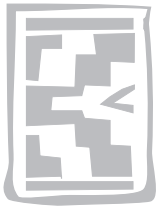

Ticks (Acari: Ixodidae) infesting camels (*Camelus dromedarius*) in Northern Sudan

A. ELGHALI[1]* and S.M. HASSAN[2]

ABSTRACT

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Monthly total body tick collections from 13-20 camels were conducted for 2 consecutive years (2000–2001) in Northern Sudan. Tick populations were correlated with locality, season, predeliction site, sex and coat colour. *Hyalomma dromedarii* was found to be the predominant (89 %) tick species infesting the camels. Other tick species found in very low numbers were *Hyalomma impeltatum* (7.7 %), *Hyalomma anatolicum anatolicum* (3.3 %), *Hyalomma truncatum* (0.29 %), *Hyalomma marginatum rufipes* (0.25 %), *Rhipicephalus praetextatus* (0.30 %) and *Rhipicephalus sanguineus* group (0.09 %). Nymphs of the genus *Hyalomma* were collected in significant numbers. Adult ticks significantly preferred to attach to the lower parts of the camel's body for feeding while the nymphs preferred the back of the animal. Female camels harboured more ticks than males while higher infestations were recorded on camels with a grey coat colour compared to those with a brown coat colour. Ticks were found on camels throughout the year and increased in numbers during March to October with a peak in September.

Keywords: Camels, *Hyalomma* spp., *Rhipicephalus* spp., Sudan, ticks

INTRODUCTION

Little publish information on ticks infesting camels is available. Camels in Egypt were found to be mainly infested by *Hyalomma dromedarii* (95 %) together with *Hyalomma marginatum* subspecies, *Hyalomma anatolicum excavatum* and *Hyalomma* species nymphs (Van Straten & Jongejan 1993). In the same area and on the same animal species Diab, El Kady & Shouky (2001) reported that *H. dromedarii, Hyalomma impeltatum, H. a. excavatum* and *H. a. anatolicum* represented 96 % of the tick population with a higher infestation in March to November and a mean monthly total of 22–78 ticks per animal. About 62 % of adult ticks were collected from the tail, anus, brisket and udder, and 91 % of nymphs were found infesting humps, neck, ears and sides. In Saudi Arabia, a total of 1 045 adult *H. dromedarii* and 174 *H. a. excavatum* together with 110 ticks that included *H. a. anatolicum*, *H. impeltatum*, *Hyalomma schulzei*, *Hyalomma truncatum*, *Hyalomma marginatum rufipes* and *Hyalomma marginatum turanicum* as well as 143 *Hyalomma* spp. nymphs were collected from 10 camels (El Khalifa, Al Asgah & Diab 1985). In Yemen, Arab Republic, the most abundant livestock ticks were *Hyalomma* spp., particularly on camels, but with a very low burden (MacArtan, Hunter, Pegram & Bourne 1987). In the Sudan, Karrar, Kaiser & Hoogstraal (1963) reported that *H. dromedarii* was the main tick species of camels together with *Amblyomma lepidum, H. impeltatum, Rhipi-*

* Author to whom correspondence is to be directed. E-mail: elghaliaahmed@hotmail.com

[1] Atbara Veterinary Research Laboratory, P.O. Box 121, Atbara, Sudan

[2] Department of Parasitology Faculty of Veterinary Medicine University of Khartoum, Sudan

