot summer of Egypt (air temp. reaches 34°C), desert-adapted Barki ewes were found to lose 20% of their Bwt after 4-days of water lack (El-Sherbiny *et al.* 1984). The present result indicates the superiority of the heavy Aardi goats to the small size black Bedouin goats (15-25 kg) known to be well adapted to endure severe dehydration. The black Bedouin goats were reported to lose 23% of their initial weight after 4-days of water deprivation (Maltz *et al.* 1984). Furthermore, the similarity in Bwt loss of Aardi goats during spring and summer despite the wide difference in the ambient temperature of the two seasons (24.8°C *vs* 35.8°C) clearly indicates that Aardi goats possess special adaptive mechanisms that enable them to economize in water and to thrive during arid conditions.

The rise in ambient temperature in summer was associated with a significant

Table 1. Least squares means and standard errors for body weight and some blood components as influenced by season, water deprivation and length of deprivation in Aardi goats.

Parameters	Season days	Control				Deprived				Overall season average
		0	2	4	Average	0	2	4	Average	
Bwt(kg)*	Spring	42.3±1.7	41.6±1.7	42.6±1.7	42.1±1.0	43.1±1.7	37.3±1.7	35.2±1.7	38.5±1.0	40.3±0.7^{D}
	Summer	46.4±1.7	48.1±1.7	46.4±1.7	47.0±1.0	47.1±1.7	41.7±1.7	38.4±1.7	42.4±1.0	44.7±0.7^{C}
	Mean	44.3±1.2^{a}	44.8±1.2^{a}	44.5±1.2^{a}	44.6±0.7^{A}	45.1±1.2^{a}	39.5±1.2^{b}	36.8±1.2^{b}	40.5±0.7^{B}	
Hb(gm%)	Spring	8.8±0.4	9.5±0.4	9.7±0.4	9.4±0.2	9.1±0.4	10.7±0.4	12.3±0.4	10.7±0.2	10.0±0.2^{D}
	Summer	11.3±0.4	10.4±0.4	11.1±0.4	10.9±0.2	10.3±0.4	13.0±0.4	13.6±0.4	12.3±0.2	11.6±0.2^{C}
	Mean	10.1±0.3^{c}	9.9±0.3^{c}	10.4±0.3^{c}	10.1±0.2^{B}	9.7±0.3^{c}	11.8±0.3^{b}	13.0±0.3^{a}	11.5±0.2^{A}	
PCV(%)	Spring	26.6±1.4	30.4±1.4	30.7±1.4	29.2±0.8	26.9±1.4	31.7±1.4	36.6±1.4	31.7±0.8	30.5±0.6
	Summer	31.9±1.4	30.3±1.4	32.0±1.4	31.4±0.8	30.8±1.4	34.3±1.4	40.9±1.4	35.3±0.8	33.4±0.6^{C}
	Mean	29.3±0.9^{c}	30.4±0.9^{bc}	31.3±0.9^{b}	30.3±0.6^{B}	28.8±0.9^{c}	33.0±0.9^{b}	38.8±0.9^{a}	33.5±0.8^{A}	
RBC($\times 10^6$/mm^3)	Spring	15.9±1.2	13.4±1.2	15.8±1.2	15.1±0.7	15.2±1.2	18.5±1.2	19.7±1.2	17.8±0.7	16.4±0.5^{D}
	Summer	20.5±1.2	18.1±1.2	19.7±1.2	19.4±0.7	19.4±1.2	20.8±1.2	26.0±1.2	21.9±0.7	20.7±0.5^{C}
	Mean	18.2±0.8^{bc}	15.7±0.8^{c}	17.8±0.8^{bc}	17.2±0.5^{B}	17.3±0.8^{bc}	19.6±0.8^{b}	22.6±0.8^{a}	19.9±0.5^{A}	
MCV(u^3)	Spring	16.7±1.4	23.9±1.4	20.7±1.4	20.4±0.8	18.1±1.4	17.6±1.4	19.1±1.4	18.3±0.8	19.3±0.6^{C}
	Summer	15.7±1.4	16.9±1.4	16.4±1.4	16.3±0.8	15.9±1.4	16.6±1.4	16.1±1.4	16.2±0.8	16.3±0.6^{D}
	Mean	16.2±1.0	20.4±1.0	18.5±1.0	18.4±0.6	17.0±1.0	17.1±1.0	17.6±1.0	17.2±0.6	
MCH(pq)	Spring	5.6±0.5	7.6±0.5	6.5±0.5	6.6±0.3	6.2±0.5	5.9±0.5	6.4±0.5	6.2±0.3	6.4±0.2^{C}
	Summer	5.6±0.5	5.8±0.5	5.7±0.5	5.7±0.3	5.3±0.5	6.3±0.5	5.4±0.5	5.7±0.3	5.7±0.2^{D}
	Mean	5.6±0.3	6.7±0.3	6.1±0.3	6.1±0.2	5.7±0.3	6.1±0.3	5.9±0.3	5.9±0.2	
MCHC(%)	Spring	33.4±1.1	31.7±1.1	31.7±1.1	32.3±0.6	34.0±1.1	33.8±1.1	33.8±1.1	33.9±0.6	33.1±0.4^{D}
	Summer	35.4±1.1	34.2±1.1	34.8±1.1	34.8±0.6	33.5±1.1	37.9±1.1	33.3±1.1	34.9±0.6	34.9±0.4^{C}
	Mean	34.4±0.8	33.0±0.8	33.2±0.8	33.5±0.4	33.8±0.8	35.8±0.8	33.6±0.8	34.4±0.4	

