CURRENT STATUS OF DISTRIBUTION OF TICKS (ACARI: IXODIDAE) INFESTING CATTLE IN SOUTH DARFUR STATE, SUDAN.

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المستخلص

أجري هذا الاستطلاع فى الفترة ما بين يونيو ٢٠٠٤ إلى مايو ٢٠٠٥ لدراسة والتعرف على أنواع القراد التي تتغذى على الأبقار في ولاية جنوب دارفور بالسودان. وقد تم جمع القراد كل شهرين من الأبقار شبه المستقرة والمستقرة وذلك من ثلاث فئات عمرية هي أقل من ٢ ، ٢ - ٤ وأكثر من ٤ سنوات. أختيرت خمسة مدن هى نيالا ، عد الفرسان ، وتلس ، ورهيد البردى وأم دافوق وهى المناطق التى لا تمارس فيها مكافحة القراد. أسفرت نتائج الدراسة عن وجود أربعة أجناس و ١٥ نوعا من القراد. وتشمل هذه الأنواع أمبليوما ليبيدم ، أمبليوما فاريقاتم ، هايالوما أناتوليكم ، هايالوما دروميدارى ، هايالوما إمبلتاتم، هايالوما روفيبس ، هايالوما إمبرسم ، هايالوما ترنكاتم ، بووفلص أنيولاتص، بووفلص ديكولوريتص ، رايبيسيفيلس أفرتساى أفرتساى ، رايبيسيفيلس قلهونى ، رايبيسيفيلس موهسامى ، رايبيسيفيلس بريتكستيتس ورايبيسيفيلس سانقاوينس سانقاوينس. تلاحظ أن أعلى معدل للقراد كان خلال موسم الأمطار. كما وجد أن الأبقار بها كميات أكبر من القراد مقارنة بالثيران في حين أن العجول بها أعداد أقل. ووجد أن الماشية ذات اللون الأبيض يلصق بها أعداد أكبر من القراد مقارنة برصيفاتها من الماشية ذات اللون البنى أو الأسود. وكشفت الدراسة أنى أنواع القراد ذات الأهمية الإقتصادية الكبرى وهى هايالوما أناتوليكم و أمبليوما ليبيدم قد وصل إنتشارها إلى الأجزاء الغربية من البلاد. ولن يكون مفاجئا أن يتواصل إنتشار هذه الأنواع غرباً وتصل دول غرب أفريقيا.

Keywords: Ticks, Current distribu

Abstract

This survey was conducted from June 2004 to May 2005 to study the current status of ticks infesting cattle in South Darfur State, Sudan. Tick collection was carried out at two months intervals from sedentary and semi sedentary cattle of three age groups namely calves less than 2 years old, 2 to 4 years old heifers or steers and more than 4 years old adults. The collection covered five localities, Nyala, Edd-alferrsan, Tulus, Reheid-albirdi and Umdafug where tick control measures were not practiced. Four genera and 15 species of ticks were identified. These included *Amblyomma lepidum*, *A. variegatum*, *Hyalomma anatolicum*, *H. dromedarii*, *H. impeltatum*, *H. rufipes*, *H. impressum*, *H. truncatum*, *Boophilus annulatus*, *B. decoloratus*, *Rhipicephalus evertsi evertsi*, *R. guilhoni*, *R. muhsamae*, *R. praetextatus* and *R. sanguineus sanguineus*. The highest tick load was during the rainy season. Cows carried more ticks than oxen while calves carried lower numbers. Cattle with white coat colour were infested by higher numbers of ticks compared to animals with brown or black coat colour. The survey revealed that *H. anatolicum* and *A. lepidum* has spread and established in western parts of the country. It will not be surprising for these economically important tick species to spread and establish in the West African countries and hence new tick borne diseases to emerge.