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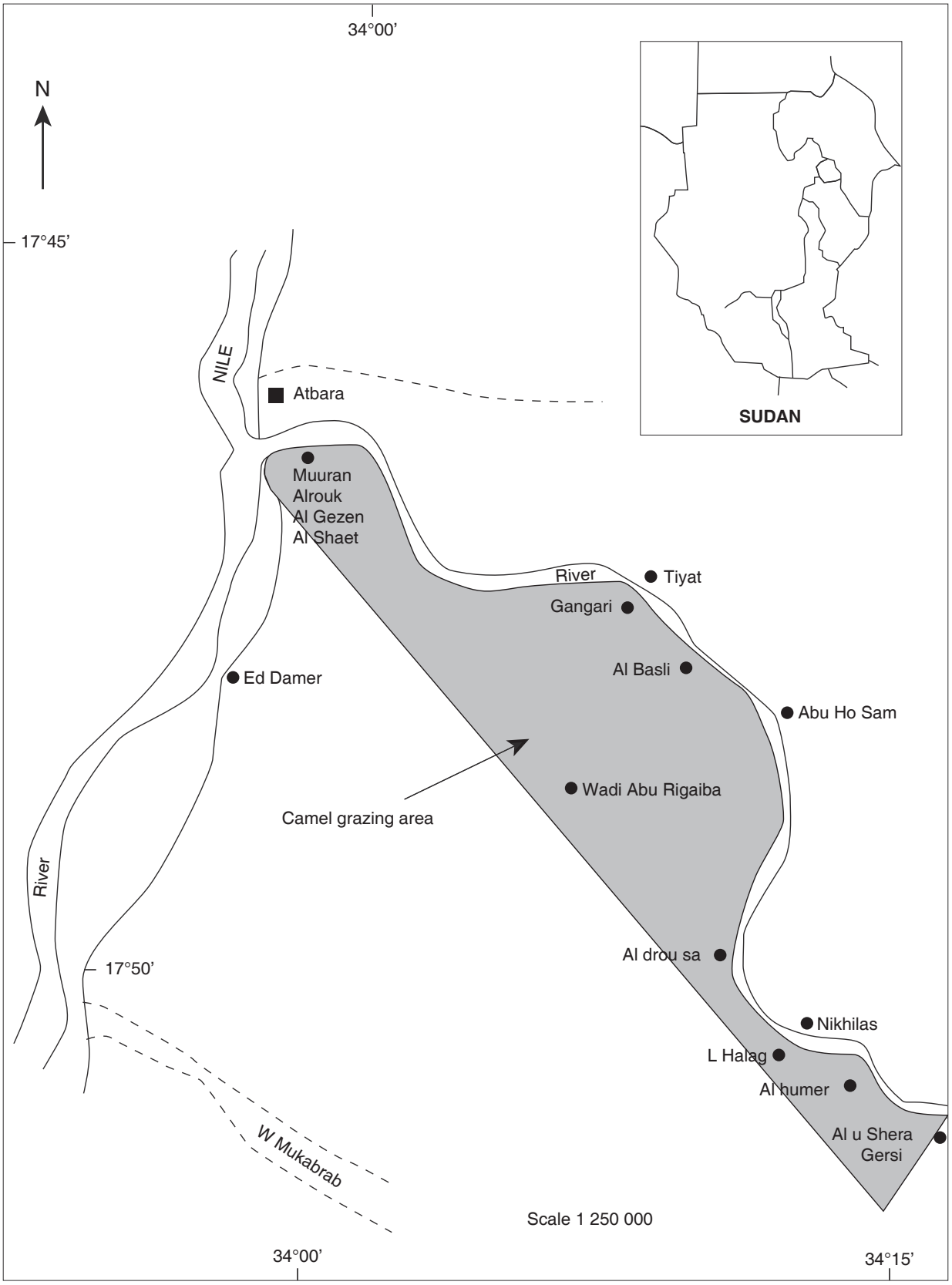

FIG. 1 Map of the study area in Nothern Sudan showing the localities from where ticks were colected (●) and Atbara Research Laboratory (■)

cephalus sanguineus sanguineus, Rhipicephalus simus, H. a. excavatum, H. truncatum and *H. m. rufipes*. Dolan, Wilson, Schwart, Newson & Field (1983) collected *H. dromedarii, H. m. rufipes* and *Rhipicephalus pulchellus* from camels in Kenya. The objective of this study was to conduct population studies of ticks infesting camels in Northern Sudan.

MATERIALS AND METHODS

The study area extends along the western banks of River Atbara starting from Ed Damer in Northern Sudan (Fig. 1). This area is in the arid (desert) zone (annual rainfall ranges between 0–100 mm) with very poor vegetation cover which mainly consists of scattered bushes and small trees, i.e. *Prosopis chilensis* and *Capparis decidua*. Large acacias such as *Acacia nilotica nilotica*, *Acacia seyal*, *Acacia tortilis tortilis, Acacia tortilis raddiana*, *Ziziphus spinachrista* and *Hyphaena thebaica* are abundant (El Amin 1989). Small-scale farms are cultivated along the river banks where camels graze. They graze on grass and post-harvest agricultural residues and browse on bushes and trees. During the wet seasons they move to the Butana area, approximately 300 km to the south-east, where the grazing is better.