●* Bwt = body weight; Hb = haemoglobin; PCV = packed cell volume; RBC = red blood cells; MCV = mean cell volume; MCH = mean cell haemoglobin; MCHC = mean cell haemoglobin concentration.

a,b,c,A,B Means in the same row bearing different superscripts differ ($p < 0.05$)

C,D Overall season averages bearing different superscripts differ ($p < 0.05$)

Table 2. Least squares means and standard errors for white blood cell counts and serum protein as affected by season, water deprivation and length of deprivation in Aardi goats

Parameters	Season days	Control				Deprived				Overall season average
		0	2	4	Average	0	2	4	Average	
WBC($\times10^3/mm^3$)*	Spring	11.1±1.3	11.2±1.3	11.2±1.3	11.2 ± 0.8^{ab}	13.5±1.3	12.2±1.3	12.0±1.3	12.6 ± 0.8^{a}	11.9 ± 0.5^{h}
	Summer	11.0±1.3	10.0±1.3	9.7±1.3	10.2 ± 0.8^{b}	7.1±1.3	7.7±1.3	9.0±1.3	7.9 ± 0.8^{c}	9.1 ± 0.5^{i}
	Mean	11.1±0.9	10.6±0.9	10.5±0.9	10.7±0.5	10.3±0.9	10.0±0.9	10.5±0.9	10.3±0.5	
TP(gm%)	Spring	6.8±0.4	7.1±0.4	7.4±0.4	7.1 ± 0.2^{c}	7.9±0.4	8.0±0.4	8.5±0.4	8.1 ± 0.2^{b}	7.6 ± 0.1^{i}
	Summer	8.1±0.4	7.9±0.4	8.0±0.4	8.0 ± 0.2^{b}	7.9±0.4	8.6±0.4	10.2±0.4	8.9 ± 0.2^{a}	8.5 ± 0.1^{h}
	Mean	7.4 ± 0.3^{C}	7.5 ± 0.3^{C}	7.7 ± 0.3^{BC}	7.6±0.1	7.9 ± 0.3^{BC}	8.3 ± 0.3^{B}	9.4 ± 0.3^{A}	8.5±0.1	
A(gm%)	Spring	4.2±0.2	4.0±0.2	4.3±0.2	4.2±0.1	4.6±0.2	4.3±0.2	4.9±0.2	4.6±0.1	4.4 ± 0.1^{i}
	Summer	4.7±0.2	4.7±0.2	4.6±0.2	4.7±0.1	4.9±0.2	4.8±0.2	5.4±0.2	5.0±0.1	4.9 ± 0.1^{h}
	Mean	4.4±0.1	4.3±0.1	4.5±0.1	4.4±0.1	4.7±0.1	4.6±0.1	5.1±0.1	4.8±0.1	
G(gm%)	Spring	2.6±0.4	3.2±0.4	3.1±0.4	2.9±0.2	3.2±0.4	3.7±0.4	3.7±0.4	3.5±0.2	3.3±0.2
	Summer	3.4±0.4	3.2±0.4	3.4±0.4	3.4±0.2	3.0±0.4	3.8±0.4	4.8±0.4	3.9±0.2	3.6±0.2
	Mean	3.0±0.3	3.2±0.3	3.2±0.3	3.2 ± 0.2^{B}	3.1±0.3	3.8±0.3	4.2±0.3	3.7 ± 0.2^{A}	
A/G(ratio)	Spring	1.8±0.2	1.3±0.2	1.5±0.1	1.5±0.1	1.8±0.2	1.3±0.2	1.4±0.2	1.5±0.1	1.5±0.1
	Summer	1.5±0.2	1.5±0.2	1.4±0.1	1.5±0.1	1.7±0.2	1.4±0.2	1.2±0.2	1.4±0.1	1.4±0.1
	Mean	1.6±0.2	1.4±0.2	1.5±0.1	1.5±0.1	1.7±0.2	1.4±0.2	1.3±0.2	1.5±0.1	

