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Seasonal Variation in Erythrocytic and Leukocytic Indices and Serum Proteins of Female Nubian Goats

[1]Abdalla M. Abdelatif, [2]Mariam Y. Ibrahim and [1]Yahia Y. Hassan

[1]Department of Physiology, Faculty of Veterinary Medicine, University of Khartoum, Sudan
[2]Department of Physiology, Faculty of Medicine Islamic University, Omdurman, Sudan

Abstract: The aim of this study was to investigate the effect of seasonal change in thermal environment on blood constituents in Nubian goats under tropical conditions of northern Sudan at Shambat (16°N). The highest mean values of maximum ambient temperature (°C) were reported in dry summer, followed by wet summer and winter, while the highest values of relative humidity (%) were recorded in wet summer and lower values in winter and dry summer. The highest values of erythrocyte count, packed cell volume (PCV) and haemoglobin concentration (Hb) were during wet summer and the lowest values were in dry summer. The erythrocyte counts during winter and dry summer did not differ significantly, while the difference in (PCV) was not significant between wet summer and winter. The mean cell volume (MCV) and mean cell haemoglobin (MCH) were significantly higher during winter compared to wet and dry summer values. The total leukocyte count (TLC) was not affected significantly by seasonal change in thermal environment. The seasonal changes in the ratios of neutrophils, lymphocytes and eosinophils were not significant. The monocyte ratio was significantly higher during wet and dry summer, compared to winter value. There was progressive significant decrease in serum albumin level from wet summer, through winter to dry summer. The serum globulins level was significantly higher in dry summer.

Key words: Goats · Season · Erythrocytic indices · Leukocytic profile · Plasma proteins

INTRODUCTION

The goat is a multipurpose animal; it produces milk, meat, skin and fibre. According to FMAR [1] the goat population in Sudan is estimated at about 42 million head. Nubian goats are among the best dairy breeds in Africa and are reputed as good milk producers in Sudan [2]. The majority of Nubian goats is reared in the northern part of the country north of latitude 12°N. This breed plays an important role in the life of many families as a favorite animal kept for milk production.

The performance of animals is a product of interaction between the environment and genotype. Since genetic potentials cannot be expressed unless an adequate environment is provided, the maintenance of productivity is essentially a function of environment. Although goats are known to be adapted to harsh environments [3] their productivity is affected adversely by extreme climatic conditions. Depression of food intake and reduction in production are commonly observed in heat- stressed goats [4]. Proper understanding of how climatic factors affect the physiological responses of the goats provides a firm basis of improving their husbandry and health status.

Previous studies on Nubian goats in Sudan dealt mostly with the productive and reproductive performance. However, in comparison with other livestock, there is paucity of information regarding seasonality in physiological responses of goats, in particular haematological changes.

Studies on blood composition are useful in assessment of health status and prediction of certain diseases. It is possible to predict occurrence of production diseases in female goats by monitoring blood constituents on a regular basis. The Compton metabolic profile test [5] is based on the concept that the laboratory measurements of certain blood constituents will reflect the nutritional status of farm animals with or without the presence of clinical abnormalities. The introduction of intensive methods of husbandry in goats for higher milk yield from minimum feed is likely to cause nutritional and production imbalances that may render them susceptible to metabolic diseases.

Corresponding Author: Dr. Abdalla Mohamed Abdelatif, Department of Physiology, Faculty of Veterinary, Medicine 13314 Shambat, Sudan

The present study was undertaken to investigate seasonal rhythmicity in haematological indices and serum proteins in Nubian goats. The data is needed for physiological characterization of this breed and helps in interpretation of climatic influences on productivity.

MATERIALS AND METHODS

Animals: The animals used in this study were 20 non-lactating and non-gestating female Nubian goats. The goats were 2-3 years old and had an average body weight of 27.0±1.4 kg at the beginning of the study. Prior to the commencement of the investigations, the animals were accustomed to the process of collection of blood samples for 4 weeks. All animals were clinically healthy and free from any physical abnormalities. The animals were kept on a farm at Shambat (latitude 16°N). They were housed in a pen constructed with bricks up to the height of 0.5 meter and shaded with bamboo.