Tick collection and identification

Total body collections of ticks from 13–20 adult camels were carried out on a monthly basis bar for 2 consecutive years (2000–2001). Ticks from each predilection site were put into separate vials containing 70 % ethanol. The vials were labeled to indicate date, time, locality, animal number, sex, host coat colour and predilection site. The predilection sites included head (head and neck), back (hump region and flank), tail (tail shaft and perineum), lower parts (brisket, belly, udder or scrotum and inner sides of thigh) and feet (knee to pad).

The ticks were identified according to Hoogstraal (1956), Hoogstraal & Kaiser (1959) and Walker *et al*. (2003), and results were recorded according to

TABLE 1 Means (± SE) of ticks collected from camels along the River Atbara and Ed damer in 2000–2001

Year	Tick species	River Atbara (123)	Ed damer (62)
2000	*H. dromedarii* (m)	125.0 ± 12.2a	49.5 ± 5.9b
	H. dromedarii (f)	40.4 ± 5.1a	13.6 ± 1.9b
	H. dromedarii (t)	165.4 ± 16.3a	63.1 ± 7.2b
	H. impeltatum (m)	12.4 ± 1.1a	3.3 ± 0.7b
	H. impeltatum (f)	5.7 ± 0.6a	0.45 ± 0.2b
	H. impeltatum (t)	18.2 ± 1.4a	3.8 ± 0.7b
	H. a. anatolicum (m)	3.8 ± 0.5a	1.1 ± 0.3b
	H. a. anatolicum (f)	7.3 ± 0.8a	0.2 ± 0.1b
	H. a. anatolicum (t)	11.1 ± 1.1a	1.2 ± 0.3b
	Hyalomma nymphs	5.0 ± 0.8a	2.5 ± 0.9b
	Mean total ticks	194.7 ± 17.3a	68.1 ± 7.8b
	Ratio (male:female)	3.1 ± 0.21b (105)	7.1 ± 1.2a (56)
2001	*H. dromedarii* (m)	111.4 ± 9.5a	40.2 ± 4.0b
	H. dromedarii (f)	43.4 ± 4.1a	13.7 ± 1.6b
	H. dromedarii (t)	154.9 ± 12.9a	53.9 ± 5.1b
	H. impeltatum (m)	10.8 ± 1.1a	2.8 ± 0.4b
	H. impeltatum (f)	0.37 ± 0.1a	0.02 ± 0.02b
	H. impeltatum (t)	11.2 ± 1.1a	2.9 ± 0.38b
	H. a. anatolicum (m)	1.02 ± 0.6a	0.02 ± 0.02b
	H. a. anatolicum (f)	0.88 ± 0.2a	0.07 ± 0.03b
	H. a. anatolicum (t)	1.9 ± 0.8a	0.1 ± 0.04a
	Hyalomma nymphs	7.9 ± 1.0a	4.9 ± 0.9b
	Mean total ticks	168.0 ± 13.7a	56.8 ± 5.3b
	Ratio (male:female)	3.6 ± 0.24a	4.6 ± 0.6a

Means (± SE) followed by the same letter in each row are not significantly different at 5 % level, based on Ryan's Q test (REGWQ)
( ) = no. of camels used
m = male
f = female
t = m + f

TABLE 2 Total tick burdens on camels in River Nile State, Northern Sudan, 2000 and 2001

Year	Location	*H. dromedarii*	*H. impeltatum*	*H. a. anatolicum*	*Hyalomma* nymphs
2000	River Atbara Ed damer	20 295 3 906	2 214 236	1 353 74	615 155
	Total no. of ticks	24 201	2 450	1 427	770
	% of adults	86.2	8.7	5.1	–
	Ratio (nymphs:adults)	1:36.5			
2001	River Atbara Ed damer	16 275 3 024	1 176 162	200 6	830 274
	Total no. of ticks	19 299	1 338	206	1 104
	% of adults	92.6	6.4	1.0	–
	Ratio (nymphs:adults)	1:18.9			
Total		43 500	3 788	1 633	1 874
% of grand total abundant adults		88.9	7.7	3.3	–
Ratio (nymphs:adults)		1:26.1			

