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Haematological profile and parasitological survey of the domestic goats and camels of St. Katherine, Sinai, Egypt

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ABSTRACT

Haematological estimations and faecal egg counts were made on 32 goats and 43 camel sampled from different wadis of St. Katherine Protectorate, Sinai, Egypt during August-September 2000. Erythrocyte counts, platelet counts, packed cell volume, haemoglobin concentration, mean corpuscular haemoglobin, mean corpuscular haemoglobin concentration and total leukocyte counts were estimated. The percentage of neutrophils, eosinophils, basophils, monocytes and lymphocytes were determined from differential counts of leukocytes. In both animals, platelet counts and mean corpuscular haemoglobin concentrations showed significant differences among wadis; in goats, such differences were also present in total leukocyte counts and % of eosinophils. In goats, lymphocytes were more abundant than neutrophils in the blood. The prevalence of parasitic infection showed that 15% of the camels were infested with gastrointestinal helminths whereas 24% of goats were infested.

KEYWORDS: haematology, gastrointestinal helminths, goats, camels, Sinai, Egypt.

INTRODUCTION

In the Middle East, goats and sheep represent the most important livestock for both the nomadic Bedouin and for settled agriculturalists. In the mountains of the Sinai Peninsula Bedouin families live a more settled existence moving between major settlements and their gardens, often located at some distance from their village homes, in distant wadis. Goats are grazed extensively in small flocks, mostly tended by young shepherdesses, moving across the arid landscape throughout the daytime. These flocks also can contain sheep, but cattle are rare in the region. Most families also possess camels and these are used for transportation between the wadis.

In recent years the authorities running St.Katherine's Protectorate have introduced a registration system for camels, in association with veterinary inspections and advice. The animals are routinely examined and drenched with antihelmintics at intervals of one month. In contrast sheep and goats do not receive the same attention, and for the most part are left untreated until overt clinical signs indicate to owners that veterinary advice is desirable. Some Bedouins introduce a mixture of wild plants as a treatment for ill goats.

The health of the domestic livestock in the region, particularly that owned by the Bedouin, is a subject that has been neglected. Relevant studies include Soliman (1960, 1961) and El-Hady (1977), but overall little is known about the prevalence of major pathogens, including parasitic infections, and about the general health of the animals. In the summer months of 2000, an expedition into the region comprised among its objectives an initial appraisal of the health of domestic livestock owned by Bedouin families in two sets of four wadis each. It was not possible to conduct a comprehensive survey, but we focused on goats and camels as examples of two domestic animals with high population densities in the region, employed for contrasting purposes, and maintained under different husbandry conditions.

In this paper we report on the extent of gastrointestinal (GI) nematode infections and on *Eimeria* spp. detected in faecal samples. Blood samples were taken and standard haematological tests were conducted to assess the general health of the animals.

MATERIALS AND METHODS

The study sites: The study was conducted during a two-week period in August-September 2000 and was carried out at the Environmental Research Centre of Suez Canal University, on the periphery of the town of St. Katherine, South Sinai, Egypt. Animals from six wadis were studied, all within 25 km^2 of the town: (1) Wadi El-Arbaein (1600-1730 m above the sea level) radiates from the town of St. Katherine, and is fully described in Willmer *et al*. (1994) and Gilbert *et al*. (1996). (2) Wadi Abu Seylah (1674 m) is part of the Plain of El Raha and is currently the site of the town's refuse dump. (3) Wadi Gebal (1863-1942 m) is a system of wadis separated from St. Katherine by a ridge of mountains, and is well know as a popular destination for trekkers (fully described in Zalat & Gilbert 1998). (4) Wadi El-Sheikh Awad (1175 m) is a flat wadi running towards the Oasis of Feiran from St. Katherine, bearing the road to Feiran and the Suez Gulf. (5) Wadi Esbaeia (1454-1608 m) is located in the central part of the highest mountains region of south Sinai and mainly covered by exposed igneous rocks (Ahmed 1998). (6) Wadi Melqa (1600 m) is the central of the town of St Katherine; most Bedouin houses and activities are located in this site.

Sampling and Experimental animals: Blood and faecal samples were taken from camels and goats. Samples from 30 goats (28 females, 2 males) were collected from Wadis Abu-Seila, Gebal, El-Arbain and El-Sheikh Awad. Samples were obtained from 30 male camels from Wadis Melqa, Abu Seylah and El-Sheikh Awad (10 camels / wadi) and from 14 camels from Wadi Esbaeia. Five millilitres of blood were collected from the external jugular vein (after cleaning the site with alcohol) of each camel and goat in a vacutainer tube with EDTA.