Climatological Measurements: The climatic data recorded during the experimental period, including ambient temperature (Ta) and relative humidity (RH) were obtained from Shambat Meteorological Unit, located about one mile from the experimental site. The experimental period was divided into 3 phases coinciding with the 3 seasons of the year known under Sudan conditions: wet summer (July-October), winter (November-February) and dry summer (March-June).

Feeding Regimen: The animals were fed Lucerne (*Medicago sativa*) and sorghum straw (*Sorghum bicolor*) offered twice daily. In addition, the animals were given regularly a concentrate composed of sorghum grain30%, cottonseed cake 20%, wheat bran 48%, sodium chloride and limestone 2%. All animals were allowed to graze outdoors for 5 hrs daily. The animals usually grazed on crop residues and browsed trees and shrubs. The animals had free access to water.

Collection of Blood Samples and Analysis: Blood samples were colleted weekly at 8:00 a.m. for a whole year (52 weeks). Five ml samples of blood were drawn from the jugular vein of each goat using disposable syringe. Immediately, 2 ml of the blood were delivered into sterile capped tubes containing disodium ethylene diamine tetra acetate (Na_2 EDTA) as anticoagulant. The remaining 3 ml were delivered into a test tube without anticoagulant.

The methods described in Schalms' Veterinary Haematology [6] with modifications suggested by Dacie and Lewis [7] were used for determination of haematological values. The anticoagulated blood samples were used immediately for the measurement of erythrocyte count, packed cell volume (PCV), haemoglobin concentration (Hb), total leukocyte count (TLC) and differential leukocyte count (DLC). The blood samples without anticoagulant were left at room temperature for 4 hrs to clot. Then the samples were centrifuged and haemolysis-free serum was harvested into glass vials and kept frozen at - 20°C. Serum samples were used for determination of the concentrations of total protein using Biuret reagent as described [8] and albumin by the colorimetric method [9]. The values derived from the measurement of the erythrocytic series were used to calculate the haematological indices, the mean cell volume (MCV), mean cell haemoglobin (MCH) and mean cell haemoglobin concentration (MCHC). Also the concentration of serum globulins fraction was calculated from the values obtained for total protein and albumin concentrations.

Statistical Analysis: The statistical analysis of the data was performed using statistical analysis system [10]. Analysis of variance (ANOVA) test was used to determine the effect of season on the parameters investigated. Mean separation was performed using Duncan Multiple Range Test.

RESULTS

Climatic Conditions: The ambient temperature and relative humidity prevailing during the experimental period (July 2007-June 2008), covering the three seasons, are shown in Table 1. The highest values of ambient temperature were recorded during May 2008, in dry

Table 1: The ambient temperature (Ta) and relative humidity (RH) at Shambat during the experimental period.

		Ta(°C)		RH (%)	
Season	Month	Min.	Max.	Min.	Max.
Wet summer	July, 2007	22.3	42.0	22	84
	August	21.0	43.0	21	71
	September	21.2	42.6	14	65
	October	21.6	42.8	9	66
		21.5	42.6	16.5	71.5
Winter	November	13.5	39.5	8	54
	December	12.0	35.5	12	50
	January, 2008	8.2	35.0	14	51
	February	9.5	39.0	5	47
		10.8	37.3	9.75	50.5
Dry summer	March	12.6	42.0	5	30
	April	14.5	44.2	4	44
	May	22.0	45.3	7	80
	June	22.5	45.0	15	64
		17.9	44.1	7.75	54.5