* WBC = White blood cell counts; TP = serum total protein; A = albumin; G = globulin; A/G = albumin to globulin ratio

a,b,c, Averages among rows and columns bearing different superscripts differ ($p < 0.05$)

A,B,C Means in the same row bearing different superscripts differ ($p < 0.05$)

i,h Overall season averages bearing different superscripts differ ($p < 0.05$)

Table 3. The percent changes in body weight and some blood constituents of Aardi goats after 2- and 4-days of water deprivation during spring and summer seasons

Measurements	Spring		Summer	
	2-days	4-days	2-days	4-days
Body weight, kg	−11.9	−17.0	−11.3	−18.3
Haemoglobin, gm %	14.7	32.4	20.6	26.7
Packed cell volume, %	10.6	27.7	9.6	31.0
Red blood cells, $\times 10^6/mm^3$	22.3	30.4	7.4	32.0
Mean cell volume, U^3	−11.4	− 3.8	1.9	− 1.1
Mean cell haemoglobin, pq	− 8.0	− 0.4	12.2	− 4.1
Mean cell haemoglobin conc., %	3.2	3.4	10.0	− 3.3
White blood cells, $\times 10^3/mm^3$	4.2	2.5	−18.2	− 5.2
Total protein, gm	10.2	17.1	7.9	27.7
Albumin, gm %	1.5	14.2	2.1	14.8
Globulin, gm %	22.6	21.3	16.3	46.3
Albumin/Globulin ratio	−14.5	−12.7	− 9.8	−23.3

increase ($p < 0.01$) in blood Hb, PCV, RBC and MCHC and a significant decrease in MCV ($p < 0.01$) and MCH ($p < 0.05$) compared to spring (Table 1). Four days of water deprivation significantly elevated ($p < 0.01$) blood Hb, PCV and RBC but no significant alterations in blood MCV, MCH and MCHC were obtained. The rise in blood Hb and PCV during water deprivation occurred during the second day and continued till the end of deprivation period, but in case of RBC the significant rise was only during the fourth day of water deprivation (Table 1). The nonsignificant interaction between treatment and season indicate that the magnitude of changes in blood Hb, PCV, RBC, MCV, MCH and MCHC in association with water deprivation were almost similar in spring and summer seasons (Table 1 and 3).

The rise in blood Hb, PCV and RBC counts during the hot summer season agrees with previous reports on sheep (More *et al.* 1980 and Sodhi 1983) and dairy cattle (Rowlands *et al.* 1975). This was attributed to the haemoconcentration effect of hot season causing a great mobilization of red blood cells from spleen, lungs and liver. This erythrocytosis was associated with decrease in RBC volume and its haemoglobin content. The increase in blood Hb, PCV and RBC counts during water deprivation is apparently due to the loss of body fluids and, consequently, blood becomes thicker and contains more etythrocytes per unit volume. This is confirmed by the obtained significant interaction between treatment and length of deprivation indicating the progressive elevation in Hb, PCV and RBC with the advance in water deprivation (Table 1).

Total leucocyte counts were significantly higher ($p < 0.01$) in spring compared with summer. Regardless of season, four days of water deprivation had no significant influence on WBC counts, although, the signifiant interaction between season and treatment ($p < 0.05$) revealed that WBC counts was significantly reduced in deprived goats only in summer season (Table 2 and 3). The lower WBC counts during the hot summer season agrees with the results reported by Roy *et al.* (1965) and Upadhyay and Rao (1985). The leucocytosis observed during the moderate temperature of spring may be caused by high glucocorticoid level, since heat exposure is known to decrease glucocorticoid concentration in cattle (Alvarez and Johnson, 1973; El-Nouty *et al.* 1978). It is possible tht the dehydration-induced lowering of WBC counts during summer season was due to an additive effect of deprivation in causing further reduction of glucocorticoids in an attempts to decrease metabolic rate.