Total erythrocyte, leukocyte and platelet counts were made using an improved Neubauer haemocytometer. The percentages of neutrophils, eosinophils, basophils, monocytes and lymphocytes were determined from differential counts of leukocytes on fixed and stained whole blood films and these data were converted to total cell counts for each cell type. Packed cell volume (PCV) was determined using the microhematocrit method, and haemoglobin (Hb) concentration was measured by the cyanmethemoglobin method using a bioMerieux kit.

Faecal egg examinations: Faecal samples collected from the rectum of each camel and goat into labelled polythene bags were maintained at 4 ºC until analysed. Flotation with saturated NaCl was done for a quantitative estimation of the number of oocytes using the Moredun technique.

Statistical analysis: Summary statistics are presented as prevalence (percentage of animals infected) and as means ± standard errors of the mean (S.E.M) and geometric means as required for quantitative data. Prevalence of parasites (binary data, presence/absence of infection) was analysed by maximum likelihood techniques based on loglinear models, using the software package Statgraphics Plus, version 7.0. Quantitative parasite data were LOG10(x+1) transformed prior to analysis to normalise the data, but all haematological measures were distributed approximately normally and were not transformed prior to analysis. The data for each species in turn were analysed by multivariate least squares analysis of variance, entering haematological measures either as all cellular components or as haemoglobin-related parameters. Initially full factorial ANOVAs were used, entering in addition to site, age (both goats and camels) as a covariate, and sex (goats). In the second stage minimum sufficient models, employing only those factors that showed significance were used to estimate the model parameters and to obtain least squares fitted means. In the case of the haemoglobin-related parameters, where extensive inter-variable correlations were expected, we first reduced the data by Principal Components Analysis, and entered principal components (PC) into multivariate analysis. Correlations between variables were examined by Spearman's rank order test. All processing of data was conducted with the software packages Microsoft Excel 97 SR-1 (for data storage) and SPSS version 9.0.0, or statistical evaluation.

RESULTS

***Measure of parasite infection*:** Overall 66.7% of the goats and 13.6% of the camels had positive faecal egg counts for GI nematodes and *Eimeria* spp. combined and this difference between the species was highly significant (χ^2=22.7, dof =1, P<0.0001). The prevalence of GI nematodes was also higher among goats (36.7%) compared with camels (13.6%, χ^2=5.3, dof=1, P=0.022), but there was no significant difference in the prevalence of the most common taxon, *Nematodirus* spp. (goats = 20%, camels = 13.6%, χ^2=0.52, dof =1, P=NS). Only goats harboured *Eimeria* spp. (46.7%) and Oxyuroids (6.7%).

Table 1 shows the data for each of the two species by wadi and some interesting differences can be seen. Only goats from Wadi Abu-Seylah carried all three GI nematode taxa together with *Eimeria* spp. Goats from Wadi Gebal did not appear to harbour any GI nematodes but were infected with *Eimeria* spp. (50%) whereas those from Wadi El-Arbaein had no *Eimeria* spp. Among camels *Nematodirus* spp. were the most common GI nematodes, although only 1-2 individuals from each wadi turned out to be positive.

The quantitative data shows that for both GI nematodes and *Eimeria* spp. infections were of comparatively low intensity. The highest FEC for *Nematodirus* spp. was 28 epg in camels and barely 8 epg in goats. The highest abundance for *Eimeria* spp. was for two goats, one from Wadi Gebal with a count of 576 and another from Wadi Abu Seylah with a count of 326 oocysts/gm/faeces. All the remaining infections were lower intensity.

Haematology - Cell counts

Goats: The full factorial model (Site + sex + age + site×sex) for the cellular components in blood samples only revealed a significant site effect (Wilks'Lambda = 0.124, $F_{18,\ 51.4}$ =3.12, P=0.001). Therefore, we fitted the minimum sufficient model with just site as a factor (Wilks'Lambda 0.093, $F_{18,\ 59.9}$ =4.38, P<0.001) and, as summarised in Table 2, this gave a highly significant difference between sites for platelet counts, and a marginally significant differences for neutrophil and eosinophil counts. Very clearly platelet counts were remarkably high in the goats from Wadi El-Sheikh Awad and lower, but nevertheless high, for Wadi Gebal. The significant differences in neutrophil counts arose because of the higher counts in Wadi Gebal and lower counts in Wadi El-Sheikh Awad, whilst in the case of eosinophils Wadi Abu Seylah had the lowest counts with little difference among the other three wadis.