TABLE 3 Total numbers of tick species collected from camels in very low numbers during 2000 and 2001 in River Nile State, Northern Sudan

Tick species	Males	Females	Total	% of total adult ticks
H. truncatum	127	16	143	0.29
H. marginatum rufipes	78	46	124	0.25
R. praetextatus	84	65	149	0.30
R. sanguineus group	26	16	42	0.09

TABLE 4 Means (± SE) of ticks collected from male and female camels in River Nile State, Northern Sudan, 2000–2001

Year	Tick species	*n*	Male camels	*n*	Female camels
2000	*H. dromedarii*	63	82.2 ± 12.3b	122	156.4 ± 16.0a
	H. impeltatum	63	8.4 ± 1.1b	122	15.9 ± 1.4a
	H. a. anatolicum	63	5.7 ± 1.2b	122	8.9 ± 1.1a
	Hyalomma nymphs	63	3.0 ± 1.0a	122	4.8 ± 0.8a
	Total ticks	63	96.3 ± 3.4b	122	181.2 ± 17.3a
	Ratio (male:female)	63	5.5 ± 1.0a	122	3.8 ± 0.4b
2001	*H. dromedarii*	33	89.8 ± 13.2b	128	127.5 ± 11.2a
	H. impeltatum	33	6.8 ± 2.1a	128	8.7 ± 0.9a
	H. a. anatolicum	33	1.1 ± 0.4a	128	1.3 ± 0.6a
	Hyalomma nymphs	33	7.9 ± 1.9a	128	6.5 ± 0.8a
	Total ticks	33	97.7 ± 14.5b	128	137.5 ± 12.0a
	Ratio (male:female)	33	3.4 ± 0.3a	128	4.1 ± 0.3a

Means (± SE) followed by the same letter in each row are not significantly different at 5 % level, based on Ryan's Q test (REGWQ)
n = no. of animals used

TABLE 5 Mean (± SE) numbers of ticks collected from camels in River Nile State in 2000 and 2001