Introduction

Ticks have great economic importance in animal production (Biswas, 2003). The global annual cost of ticks and tick – borne diseases (TBDs) have been estimated between US$ 13.9 and US$ 18.7 billion (de Castro, 1997). They are widely distributed throughout the world especially in tropical and sub tropical areas and their impact on animal production is important wherever they occur (FAO, 2004). In the Sudan, there are 68 tick species under eleven genera infesting variety of domestic and wild animals, reptiles and birds (Hoogstraal, 1956; Osman, 1978). Salih *et al*. (2004) reported 12 species of ticks infesting cattle in different localities in central, western, eastern and northern Sudan. Distribution of these species is governed by climatic variations and has changed due to deforestation, desertification, animal movement and the extended mechanized

agriculture schemes. The objectives of this study were to determine the current prevalence and seasonal distribution of ticks infesting cattle in South Darfur.

Materials and Methods

South Darfur State is situated in the western parts of the Sudan between latituates 8^{o} 30' to 13^{o} N and longitudes 23^{o} 15' to 28^{o}E and shares the international borders with Republic of Central Africa and Chad (Map 1). Climate varies from low rainfall savannah (300-800 mm) in the northern parts to the clay high rainfall woodland savannah (400-1300 mm) in the southern parts where the lowland is covered with broad leaves wooded savanna trees and grass. In summer (March-June) the climate is dry and hot, while in autumn (July- October) it is wet and cold. During winter (November - February), the climate is cool. The ambient temperature in northern parts varies from 10^{o}C to 35^{o}C and in southern parts from 15.9^{o}C to 40.7^{o}C to (Suliman, 2003). Due to the diminishing resources, seasonal and annual migration is essential for livestock survival, both in pastoral and agro-pastoral systems. Other reasons are to avoid build up of worms and attacks by tsetse flies, biting midges and other pests. The nomadic system of life is characterized by migration of pastoralist with their animals for long distances from south to north in the rainy season and to south at the end of the rainy season a fact that largely contributes in dissemination of ticks and TBDs. At the beginning of the rainy season, they migrate from far southern parts of Darfur and neighbouring countries to Northern Darfur and North West Darfur states. This pattern has changed to some extent due to civil unrest and conflict in Darfur region. Some pastoralists have changed their migration from North Darfur State to South Darfur and far south western parts of West Darfur to avoid the conflict area. At the end of the rainy season, reversed migration occurs to the neighbouring West African counties. However, this new situation delivered more problems to livestock particularly ticks and TBDs. This survey was carried out in five localities in South Darfur namely, Nyala, Edd-alferrsan, Tulus, Reheid Alberdi and Umdafug (Map 1). Meteorological data were recorded throughout the study period from Nyala.

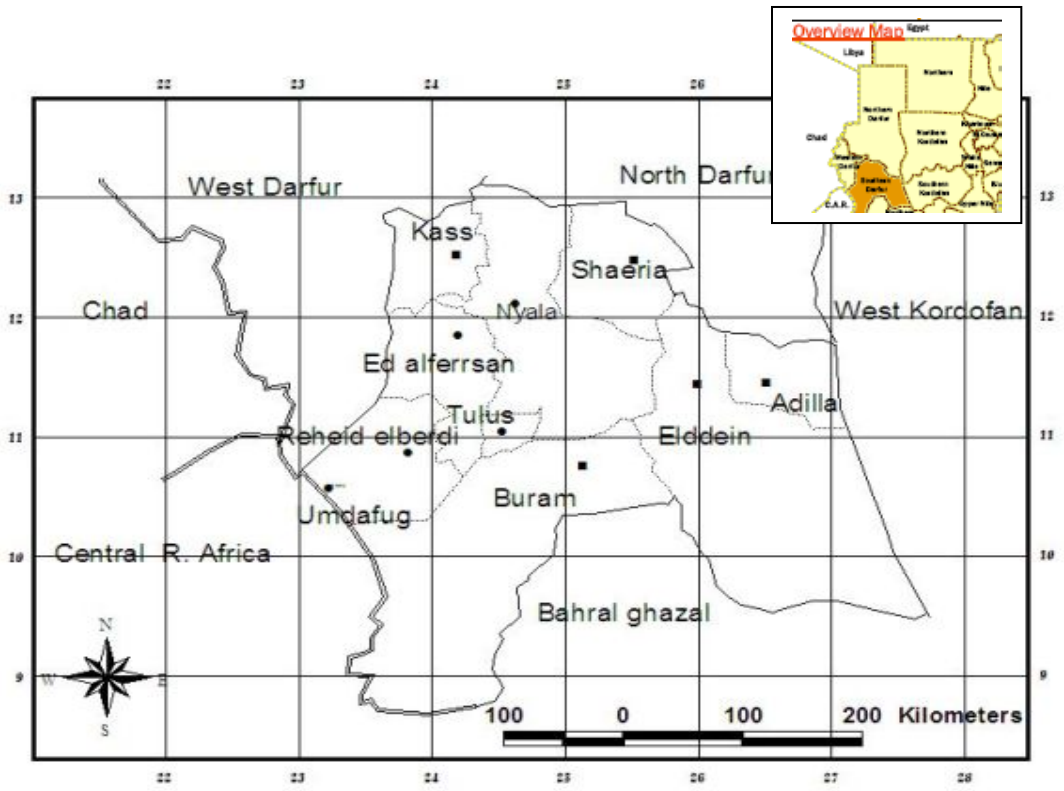
tion, Darfur, Sudan.