Camels: Full factorial analysis (site + site×age; all camels were males) gave no significant effects but when we entered just site as a factor in a 1-way ANOVA, platelet counts were just outside significance. The data in Table 3 show that camels from Wadi El-Arbaein appeared to have marginally higher platelet counts compared to camels from other wadis.

Haematology -Haemoglobin-related parameters

Goats: The various standard measures of red blood cell concentration, volume and haemoglobin content show different degrees of inter-relationship (Tables 4B and 5B). Therefore, we first attempted to reduce these to principal components. For goats, PC1 accounted for 52.1% of the variation and PC2 31.1% of the remainder. PC1 had high positive loadings from HB (0.673), MCV (0.888), MCH (0.985) and MCHC (0.627), a lesser loading from PCV (0.345) and a negative loading from RBC (-0.635). In contrast the loadings for PC2 were RBC (0.758), PCV (0.810), HB (0.728), MCV (-0.248), MCH (-0.156) and MCHC (0.137). PC1 and PC2 were then analysed by multivariate ANOVA, first in a full factorial model and then in a 1-way ANOVA with only site as a factor. Neither of these analyses revealed any significant effects.

Consequently we entered all of these variables in a multivariate analysis, with just site as a factor. Again none of the variables showed significant differences between sites although for MCHC the values were only marginally outside significance. The fitted least squares means in Table 4A show that MCHC was highest in Wadi Gebal. Close examination of this table also reveals that the mean values for all of the other variables, except red blood cell concentration, were highest in Wadi Gebal. Interestingly this wadi was located at the highest altitude (mean altitude = 1891m).

***Camels**:* For camels the standard 6 measures reduced to three principal components. PC1 (RBC=-0.677, PCV=0.108, HB=0.527, MCV=0.772, MCH=0.996, MCHC=0.532) accounted for 43.6% of the variation. PC2 (RBC=0.719, PCV=0.491, HB=0.848, MCV=-0.463, MCH=0.02, MCHC=0.602) accounted for 34.2% of the variation and PC3 (RBC=0.132, PCV=0.864, HB=0.05, MCV=0.433, MCH=-0.05, MCHC=-0.594) for a further 21.8%. In a multivariate analysis with site as a factor only PC3 varied marginally between sites ($F_{3,40}$=3.092, P=0.038).

In a further multivariate analysis of all six variables, as in the case of goats, only MCHC showed significant variation between sites ($F_{3,40}$=3.308, P=0.030). The data in table 5 show that MCHC was highest in camels from Wadi Esbaeia and similarly low in camels from Wadi Melqa and El-Arbaein.

Relationships between measures of parasite infection and haematological parameters

As a first step we conducted a multiple correlational analysis (Spearman's Rank Order), entering all measures of parasite infection and all haematological parameters, for both goats and camels. No significant relationships were detected in the case of camels, but in the case of goats 6 relationships were significant at P= 0.05. Because of the very large number of tests carried out, these results are presented only as a guide and the strongest of these are illustrated in Figs 1 and 2.

However, since in the case of platelet counts and MCHC, significant and borderline differences between wadis had been detected earlier, in order to control for possible errors arising from clustering of infections in particular wadis, we repeated 1-way ANOVAs on all the haematological parameters in Table 6, entering abundance of parasites as covariates (Log10[x +1]). The relationship between combined nematode EPGs and plasma haemoglobin concentration and MCHC retained significance. Interestingly the site effect on MCHC was lost completely when we entered the parasite measure. Similarly the positive relationship between *Eimeria* spp. infection and platelet concentration retained significance although in this case the site effect on platelets also retained high significance