Serum total proteins was significantly higher ($p < 0.01$) in summer compared with spring. This was due to the significant increase ($p < 0.01$) in A and the slight rise in G resulting in nonsignificant alterations in A/G ratio. Water deprivation for four days also increased TP ($p < 0.01$) due to its significant elevation ($p < 0.01$) of both protein fractions, but the increase in A was less than that of G resulting in a lower A/G ratio. Most of the rise in TP and its fractions occurred during the last two days of deprivation (Table 2 and 3). The significant interaction ($p < 0.05$) between season and treatment revealed that the highest increase in TP (27.7%) occurred in summer dehydrated goats (Table 2 and 3). Furthermore, the significant treatment X time interaction showed that TP rose significantly as dehydration continued (Table 2 and 3).

The rise in TP concentration during hot summer agrees with the finding of More *et al.* (1980), who reported a rise in serum protein of sheep after exposure to heat. Also, Guerrini *et al.* (1982) working with sheep found that, plasma protein concentrations increased on exposure to both hot humid and hot dry environment. The progressive rise in serum total proteins upon dehydration, particularly in summer, could be a physiological attempt to maintain plasma volume.

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تأثير فصل السنة والحرمان من الماء على صفات الدم الخلوية وغير الخلوية في الماعز العارضي

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قسم الانتاج الحيواني ـ كلية الزراعة ـ جامعة الملك سعود ـ ص. ب ٢٤٦٠ الرياض ١١٤٥١
المملكة العربية السعودية

أجريت هذه الدراسة بغرض تقييم مدى تأقلم الماعز العارضي على ظروف البيئة الجافة. استخدم في هذه التجربة ستة ذكور ماعز عارضي لدراسة تأثير فصلي الربيع والصيف وكذلك الحرمان من الماء لمدة أربعة أيام خلال كل فصل وذلك على بعض صفات الدم الخلوية وغير الخلوية. وجد أن إرتفاع درجة الحرارة المحيطة بالحيوان خلال فصل الصيف يسبب زيادة معنوية في نسبة هيموجلوبين الدم، نسبة المكونات الخلوية، عدد كرات الدم الحمراء، نسبة الهيموجلوبين إلى المحتوى الخلوي، تركيز البروتينات الكلية والالبيومين في مصل الدم بينما أدت إلى انخفاض معنوي في متوسط حجم الكرة الحمراء، متوسط محتوى الخلية الحمراء من الهيموجلوبين وعدد كرات الدم البيضاء مقارنة بمستوياتهما خلال فصل الاعتدال الربيعي.

كما أظهرت نتائج هذه الدراسة أن حرمان الماعز من الماء لمدة أربعة أيام يصحبه فقدان في وزن الجسم يبلغ ١٧٪، ١٨٪ بنهاية اليوم الرابع خلال فصلي الربيع والصيف على التوالي. وكان ذلك مصحوباً بارتفاع معنوي في نسبة هيموجلوبين الدم، نسبة المكونات الخلوية وعدد كرات الدم الحمراء وذلك بنفس الدرجة تقريباً خلال فصلي الربيع والصيف، دون أي تغيير في عدد كرات الدم البيضاء، ولقد كان الإرتفاع في نسبة هيموجلوبين الدم ونسبة المكونات الخلوية مؤكداً بعد مرور يومين على بدء الحرمان من الماء واستمرت في الإرتفاع حتى اليوم الرابع من الحرمان من الماء، كما ارتفع تركيز البروتينات الكلية في مصل الدم خلال فترة الحرمان من الماء كنتيجة لزيادة تركيز كلاً من الألبيومين

والجلوبيولين. ونظراً لأن الزيادة في تركيز الألبيومين كانت أقل من الجلوبيولين فقد حدث إنخفاض في نسبة الألبيومين إلى الجلوبيولين كما أشارت النتائج إلى أن إرتفاع تركيز بروتينات مصل الدم خلال فترة الحرمان من الماء كان بدرجة أعلى خلال فصل الصيف وأن الإرتفاع استمر مع إطالة فترة الحرمان من الماء.

التماثل في مقدار الفقد في وزن الجسم خلال فصلي الربيع (٨, ٢٤ م) والصيف (٨, ٣٥ م) وفي حجم التغيرات في صفات الدم الناشئة عن الحرمان من الماء، تشير بوضوح إلى أن الماعز العارضي متأقلمة جيداً على المعيشة في البيئات الجافة.