Table 2: Seasonal variation in erythrocytic indices of the Nubian goats

Parameter	Season: Wet summer	Winter	Dry summer	Overall mean	S.L.
RBC ($x10^6/\mu l$)	$12.06^a \pm 1.65$	$11.24^b \pm 1.63$	$10.88^b \pm 1.56$	11.39 ± 1.61	***
PCV (%)	$28.95^a \pm 2.22$	$28.24^a \pm 2.51$	$26.25^b \pm 2.51$	27.81 ± 1.40	***
Hb (g/dL)	$9.31^a \pm 0.71$	$9.05^b \pm 0.90$	$8.43^c \pm 0.82$	8.93 ± 0.81	***
MCV (fl)	$24.00^b \pm 3.45$	$25.12^a \pm 2.80$	$24.12^{ab} \pm 3.42$	24.41 ± 3.22	*
MCH (pg)	$7.72^b \pm 0.99$	$8.05^a \pm 0.79$	$7.75^b \pm 0.95$	7.84 ± 0.91	*
MCHC (%)	$32.15^a \pm 1.07$	$32.06^a \pm 1.34$	$32.16^a \pm 1.26$	32.12 ± 1.22	NS

Means within the rows bearing different superscripts are significantly different
* : P<0.05 *** : P<0.001 NS : Not significant

Table 3: Seasonal changes in leukyocytic series of the Nubian goat

Leukyoctyic series	Season: Wet summer	Winter	Dry summer	Overall mean	S.L.
WBC ($x10^3/\mu L$)	$10.21^a \pm 1.70$	$10.47^a \pm 1.98$	$9.80^a \pm 2.31$	10.16 ± 2.00	NS
Neutrophils (%)	$31.13^a \pm 4.14$	$30.67^a \pm 4.61$	$30.59^a \pm 4.65$	30.80 ± 4.47	NS
Lymphocytes (%)	$63.83^a \pm 4.47$	$64.69^a \pm 4.80$	$64.55^a \pm 4.60$	64.36 ± 4.62	NS
Monocytes (%)	$2.40^a \pm 0.95$	$1.83^b \pm 0.88$	$2.14^a \pm 1.05$	2.12 ± 0.96	*
Eosinophils (%)	$2.64^a \pm 1.06$	$2.73^a \pm 1.25$	$2.72^a \pm 1.15$	2.70 ± 1.15	NS
Basophils (%)	$0.01^a \pm 0.05$	$0.00^a \pm 0.00$	$0.00^a \pm 0.00$	0.003 ± 0.02	NS

Means within the rows bearing different superscripts are significantly different
* : P<0.05 NS : Not significant

Table 4 Seasonal fluctuations in total protein albumin and globulin of the Nubian goats

Parameter	Season: Wet summer	Winter	Dry summer	Overall mean	S.L.
Total protein, (g/dL)	$6.91^a \pm 0.06$	$7.04^a \pm 0.90$	$6.98^a \pm 0.72$	6.98 ± 0.89	NS
Albumin (g/dl)	$3.44^a \pm 0.42$	$3.32^{ab} \pm 0.65$	$3.17^b \pm 0.53$	3.31 ± 0.54	**
Globulins (g/dL)	$3.68^a \pm 2.12$	$3.68^a \pm 0.97$	$3.81^b \pm 0.75$	3.72 ± 1.28	*

Means within the row bearing different superscripts are significantly different
* : P<0.05 ** : P<0.01 NS : Not significant

summer while the minimum values were recorded during January 2008 in winter. The relative humidity was at minimum during dry summer and the highest values were recorded in wet summer.

Erythrocytic Series: Table 2 shows the seasonal changes in erythrocytic indices of goats. The highest mean value of erythrocyte count was measured during wet summer. The mean value for wet summer was higher (P<0.001) compared to values obtained for winter and dry summer. Winter and dry summer values were not significantly different. The (PCV) was significantly (P<0.001) lower in dry summer compared to wet summer and winter values. The (Hb) concentration was significantly (P<0.001) lower in dry summer compared to wet summer and winter values. Also it was noted that the Hb concentration was higher in winter compared to dry summer value.