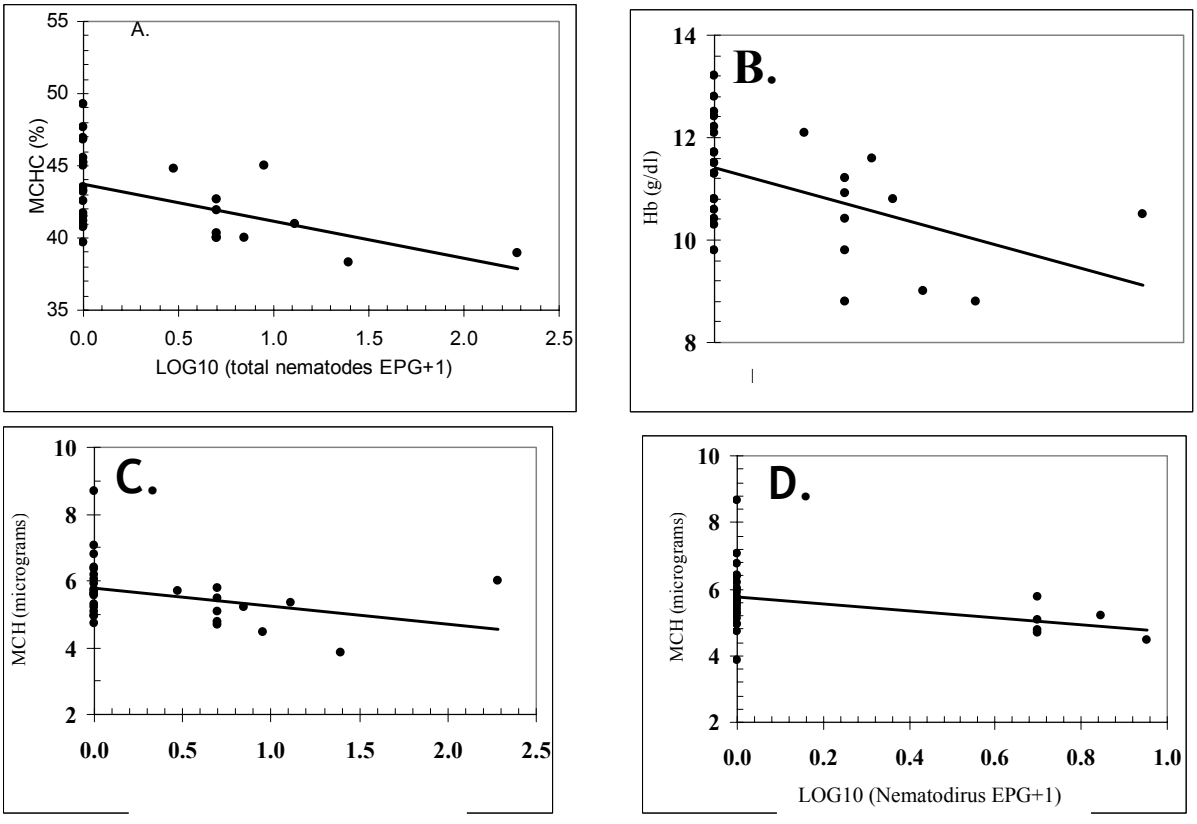

Fig. 1: Relationships between measures of total nematodes and Nematodirus infections and haematological parameters

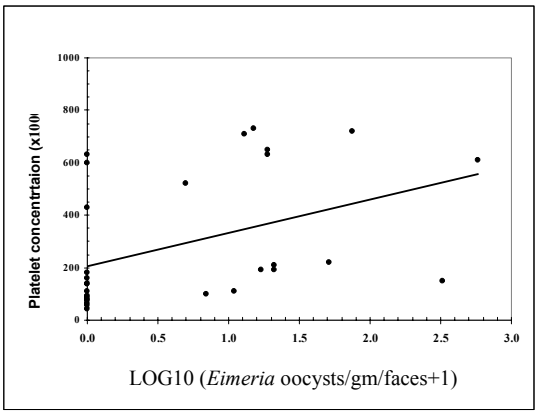

Fig. 2: Relationships between measures of Eimeria oocysts infections and haematological parameters

DISCUSSION

As far as we are aware this is the first study of the relationships between GI nematode and protozoan infections, and haematological parameters in goats and camels in the high altitude setting of St.Katherine in the Sinai. Most of our study sites radiated from or were close to St.Katherine and their average altitude ranged from 1600 m in wadi Melga to 1891 m in wadi Gebal.

The study was conducted in the hot dry season (August and September) because an opportunity arose (as part of a larger expedition to the region that explored the ecology of each of the wadis in turn) to sample the domestic animals of the Bedouin families that live in the wadis. The results of the parasite survey indicate that both prevalence and abundance of infections was generally low, and this is perhaps not surprising because of the season in which the study was conducted. GI nematode infections would be expected to peak in the months during the late rainy season and immediately afterwards (during November, December, January and February) when transmission is most likely to be successful. Nevertheless some interesting observations can be made on our data.