Month	*n*	*H. dromedarii*	*H. impeltatum*	*H. a. anatolicum*	*Hyalomma* nymphs	Total ticks	Ratio (male:female)
2000							
January	20	70.9 ± 8.4b	17.3 ± 3.4a	15.5 ± 3.5a	1.8 ± 0.6b	103.7 ± 11.8b	2.9 ± 0.3b
February	20	70.4 ± 10.1b	10.9 ± 2.1a	9.5 ± 3.0ab	0.4 ± 0.2b	90.8 ± 14.1b	5.8 ± 1.4ab
March	17	82.2 ± 17.3b	11.4 ± 3.2a	7.0 ± 1.7ab	3.4 ± 2.3ab	100.6 ± 1.9b	6.6 ± 1.6ab
May	16	84.6 ± 17.6b	14.1 ± 3.6a	14.0 ± 5.1a	3.6 ± 1.2ab	113.1 ± 24.1b	2.1 ± 0.2b
June	19	104.7 ± 22.4b	8.6 ± 1.9a	6.9 ± 2.0ab	3.7 ± 1.7ab	120.2 ± 25.7b	4.6 ± 1.1ab
July	16	124.2 ± 24.9b	9.9 ± 2.6a	9.4 ± 2.9ab	2.4 ± 1.0ab	143.5 ± 29.4ab	8.1 ± 3.0a
August	16	136.3 ± 42.1ab	11.1 ± 3.4a	4.8 ± 1.3ab	9.3 ± 4.0ab	152.2 ± 45.9ab	3.8 ± 0.8b
September	14	256.6 ± 73.0a	18.1 ± 5.3a	1.8 ± 0.7b	3.6 ± 2.0ab	276.5 ± 78.2a	6.5 ± 1.7ab
October	17	252.5 ± 63.7a	17.4 ± 4.7a	2.4 ± 0.7b	2.9 ± 1.5ab	272.4 ± 68.2a	3.0 ± 0.3b
November	15	171.1 ± 51.5ab	12.7 ± 3.8a	6.7 ± 1.8ab	11.3 ± 3.6a	190.6 ± 55.7ab	2.4 ± 0.4b
December	15	137.9 ± 33.2ab	16.6 ± 4.5a	4.7 ± 2.0ab	5.9 ± 2.4ab	159.3 ± 39.9ab	2.7 ± 0.3b
2001							
January	13	154.8 ± 42.6ab	13.1 ± 3.4ab	2.8 ± 1.0a	9.0 ± 2.2ab	170.7 ± 46.0a	2.4 ± 0.3
February	14	89.4 ± 26.4ab	3.7 ± 2.7ab	1.3 ± 0.5a	9.5 ± 3.0ab	99.4 ± 29.2a	3.8 ± 0.6
March	16	170.8 ± 47.6a	15.8 ± 5.1a	2.1 ± 0.6a	5.7 ± 1.8ab	188.6 ± 51.9a	2.8 ± 0.3
April	15	158.5 ± 49.2ab	8.4 ± 3.1ab	0.7 ± 0.3a	6.0 ± 1.8ab	167.8 ± 52.4a	3.6 ± 1.3
May	16	115.3 ± 21.5ab	7.1 ± 2.2ab	0.6 ± 0.3a	4.3 ± 1.8ab	123.0 ± 23.4a	3.4 ± 0.5
June	19	121.2 ± 2.9ab	5.6 ± 1.2b	0.2 ± 0.1a	8.0 ± 2.6ab	126.9 ± 23.0a	4.1 ± 0.7
July	17	158.6 ± 27.0ab	4.5 ± 0.9b	0.4 ± 0.3a	12.4 ± 4.0a	163.5 ± 27.7a	5.8 ± 0.8
October	16	93.5 ± 8.3ab	7.3 ± 1.7ab	0.0 ± 0.0a	3.2 ± 0.8b	100.8 ± 8.9a	4.3 ± 0.9
November	18	60.8 ± 10.9b	8.4 ± 1.1ab	4.4 ± 4.4a	3.6 ± 1.6b	73.6 ± 11.8a	5.2 ± 0.7
December	17	86.5 ± 16.1ab	6.0 ± 1.4ab	0.4 ± 0.2a	6.6 ± 1.7ab	92.9 ± 16.7a	3.4 ± 0.9

Means (± SE) followed by the same letter in each column are not significantly different at 5 % level, based on Ryan's Q test (REWGQ)

n = no. of animals used

TABLE 6 Mean (± SE) number of ticks collected from different sites on camels

Tick species	Head	Back	Tail and under tail	Lower parts	Feet
H. dromedarii	22.7 ± 1.7b	1.7 ± 0.42c	23.8 ± 1.6b	76.9 ± 7.4a	18.6 ± 1.6b
H. impeltatum	1.7 ± 0.16b	0.09 ± 0.02c	1.9 ± 0.2b	5.4 ± 0.6a	1.2 ± 0.1b
H. a. anatolicum	0.06 ± 0.02b	0.03 ± 0.02b	0.24 ± 0.04b	1.2 ± 0.2a	0.25 ± 0.06b
Hyalomma nymphs	1.04 ± 0.26b	4.5 ± 0.5a	0.3 ± 0.1b	0.9 ± 0.2b	0.24 ± 0.15b
Ratio (male:female)	4.1 ± 0.3ab	2.8 ± 1.1b	3.4 ± 0.2ab	3.2 ± 0.2b	4.6 ± 0.9a

Means (± SE) followed by the same letter in each row are not significantly different at 5% level, based on Ryan's Q test (REWGQ)
No. of animals = 249

TABLE 7 Mean (± SE) number of ticks collected from male and female camels of different coat colour in River Nile State in 2000 and 2001