Ticks collection

Ticks were collected at two monthly intervals for 12 months from June 2004 to May 2005. Thirty heads of cattle from each locality were used. These cattle were of three age groups i.e. less than two years old calves, two to four years old heifers or steers and older than four years cows or bulls. The same animals were used every time. All visible attached ticks were collected in vials containing 70% ethanol that were labeled indicating locality, animal number, age, coat colour, sex and date of collection. Identification was carried out according to Hoogstraal (1956), Okello-Onen *et al.* (1999), Walker *et al.* (2000) and Walker *et al.* (2003) methods. They were recorded according to sex and developmental stages.

Statistical analysis

Ticks collected were subjected to appropriate general liner model (GLM) procedure of statistical analysis using SAS package. The SAS was used to perform analysis of variance (ANOVA) and mean separations were performed using Ryan-Einto-Gebriel-Welsch multiple Q test (REGWQ) according to Day and Quinn (1989). Tick counts were transformed to $\sqrt{(\log10(x + 1) + 0.5)}$ scale before being subjected to ANOVA according to Hassan *et al*. (1992). Correlation analysis was carried out to relate tick abundance to meteorological data.



Map (1) Localities ● from where ticks were collected during 2004 – 2005.

Results

Four genera of ticks were identified namely *Amblyomma, Boophilus, Hyalomma* and *Rhipicephalus***.** The species included *A. lepidum, A. variegatum***,** *B. annulatus, B. decoloratus, H. anatolicum, H. dromedarii, H. impeltatum, H. impressum, H. rufipes, H. truncatum, R. evertsi evertsi, R. guilhoni, R. muhsamae, R. praetextatus* and *R. sanguineus sanguineus*. The highest mean total ticks (25.08±2.0) per animal were collected in Tulus, while the lowest mean total ticks (15.74±1.3) were collected in Umdafug (Table 1). No significant difference ($P \geq 0.05$) was observed between tick load and host sex. Similarly, there was no significant difference ($P \geq 0.05$) between numbers of ticks feeding on different age groups of cattle. Nevertheless, the highest mean ticks (21.4±1.5) infested animals aged between two to four years old followed by calves aged less than two years old and the least mean tick infestation (15.8±1.4) infested calves aged less than two years old and less. On the other hand, there was no significant difference ($P \geq 0.05$) between tick infestation and host coat colour. However, the highest mean ticks (20.7±0.9) infested cattle with white coat colour followed by brown coat colour (20.3±1.3) and the least tick load (17.6±1.6) fed on cattle with black coat colour (Table 2).

Amblyomma lepidum

This tick species was reported in all localities. The highest mean (3.33±0.4) was recorded in Edd-alferrsan, while the least mean (0.11±0.1) was in Nyala (Table 1). *A. lepidum* was relatively high in December and April and low in September and February (Table 3). There was no significant correlation between *A. lepidum* and monthly temperature, relative humidity and total monthly rainfall (Table 4).