Firstly, GI infections in camels were significantly less prevalent than in goats and the explanation for this lies in the introduction by the Park authorities of a registration system for all camels in the region (all camels now carry numbered ear tags). These are inspected by Park Ranger Veterinary Surgeons at the first five days of the month and are given bendazole derivative drug as a routine treatment for various infections including GI nematodes. In contrast, to the best of our knowledge, goats are not given anthelmintic treatment by their owners. Of the trichostrongyloid species that could be differentiated in faecal specimens, *Nematodirus* spp. were clearly frequent in the region, with a concentration of infections in Wadis Abu-Seylah and El-Arbaein in the case of goats, and presence in small numbers of camels right across all four sites. The species infecting goats and camels are likely to be Strongylorine-type eggs, *Strongyloides spp., Trichuris spp* and *Nematodrius spp.* (Soliman 1960, 1961; El-Hady 1977). Mcculloch *et al.* (1986), Broomker *et al.* (1989) and Fivaz *et al.* (1990) reported *Trichostrongylus* and *Nematodrius spp.* in Angora goats. However, Horak *et al.* (2001) reported *Nematodrius spp.* in Angora goats in the southern Karoo. Moreover, Nwosu *et al.* (1996) reported egg types of *Strongyloids, Trichuris, Trichostrongylus* and *Nematodrius* in Nigerian goats. At the levels detected in our study they are unlikely to represent a major threat to the welfare of the animals nor to the Bedouin livestock owner's economy, but, at this stage and until we have conducted a detailed survey in the post rainy season, we cannot be certain.

Interestingly *Eimeria* spp. were the most common protozoa infecting goats, although the goats sampled in Wadi El-Arbaein did not carry infection. Perhaps surprisingly our assays did not reveal cestode infections, but additional observations on post-mortem material indicated that *Moniezia* spp. were present in the goat populations in the region.

The haematological parameters recorded in this study are all conventional measures that are routinely screened in veterinary inspections. Values for goats are well known (Shaikh

2000) although there is less reliable information on the range for camels (Egbe-Nwyi *et al.* 2000). The goats owned by the Bedouin in the St.Katherine region belong to a balady breed known as local Delta strain, *Capra hiricus* (Agriculture and water investigations of Sinai, 1981) which was studied by Soliman (1960, 1961) and El-Hady (1977).

It perhaps not surprising that goats from Wadi Gebal, which was the wadi situated at the highest altitude, showed higher values for haemoglobin-related measures, although only one of these (MCHC) achieved significance (although in subsequent analyses this was lost completely when we controlled for the abundance of nematode infections). Among camels the picture was less clear. Again MCHC was the only measure showing significant variation between wadis. MCHC peaked in camels from Wadi Esbaeia, and interestingly three of the remaining five measures also showed highest averages for animals from this wadi. Most of the haemoglobin related measures were highly inter-correlated, but among both camels and goats only the red blood cell concentration showed negative correlations with other parameters. However, reassuringly, red blood cell count did correlate positively with both packed cell volume and with blood haemoglobin concentration. The highest positive correlation among both host species was between mean corpuscular volume and mean cell haemoglobin. Chaudhary & Igbal (2000) studied the incidence, biochemical and haematological alterations induced by natural trypanosomosis in racing dromedary camels and found that a significant decrease ($P< 0.05$) in RBCs. Hb, PCV and lymphocyte, while a significant ($P< 0.05$) increase in WBCs and neutrophils was noted in trypanosomosis positive samples. Abatan (1999) noticed that susceptibility to *Trypanosoma congolense* infection followed atrazine toxicosis in two breeds of goats (indigenous and Boer goat) and mentioned that indigenous goat group exhibited significant decrease in erythrocyte counts, PCV and MCV values. Haematological changes and antibody response in trypanotolerant sheep and goats followed experimental *Trypanosoma congolense* infection were studied. The infected animals showed a persistent parasitemia with a chronic anemia and significantly lower PCV, RBCs count and hemoglobin content (Goossens *et al* 1998).

Interestingly platelet counts among goats showed the greatest variation between wadis. The highest levels were recorded in Wadis Gebal and El-Sheikh Awad in both of which *Eimeria* spp showed high prevalence and overall there was a significant positive relationship between the abundance of *Eimeria* spp. and platelet counts (after controlling for the site effect). *Eimeria* spp. are known to be major causes of blood loss in poultry (Wetzel 1952) and in this respect it is perhaps surprising that the abundance of *Eimeria* spp. infections did not show any significant negative correlations with parameters reflecting anaemia. However, the infections were mostly very low intensity, and it is tempting to suggest that at this time of the year, following perhaps more intense transmission in the rainy season the animals may have acquired some resistance to infection. The higher platelet counts in these two wadis may therefore reflect the containment of blood loss from the intestine and repair of damage. Both neutrophil and eosinophil counts were also highest in Wadi Gebal, although lower in Wadi El-Sheikh Awad, and it was not possible to relate these differences to parasite infections.