Camel gender	Tick species	Grey	Brown
Female	*H. dromedarii* (m)	140.3 ± 14.6a	71.4 ± 6.0b
	H. dromedarii (f)	54.8 ± 6.2a	26.7 ± 3.1b
	H. dromedarii (t)	195.0 ± 19.7a	98.2 ± 8.3b
	H. impeltatum (m)	13.7 ± 1.4a	5.6 ± 0.6b
	H. impeltatum (f)	1.1 ± 0.3a	0.54 ± 0.4b
	H. impeltatum (t)	14.8 ± 1.5a	6.2 ± 0.9b
	H. a. anatolicum (m)	1.3 ± 0.6a	0.2 ± 0.1b
	H. a. anatolicum (f)	2.0 ± .3a	0.6 ± 0.3b
	H. a. anatolicum (t)	3.3 ± 0.8a	0.8 ± 0.3b
	Hyalomma nymphs	7.8 ± 1.1a	6.0 ± 0.8a
	Total	213.2 ± 21.1a	105.1 ± 8.9b
	Ratio adult	3.8 ± 0.3a	4.0 ± 0.4a
Male	*H. dromedarii* (m)	79.0 ± 13.1a	42.9 ± 7.9a
	H. dromedarii (f)	27.2 ± 3.8a	12.5 ± 3.2b
	H. dromedarii (t)	106.2 ± 16.0a	55.4 ± 10.8a
	H. impeltatum (m)	6.5 ± 1.3a	6.4 ± 3.6a
	H. impeltatum (f)	0.9 ± 0.2a	0.4 ± 0.4a
	H. impeltatum (t)	7.4 ± 1.3a	6.8 ± 3.5a
	H. a. anatolicum (m)	0.9 ± 0.2a	0.2 ± 0.2b
	H. a. anatolicum (f)	1.1 ± 0.3a	0.7 ± 0.5a
	H. a. anatolicum (t)	1.9 ± 0.4a	0.9 ± 0.7a
	Hyalomma nymphs	7.7 ± 1.7a	2.9 ± 0.8a
	Total	115.5 ± 17.3a	63.1 ± 13.4a
	Ratio (male:female)	4.0 ± 0.6a	4.4 ± 0.7a

Means (± SE) followed by the same letter in each row are not significantly different at 5% level, based on Ryan's Q test (REWGQ
Females: grey 108, brown 74
Males: grey 50, brown 17
m = male, f = female and t = m + f

TABLE 8 Correlation analysis between ticks collected from camels with monthly meteorological values in 2000–2001 in River Nile State

Year	Met. data	*H.* nymphs	*H. d.*	*H. i.*	*H. a. a.*	Total ticks
2000	Min. (185)	0.02	0.16*	–0.02	–0.02	0.15*
	Max. (168)	0.06	0.12	–0.06	–0.1	0.1
	Rh9 (185)	–0.003	0.01	0.1	0.001	0.01
	Rh3 (185)	–0.13	–0.05	0.11	0.08	–0.04
	Rain (185)	0.24***	0.08	–0.01	–0.03	0.07
2001	Min. (172)	0.02	0.02	–0.17*	–0.1	–0.005
	Max. (172)	–0.01	0.04	–0.16*	–0.11	0.2
	Rh9 (172)	0.09	–0.11	–0.003	0.08	–0.09
	Rh3 (172)	0.02	–0.16*	–0.01	0.08	–0.14
	Rain (172)	0.11	–0.1	–0.07	–0.07	–0.1

* $P \leq 0.05$, ** $P \leq 0.01$ and *** $P \leq 0.001$
H. d. = *H. dromedarii*
H. i. = *H. impeltatum*
H. a. a. = *H. a. anatolicum*
Min. = minimum temperature
Max. = maximum temperature
Rh9 = relative humidity at 900 h
Rh3 = relative humidity at 1 500 h
( ) = no. of observations

the body site and genus, species, gender and developmental stage of each tick collected. The parameters studied included tick species infesting camels, seasonality, effects of camel gender and coat colour and preferred attachment sites of each tick species. The number of ticks was correlated with the mean monthly minimum ambient temperatures, mean monthly maximum ambient temperatures, and mean ambient relative humidity and total monthly rainfall.

RESULTS

In the 2 study years 2000 and 2001, *H. dromedarii* represented 86.2 % and 92.6 %, respectively, of the ticks infesting the camels (Table 1), with a mean of 88.9 % (Table 2). Mean tick numbers per camel were 165.4 ± 16.3 and 154.9 ± 12.9 in 2000 and 2001, respectively. Other ticks collected in some numbers were *H. impeltatum* (7.7 %) and *H. a. anatolicum* (3.3 %) (Table 2). Tick species found in very low numbers were *H. truncatum*, *H. marginatum rufipes*, *Rhipicephalus praetextatus* and *R. sanguineus group* (Table 3).