Amblyomma variegatum

The African bont tick was reported in all localities with the highest mean tick load (3.39±0.4) in Reheid-alberdi, followed by Edd-alferrsan (3.39±0.7), while the lowest mean was in Nyala (1.69±0.4) (Table 1). This tick occurs in more number in the wet months of June, July and

August and also in dry months of March and April, while the lowest mean was in the dry seasons of January and February (Table 3). There was no significant correlation between its tick number and mean monthly ambient temperature, but there was positive significant correlation with relative humidity and total rainfall (Table 4).

Boophilus annulatus

This tick species was reported in all the study area. The highest mean tick load (4.54±0.4) was in Tulus, while the least mean (0.27±0.1) was in Edd-alferrsan (Table 1). This tick was common in March, July, September and November, while having lower mean in June and August (Table 3). There was a significant positive correlation between its mean number and ambient temperature, while their number had no significant correlation with relative humidity and total monthly rainfall (Table 4).

Boophilus decoloratus

This tick species was recorded in all the localities, with the highest mean tick load (4.30±0.5) in Tulus and the lowest mean (1.46±0.3) was recorded in Nyala (Table 1). The seasonality pattern of this tick was similar to *B. annulatus* (Table 3). There was a negative significant correlation between its number, temperature and total rainfall, but there was no significant correlation between its number and relative humidity (Table 4).

Hyalomma truncatum

This tick species was recorded in all the study area. The highest mean tick (3.72±0.4) was found in Umdafug, while the lowest number (0.62±0.1) was in Tulus (Table 1). There was a clear pattern of seasonality of this tick. The highest mean number was in May and July, while the lowest was in September and December (Table 3). There was no significant correlation with ambient temperature, relative humidity and total rainfall (Table 4).

Hyalomma rufipes

This tick species was abundant in all localities. The highest mean tick load (7.83±0.8) was found in Tulus, while the lowest mean (5.09±0.5) was in Nyala (Table 1). There was no clear pattern of

seasonality (Table 3). There was a negative significant correlation between its number and relative humidity and total rainfall, but there was no significant correlation with the ambient temperature (Table 4).

Hyalomma impeltatum

This tick species was more common in Nyala and Tulus, with low occurrence in other localities. The highest mean tick load (10.17±1.3) was in Nyala, while the lowest mean (0.0±1.0) was in Edd-alferrsan (Table 1). There was a clear pattern of seasonality. The highest mean number was in May and July, while the lowest was in September and December (Table 3). There was a significant correlation with ambient temperature, but no significant correlation with relative humidity and total rainfall (Table 4).

Hyalomma dromedarii

This species was found in low numbers compared with other *Hyalomma* species in all localities. The highest mean (0.95±0.2) was recorded in Edd-alfersan, while the lowest mean (0.10±0) was in Umdafug (Table 1). There was no clear pattern of seasonality as there was no significant difference ($P \geq 0.05$) in seasonal occurrence (Tables 3, 4).

Ticks found in low numbers

The tick species recorded in very low numbers were R. e. evertsi, R. s. sanguineus, R. praetextatus, R. guilhoni, R. muhsamae, H. impressum and H. anatolicum (Table 5).

Hyalomma anatolicum

This xerophilic species was only found in Nyala where it was reported in a high abundance in July followed by low abundance in March and in very low numbers in January. It was not found in other months of the year. Only one male was found In Umdafug (Table 5).

Hyalomma impressum

This tick species was found in all localities with the exception of Edd-alferssan. The highest prevalence was in Reheid-alberdi while the lowest was in Tulus. The highest mean was in March and June in Reheid-alberdi**,** while in Umdafug it was in February and June. It was not found in November in the localities mentioned and Tulus, while it was found in the same month in Nyala (Table 5).