Our attempts to relate measures of parasite infection to haematological parameters encountered mixed fortune. Initially some interesting relationships were detected in the raw data, but when we controlled for site effects, only three of these retained significance. Indeed one of these (combined nematode EPGs and MCHC) was the major determinant of variation in the data, such that the site effects was lost when combined nematode EPGs were entered as a covariate in the analysis. In contrast in the case of *Nematodirus* spp. the initial relationship between the measure of parasite infection and platelet concentration clearly arose through the site effect.

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REFERENCES

Abatan MO (1999) Susceptibility to *Trypanosoma congolense* infection followed atrazine toxicosis in two breeds of goats. Tropical veterinarian 17(3-4), 125-133.

Agricultural and water investigations of Sinai (1981) Desert Research Institute, Dames and Moore with the Ministry of Development and New Communities. A.R.E., Animal Production Part VI.

Boomker J, Horak IG & Ramsay KA (1994) Helminth and arthropod parasites of indigenous goats in the northern Transvaal Onderstepoort. J. Vet. Res. 61(1) 13-20.

Broomker J, Horak IG & Macivor KMDF (1989) Helminth parasites of grysbok common duikers and Angora and Boer goats in the valley bushveld in the Eastern Cape Province South Africa. Onderstepoort. J. Vet. Res. 56(3): 165-172.

Chaudhary ZI & Igbal J (2000) Incidence, biochemical and haematological alterations induced by natural trypanosomosis in racing dromedary camels. Acta Tropica. 77(2): 209-213.

Egbe-Nwyi TN, Wafar E & Nwaosu SC (2000) Haematological and biochemical values in apparently healthy camels (*Camelus dromedarius*) in semi-arid zone of Borni State, Nigeria. *Tropical Veterinarian*, 18(3-4): 128-133.

El-Hady M (1977) Study on some helminth parasites of ruminants in Assiut Governorate. M.V.Sc. Thesis, Fac. Vet. Med.; Assiut University, Egypt.

Fivaz BH, Horak IG & Williams EJ (1990) Helminth and arthropod parasites of Angora goats on irrigated kikuyu grass pastures in the Eastern Capaae Province South Africa. J. of the South Africa Veterinary Association. 61(3): 112-116.

Gilbert F, Willmer P, Semida F, Ghazoul J & Zalat S (1996) Spatial variation in selection in a plant-pollinator system in the wadis of Sinai, Egypt. *Oecologia*. 180: 479-487.

Goossens B, Osaer S, Kora S & Ndao M (1998) Haematological changes and antibody responses in trypanotolerant sheep and goats followed experimental *Trypanosoma congorense* infection. Vet. Parasitology 79(4) Nov. 27: 283-297.

Horak IG, Macivor KMF & Greef CJ (2001) Parasites of domestic and wild animals in South Africa. XXXIX. Helminth and arthropod parasites of Angola goats in the southern Karoo. Onderstepoort J. Vet. Res. 68(1): 27-35.

Mcculich B, Dalbock RR & Kuehn HG (1986) The relation of climate and topography to gastrointestinal nematode worm egg counts of Angora goats in the eastern cape South Africa. Onderstepoort J. Vet. Res. 53(3): 167-178.

Nwosu CO, Ogunrinade AF & Fagbemi BO (1996) Prevalence and seasonal changes in the gastrointestinal helminths of Nigerian goats. J. of Helminthology 70(4): 329-333.

Shaikh ID (2000) Effect of age and sex on haematological parameters in Beetal X Osmanabadi crossbred goats. Indian Veterinary Journal. 7(5): 389-392.

Soliman KN (1960) Observation on some diseases of farm livestock in Sudan with reference to some in Egypt. J. Arab. Vet. Med. Ass. 20(2): 77-78.

Soliman KN (1961) Observation on some internal parasite of sheep. J. Arab. Vet. Med. Ass. 21(3): 157-176.

Wetzel R (1952) Vet. Med. J. Giza, 4(4): 251.

Willmer P, Gilbert F, Ghazoul J, Zalat S & Semida F (1994) A noval form of territoriality: daily paternal investment in an anthrophorid bee. *Animal Behaviour*. 48: 535-549.

Zalat S & Gilbert F (1998) A walk in Sinai: St. Katherine to Al Galt Al Azraq (The Blue Pool). Cairo, Egypt, El Haramen Press.