The (MCV) measured during winter was higher (P<0.05) compared to values obtained during wet and dry summer conditions. The (MCH) was higher (P<0.05) during winter compared to wet and dry summer values, that were almost similar. There was no significant effect of season on (MCHC).

Leukocytic Profile: Table 3 shows the seasonal changes in leukocytic profile. There was no significant difference between the values of total leukocyte count obtained for the three seasons. The data depicted in Table 3 also indicate that the influence of season on the ratios of neutrophils, lymphocyes, eosinophils and basophils was not significant. However, the ratio of monocytes measured during wet summer and dry summer was significantly (P<0.05) higher compared to the value obtained in winter.

Serum Proteins: The effect of season on concentrations of serum proteins is shown in Table 4. There were no significant seasonal changes in the concentrations of serum total protein. However, there was a progressive significant (P<0.01) decrease in the concentration of serum albumin, from wet summer, through winter to dry summer. Serum globulins level was significantly (P<0.05) higher in dry and wet summer compared to winter value.

DISCUSSION

During the experimental period, the animals have been exposed to marked seasonal changes in ambient temperature and relative humidity (Table 1). Seasonal changes in the thermal environment influence the physiological responses of animals. Usually measurements of body temperature and respiration rate are considered as indices of the degree of climatic stress to which the animals are exposed [11-13]. Previous studies on thermoregulatory response of goats indicated that the body temperature and respiration rate of goats increase with rise in ambient temperature [14-16]. Marked seasonal changes in rectal temperature, respiration rate and energy expenditure were also reported in goats under tropical conditions [17, 18].

An increase in body temperature of goats is usually associated with rise in water intake and depression of food intake [19, 20]. Thermal stress causes the rostral cooling centre of the hypothalamus to stimulate the medial satiety centre which inhibits the appetite centre resulting in reduced dietary intake [21]. Under subtropical conditions, the water consumption of goats was greater in summer than in winter and spring [22]. Such nutritional changes influence the composition of blood in goats. Furthermore, at high ambient temperature, peripheral vasodilation and redistribution of cardiac output are associated with expansion of blood volume and haemodiltuin [23, 24]. Haemodilution was observed both in fed and food-deprived goats during heat stress [25]. During heat exposure increases in cardiac output and cutaneous blood flow associated with redistribution of blood to peripheral tissues have been indicated in goats and sheep [26, 27]. The lower values of erythrocyte count, (PCV) and (Hb) concentration obtained during dry summer in Nubian goats could be attributed partly to a low level of nutrition. Pervious studies indicated depression of food intake of goats with rise in ambient temperature [28, 29]. The lowering in the values of erythrocyte count, (PCV) and (Hb) concentration reported in the present study may be attributed in part to haemodilution. Vasodilation which occurs when animals are exposed to heat causes a decline in the hydrostatic blood pressure below the blood colloidal pressure so that more interstitial fluid fluid passes into the intravascular compartment [30]; the increase in plasma and extracellular volume is apparently in proportion to the thermoregulatory requirement [31, 32]. Merino sheep had higher plasma volume during summer compared to winter value [33] and an inverse relationship of PCV with atmospheric temperature has been reported in Nale sheep [34].

The decline in erythrocyte count and consequently (PCV) and (Hb) in dry summer could be related to depression of thyroid secretion which is associated with decreased erythropoiesis. Thyroid hormones increase the proliferation rate of erythroid progenitors [35, 36] and enhance the production of erythropoietic growth factors [37, 38]. Usually adjustment in thyroid response is chronic and as a result summer thyroid activity is lower than during winter [39]. A depression of thyroid hormone secretion during summer was reported in goats [40] and sheep [41-43]. The relatively high mean values of erythrocyte count, (PCV) and (Hb) during wet summer obtained in the current study could be associated with improvement of nutritional status of goats. The feed available to the goats during grazing was more nutritious during wet summer than other seasons. A positive relationship between rainfall and the level of crude protein of pasture plants has been reported [44].