The ratio of male to female ticks ranged between 3.1 ± 0.21 and 7.1 ± 1.2 for the 2 years, respectively. The total ratio of *Hyalomma* nymphs to adults of all *Hyalomma* species was 1:26.1. Female camels were found to carry more ticks than males. This result was highly significant for *H. dromedarii* (Table 4).

Hyalomma dromedarii numbers increased from April and reached a peak in September and October in 2000 (Table 5). In 2001, the highest infestation was recorded in March although there was no significant difference between months. *Hyalomma impeltatum* showed no significant differences between months in 2000 but the least mean tick numbers were collected in July and August. Peak numbers of this species were collected in March 2001 (Table 5) and the least in February, June and July. More *H. a. anatolicum* were collected in January 2000 and in November 2001 with no significant differences between months. *Hyalomma* nymphs were prevalent throughout 2000 and 2001 with peaks in November 2000 and July 2001 (Table 5). The total numbers of adult ticks collected were significantly higher in 2000 during September and October and from January to June but in 2001 there were no significant differences in the total numbers ticks collected per month. During the collection period, male ticks outnumbered females with the exception of *H. a. anatolicum* (Table 5).

The udder, scrotum, belly and brisket were the preferred sites for feeding of *H. dromedarii* (53.5 %), *H. impeltatum* (52.5 %), and *H. a. anatolicum* (65.4 %) (Table 6). The hump and sides was much less preferred (1.2 %, 0.9 % and 1.7 % of *H. dromedarii, H. impeltatum* and *H. a. anatolicum*, respectively) while the nymphs preferred the back (64.5 %) (Table 6).

Female camels with a grey coat colour harboured significantly more ticks than females with a brown coat colour (Table 7). This was shown clearly by individual tick species, their gender and also with mean total ticks collected. However, there were no significant differences in the numbers of nymphs harboured by grey and brown female camels. Male grey coloured camels harboured more ticks than brown coloured males but the difference was only significant for female *H. dromedarii* and for male *H. a. anatolicum*.

Hyalomma dromedarii infestation was positively correlated in 2000 with mean minimum and maximum ambient temperatures, relative humidity and rainfall (Table 8) while in 2001, this was positively correlated only with mean minimum and mean maximum ambient temperatures. *Hyalomma impeltatum* in 2000 and *H. a. anatolicum* in both years were found to increase with increased humidity and decreased temperature. Generally, tick infestation was not strongly correlated with meteorological values. It was, however, observed that *Hyalomma* nymphs significantly increased in number with rainfall during 2000.

DISCUSSION

This study was conducted in a semi-desert zone where rainfall is very low and of short duration (July to September). The River Atbara is a factor in that it creates suitable microhabitats for ticks with acacia trees, bushes, few grasses and cultivated areas and plays a role with the movement of camels to Butana from July to November in impacting on the seasonal population changes of ticks.

In the present study, *H. dromedarii* represented the main tick species infesting camels (88.9 %) followed by *H. impeltatum* (7.7 %) and *H. a. anatolicum* (3.3 %). It was also found that *H. dromedarii* females were the main tick species found engorged on the camels, while females of the other species (*H. impeltatum, H. a. anatolicum, H. m. rufipes* and *Rhipicephalus* spp.) were not engorged or only partially engorged. This could be due the fact that cam-

els are not the preferred hosts of the latter tick species.

Other tick species found in this study in small numbers were *H. truncatum*, *H. m. rufipes, R. sanguineus* group and *R. praetextatus*. In Egypt, the main tick species infesting camels is *H. dromedarii* representing up to 95 % of ticks (Van Straten & Jongejan, 1993; Diab *et al.* 2001). In Eastern Sudan, Karrar *et al.* (1963) reported that *H. dromedarii* is the main tick species feeding on camels. Other tick species they found on camels were *R. sanguineus, R. simus*, *H. a. excavatum* and *Amblyomma lepidum*. In the current study, *A. lepidum* was not found despite the fact that some camels are taken each year to the Butana area where this tick species was previously found (Karrar *et al.* 1963). Ahmed (1999) studied tick infestations on sheep in the study area and found that 74 % of the ticks were *H. a. anatolicum*, 15 % *R. sanguineus* group, 2 % *R. simus*, 9 % *Rhipicephalus evertsi evertsi* and 0.5 % *H. dromedarii*. This strongly implies that sheep are not preferred hosts for *H. dromedarii,* while camels are not preferred hosts for *H. a. anatolicum*. He also reported that sheep were not infested with *H. impeltatum, H. truncatum* and *H. m. rufipes*. In the current study *R. e. evertsi* was not found feeding on the camels. These two studies in the same ecological zone where camels and sheep co-exist imply that there is a strong host preference of these ticks.