الملخص العربى

حصر وقياس معايـير دموية وطفيلية في الماعز والجمال المحلية بسانت كاترين – سيناء – مصر

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تم قياس معايـير الدم وعد بيض الطفيليات ببراز ذكور 32 فرد من الماعز و43 من الجمال المنتشرة فى وديان محمية سانت كاترين بجنوب سيناء وذلك خلال الفترة من أغسطس حتى سبتمبر عام 2000م، وقد تم تقدير وعد كريات الدم الحمراء والصفائح الدموية وحجم كريات الدم المضغوطة وتركيز الهيموجلوبين وتعيين النسب الدموية وعد كريات الدم البيضاء الكلي والتباييني في كل من دم الماعز والجمال في منطقة الدراسة. وقد أظهرت نتائج كل من الصفائح الدموية ومتوسط تركيز الهيموجلوبين في الخلية الحمراء تغيراً معنوياً بين الأودية في كل من الحيوانيين – في حين أظهرت النتائج تغيراً معنوياً في العد الكلي لكريات الدم البيضاء والعد التبايني للخلايا الحمضية فقط في ماعز الأودية المختلفة. كما أظهرت الدراسة أيضاً أن الخلايا الليمفاوية كانت تزيد في نسبتها عن الخلايا المتعادلة في ماعز ألأودية المختلفة. أيضا أوضحت الدراسة أن 15% من الجمال و24% من الماعز التى تم دراستها كانت مصابة بالديدان المعدمعوية، وكانت هناك علاقة بين معدل الإصابة بالطفيليات وتغير معدلات الدم فى الماعز ولم تظهر تلك العلاقة فى الجمال.

Table 1. Summary of the faecal egg counts from goats and camels of Bedouin families living in 6 different wadis in the St. Katherine area of the Sinai.

		Goats					Camels				
Site	Parasites	%	Mean ± SEM		GM	Range	%	Mean ± SEM		GM	Range
Wadi Gebal											
	Eimeria spp.	50	76.5	71.4	4.58	0-576	nd				
Wadi El-Sheikh Awad											
	Trichostrongyloids	38	2.3	1.5	0.93	0-12	nd				
	Eimeria spp.	75	17.5	8.5	7.47	0-74	nd				
Wadi Abu Seylah											
	Nematodirus spp.	33	2.0	1.4	0.89	0-8	20	3.8	2.9	0.78	0-28
	Trichostrongyloids	17	10.7	10.7	1.01	1-64					
	Oxyuroids	33	25.0	20.6	2.83	0-126					
	All nematodes	67	37.7	30.7	6.74	0-190					
	Eimeria spp.	67	68.7	52.0	12.46	0-326					
Wadi El Arbaein											
	Nematodirus spp.	50	2.3	0.9	1.33	0-6	10	1.6	1.6	0.33	0-16
	Trichostrongyloids						10	0.2	0.2	0.12	0-2
	All nematodes						10	1.8	1.8	0.34	0-18
Wadi Melqa											
	Nematodirus spp.	nd					20	1.4	1.0	0.49	0-10
Wadi Esbaeia											
	Nematodirus spp.	nd					7.1	0.1	0.1	0.08	0-2

nd. Not done because insufficient numbers or no goats/camels were present in the wadi

Table 2. Summary of cell counts in blood samples from goats from 4 different wadis in St. Katherine, Sinai.

	Wadi Gebal	Wadi El-Sheikh Awad	Wadi Abu Seylah	Wadi El-Arbaein
RBCs (x 10^6)	19.51 ± 0.87	18.94 ± 0.86	21.02 ± 1.00	20.93± 0.86
Platelets (x 10^4)***	261.38 ± 45.84	623.75 ± 45.84	175.00 ± 52.93	72.25 ± 45.84
Neutrophils (10^3) **	5.54 ± 0.60	2.85 ± 0.60	4.97 ± 0.70	4.05 ± 0.60
Eosinophils (10^3) *	1.09 ± 0.17	0.75 ± 0.17	0.32 ± 0.19	0.72 ± 0.17
Lymphocytes (10^3)	6.52 ± 0.80	4.65 ± 0.80	6.82 ± 0.92	5.84 ± 0.80
Monocytes (10^3)	0.07 ± 0.04	0.09 ± 0.04	0.14 ± 0.05	0.15 ± 0.04

Table 1. Summary of the faecal egg counts from goats and camels of Bedouin families living in 6 different wadis in the St. Katherine area of the Sinai.