The present results for seasonal changes in erythrocyte count and (Hb) concentration in Nubian goats are in agreement with the findings of other workers in goats [45] and sheep [46, 34]. However, Holman and Dew [47] reported higher values of erythrocyte count, (PCV) and (Hb) during summer compared to winter values. These variations in responses of goats may be attributed to differences in environmental conditions as well as nutritional factors. Pospisil *et al*. [48] reported lower values of these indices in winter for Cameroon goats kept in temperate environment and attributed that to the change in diet.

The current results indicate that the (MCV) and (MCH) were significantly higher in winter compared to values obtained in wet and dry summer (Table 2). The lowest MCV (24.00 fl) was obtained in wet summer with the highest number of erythrocytes. The low (MCV) value obtained could be related to the negative correlation between size and number of erythroytes that has been suggested [49]. The values obtained in the present study for (MCV) and (MCH) during winter and wet summer are in general agreement with previous findings [50] that reported high values of (MCV) and (MCH) in cold dry environment compared to values in hot humid conditions.

The relative constancy of (MCHC) in the present study may be attributed to concomitant increase or decease in Hb concentration or (PCV) levels. Similarly Scelza and Knoll [51] reported an almost steady level of (MCHC) during different seasons in kangaroo rats.

The results indicate that the (TLC) showed apparently limited fluctuations ranging between 9.00 x $10^3/\mu L$ in dry summer and 11.93 x $10^3/\mu L$ in winter (Table 3). There were no marked seasonal changes in (TLC). Similarly, other workers [45, 52] did not report significant effect of season on (TLC) in goats. Similar findings were also previously reported by other workers in sheep [53, 54]. However, the highest values of (TLC) were obtained during winter with a slight reduction during dry summer (Table 3). The reduction could be associated with physiological responses to hot climate which include decrease in food intake and expansion of plasma volume resulting in haemodilution.

The seasonal change in climate in the present study had no significant effects on the ratios of neutrophils, lymphocytes, eosinophils and basophils. The results agree with the findings in Barki ewes [54]. The ratio of monocytes during wet and dry summer was higher compared to the value obtained in winter (Table 3). This result is consistent with the findings [55] that reported slightly higher monocyte ratio during summer in Dhofari goats. The increase in monocyte in summer in the present study could be associated with increase in cortisol secretion. Monocytes respond to elevation in blood corticosteroid concentration, but species differences are seen with the type of response and the mechanism of monocytosis which occurs in some species is not known [56].

In the current study, serum albumin concentration was highest during wet summer and lowest during dry summer (Table 5). This pattern could be associated with changes in nutritional status, more vegetation being available to goats while grazing during wet summer. A direct relationship between nutritional status or protein intake and serum albumin level has been established in ruminants [57-59]. The decease in serum albumin level during dry summer in the present study could also be attributed in part to expansion of plasma volume resulting in haemodilution. The plasma volume increased by 17% during tropical summer in Merino sheep [33]. Pervious studies revealed reduction in albumin level during dry summer in goats [53] and sheep [54].

The season had no significant effect on the concentrations of serum total protein in Nubian goats (Table 4). It could be speculated that the rise in albumin level during winter along with concomitant decline in globulin level abolished the seasonal pattern in serum total protein. The higher serum globulins level reported during dry summer may suggest that the goats are more adapted to arid environments so that their immunity is potentiated. Previous studies have shown higher immunoglobulins levels in the dry season for Moxosto goats [60] and Dhofari goats [55], that were correlated with lower morbidity and mortality.

CONCLUSIONS

Seasonal changes in thermal environment and related nutritional factors influenced the erythrocytic indices and serum albumin in Nubian goats under intensive management. The leukocytic profile and serum total protein concentration were not significantly influenced by season. Future studies should investigate the circannual endocrine responses and mineral profile in gestating and lactating goats.

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