In this study most ticks were collected from the lower parts of the camels. Unlike other animal species (Hoogstraal 1956), the tail, despite the fact that it is short in camels, was found to be an important feeding site of ticks particularly the edges. This could be due the fact that the tail of camels has a less fat component or that due to the physiological status of camels in that the body temperature fluctuates during the day and that of the tail is possibly the least affected. The high percentage (64.5 %) of nymphs found on the back particularly the hump also differs from other animal species. This is could be due to the fact that the nymphs (which attached as larvae) seek shelter within the hairy hump area and that it provides more humidity, or it may be that *H. dromedarii* nymphs prefer the back of their hosts. For instance, Hassan (1997) working on cattle, found that nymphs of *Rhipicephalus appendiculatus* and *Amblyomma variegatum* preferred the head region and the underside of the hosts, respectively. The high number of ticks collected from under the tail in this study is in agreement with the findings of Diab *et al.* (2001). *Hylomma m. rufipes* was found mainly under the tail particularly around the anus. The predilection site of this tick species is not different from that of cattle (Hoogstraal 1956; Hassan 1997).

Seasonality of ticks infesting camels was observed by Diab *et al.* (2001) who reported that high tick infestations in Egypt occurred during March to November. In the present study, there was no clear pattern of seasonality. Ticks were found on camels throughout the year but it was observed that the highest infestation occurred from March to October. This could be attributed to the fact that the non-parasitic flat stages could survive well during winter which was reflected as infestations during the following summer. On the other hand, it was observed that ticks do not go into diapause during winter when ambient temperature drops to about 10 °C. *Hylomma a. anatolicum* feeding on sheep in the same area were also not found to go into diapause, according to Ahmed (1999) who found high infestations in winter. It is also possible that *H. dromedarii* unlike *R. appendiculatus* (Pegram & Banda 1990) does not go into diapause.

This study revealed that female camels carried significantly more ticks than the males. This was true for all adult tick species. Hassan (1997) reported similar findings for cows with higher loads of *R. appendiculatus* and *A. variegatum* than oxen. Pregnancy and lactation stress may lower the resistance of females to tick infestation (Ali 2004). However, this was not true for nymphs as both genders of camels carried loads the differences of which were not significant. This could be due to differences in resistance of male and female camels against larvae that feed and moult on the host, but not against nymphs.

Camels with a grey coat colour carried significantly more ticks than those with a brown coat colour. This was true for all tick species particularly those which were found feeding on female camels. Working with cattle, Hassan (1997) found that hosts with a black coat colour were infested with fewer *R. appendiculatus* and *A. variegatum* compared to cattle of a brown and white coat colour. He attributed this phenomenon to the fact that a dark coat colour absorbs more heat, changing the microhabitat of the ticks which leads to a high mortality rate or the ticks dropping off without feeding. Camels in this area are of two types, namely brown and grey, and the difference in tick load may indicate a difference in their innate resistance to tick infestation.

The current study revealed that male ticks of all species except *H. a. anatolicum* outnumbered females. Similar results were reported by Hoogstraal (1956),

Kaiser, Sutherst, Bourne, Gorissen & Floyd (1988) and Hassan (1997). This is due to the fact that females detach from the hosts after a few days of feeding to oviposit while males remain for several weeks before dropping (Hoogstraal 1956). However, *H. a. anatolicum* females were found to outnumber males. This could be due to the fact that camels are probably not their preferred hosts and hence males either do not attach or drop off without attaching. Very few engorged *H. a. anatolicum* females were collected indicating that few males were available for mating with females to complete engorgement.

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