		Goats					Camels				
Site	Parasites	%	Mean ± SEM		GM	Range	%	Mean ± SEM		GM	Range
Wadi Gebal											
	Eimeria spp.	50	76.5	71.4	4.58	0-576	nd				
Wadi El-Sheikh Awad											
	Trichostrongyloids	38	2.3	1.5	0.93	0-12	nd				
	Eimeria spp.	75	17.5	8.5	7.47	0-74	nd				
Wadi Abu Seylah											
	Nematodirus spp.	33	2.0	1.4	0.89	0-8	20	3.8	2.9	0.78	0-28
	Trichostrongyloids	17	10.7	10.7	1.01	1-64					
	Oxyuroids	33	25.0	20.6	2.83	0-126					
	All nematodes	67	37.7	30.7	6.74	0-190					
	Eimeria spp.	67	68.7	52.0	12.46	0-326					
Wadi El Arbaein											
	Nematodirus spp.	50	2.3	0.9	1.33	0-6	10	1.6	1.6	0.33	0-16
	Trichostrongyloids						10	0.2	0.2	0.12	0-2
	All nematodes						10	1.8	1.8	0.34	0-18
Wadi Melqa											
	Nematodirus spp.	nd					20	1.4	1.0	0.49	0-10
Wadi Esbaeia											
	Nematodirus spp.	nd					7.1	0.1	0.1	0.08	0-2

nd. Not done because insufficient numbers or no goats/camels were present in the wadi

Table 2. Summary of cell counts in blood samples from goats from 4 different wadis in St. Katherine, Sinai.

	Wadi Gebal	Wadi El-Sheikh Awad	Wadi Abu Seylah	Wadi El-Arbaein
RBCs (x 10^6)	19.51 ± 0.87	18.94 ± 0.86	21.02 ± 1.00	20.93± 0.86
Platelets (x 10^4)***	261.38 ± 45.84	623.75 ± 45.84	175.00 ± 52.93	72.25 ± 45.84
Neutrophils (10^3) **	5.54 ± 0.60	2.85 ± 0.60	4.97 ± 0.70	4.05 ± 0.60
Eosinophils (10^3) *	1.09 ± 0.17	0.75 ± 0.17	0.32 ± 0.19	0.72 ± 0.17
Lymphocytes (10^3)	6.52 ± 0.80	4.65 ± 0.80	6.82 ± 0.92	5.84 ± 0.80
Monocytes (10^3)	0.07 ± 0.04	0.09 ± 0.04	0.14 ± 0.05	0.15 ± 0.04

Table 5A. Summary of haemoglobin related parameters in blood from camels from 4 different wadis in St. Katherine, Sinai.

	Wadi Abu Seylah	Wadi El-Arbaein	Wadi Melqa	Wadi Esbaeia
RBCs (x 10^6)	11.61 ± 0.68	11.99± 0.68	12.18 ± 0.68	12.60± 0.57
Packed cell volume (%)	25.10 ± 0.75	23.70 ± 0.75	23.50 ± 0.75	23.57 ± 0.64
Haemoglobin concentration (g/dl)	12.09 ± 0.62	12.00 ± 0.62	11.92 ± 0.62	13.21 ± 0.52
Mean corpuscular volume (μ^3)	21.97 ± 1.00	20.16 ± 1.00	19.94 ± 1.00	18.99 ± 0.85
Mean cell haemoglobin (μg)	10.57 ± 0.64	10.28 ± 0.64	10.11 ± 0.64	10.65 ± 0.54
MCHC (%)*	48.34 ± 1.98	50.77 ± 1.98	50.67 ± 1.98	56.00 ± 1.68

Table 5B. Correlations between residuals of haemoglobin related parameters following multivariate analysis

	PCV	HB	MCV	MCH	MCHC
RBCs (red blood cells)	0.453	0.229	-0.795	-0.678	-0.093
PCV (packed cell volume)	-	0.584	0.160	0.068	-0.094
HB (Haemoglobin concentration)	-	-	0.111	0.543	0.750
MCV (Mean corpuscular volume)	-	-	-	0.791	0.013
MCH (Mean cell haemoglobin)	-	-	-	-	0.617

Table 6. Correlational relationships between measures of abundance of parasite infection and haemoglobin-haematological parameters in goats.

				ANOVA			
		Correlation		Parasite measure 1		Site effect 2	
Measure of parasite abundance	Haematological parameter	r_s	*P*	*F*	*P*	*F*	*P*
Nematodirus spp.	Platelet concentration	-0.376	0.041	0.386	NS	63.11	<0.001
	Mean cellular haemoglobin	-0.432	0.017	1.056	NS	1.015	NS
All nematodes	Haemoglobin concentration	-0.495	0.005	4.997	0.035	0.188	NS
	Mean cellular haemoglobin	-0.417	0.022	0.543	NS	1.00	NS
	MCHC	-0.522	0.003	5.306	0.03	1.85	NS
Eimeria spp.	Platelet concentration	0.584	0.001	4.928	0.036	25.215	<0.001

1. All models = site + log (parasite measure +1). In all cases $F_{1,25}$; 2. In all cases $F_{3,25}$.