Rhipicephalus evertsi evertsi

This tick species was found throughout the year in Nyala, with the highest mean in September while the lowest was in January. In Edd-alferrsan, it was recorded in low numbers in all months except in November. Similarly, in Tulus it was found throughout the year but disappeared in July. In Reheid-alberdi, one male was recorded in each of January, March and August. This tick species was not recorded in Umdafug (Table 5).

Rhipicephalus sanguineus sanguineus

This tick species was recorded in Nyala and Edd-alferrsan only in September and June, respectively. However, it was found in Tulus in all months except in June. In Reheid-alberdi, it was found only in January, August and November. This species was not recorded in In Umdafug and Reheid-alberdi (Table 5).

Rhipicephalus praetextatus

This tick species was reported in Reheid-alberdi in January, June and August, while in Umdafug it was found only in August. It was not found in other localities (Table 5).

Rhipicephalus guilhoni

This tick species was found in Reheid-alberdi in June and November. In Umdafug it was recorded only in January and April. It was not found in Nyala, Edd-alferran and Tulus (Table 5).

Rhipicephalus muhsamae

This tick species was found in Edd-alferrsan only in June, while in Reheid-alberdi it was observed in January, August and November and in Umdafug in all months with the exception of March and April. It was not recorded in Nyala and Tulus (Table 5).

Table (1) Mean (± SE) numbers of ticks per animal collected from cattle in different localities in South Darfur during 2004 - 2005.

Location	*A. lepidum*	*A. variegatum*	*B. annulatus*	*B. decoloratus*	*H. dromedarii*	*H. rufipes*	*H. impeltatum*	*H. truncatum*
Nyala	0.11± 0.1c	1.69± 0.4b	1.46±0.5b	1.46± 0.3b	0.46± 0.1b	5.09± 0.5b	10.17± 1.3a	1.35± 0.2b
Eddalfirsan+	3.33±0.4a	3.39±0.7ab	0.27±0.1c	3.68± 0.4a	0.95± 0.2a	7.21± 0.6a	0.01± 0c	0.82±0.1bc
Tulus	0.34± 0.1c	2.52± 0.6b	4.54± 0.4a	4.30± 0.5a	0.44± 0.1b	7.83± 0.8a	4.46± 1.5b	0.64± 0.1c
Reheidalberdi	0.36± 0.1c	3.39± 0.4a	1.74± 0.4b	3.52± 0.4a	0.32± 0.1bc	7.26± 0.6a	0.12± 0c	1.59± 0.2b
Umdafug	0.96± 0.2b	2.94± 0.5ab	0.97± 0.2b	1.63± 0.3b	0.10± 0c	5.30± 0.5ab	0.02± 0c	3.72± 0.4a

Number of observations =180 in each locality. + number of observations = 150.

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

Table (2) Mean (±SE) numbers of ticks per animal affected by sex, age groups and coat colour in South Darfur during 2004- 2005

		A. lepidum	*A. variegatum*	*B annulauts*	*B. decoloratus*	*H. dromedarii*	*H. rufipes*	*H. impeltatum*	*H. truncatum*
Animal sex	Male (218)	0.85±0.2a	2.64±0.5a	2.71±0.4a	3.53±0.4a	0.42±0.1a	7.03±0.6a	2.21±0.7a	1.44±0.2a
	Female (651)	0.97±0.1a	2.80±0.3a	1.68±0.2b	2.69±0.2a	0.44±0.1a	6.35±0.3a	3.35±0.5a	1.72±0.1a
Animal age groups									
	< 2 (152)	0.56±0.1a	2.26±0.4a	1.700.3b	1.93±0.3b	0.42±0.1a	5.29±0.6b	2.040.8b	1.58±0.3a
	2-4 (240)	0.82±0.2a	2.79±0.5a	2.680.3a	3.78±0.4a	0.44 ±0.1a	6.52±0.5a	3.05±1.1b	1.31±0.2a
	>4 (477)	1.12±0.1a	2.91±0.3a	1.63±0.2b	2.76±0.2b	0.44±0.1a	6.92±0.4a	3.40±0.5a	1.84±0.2a
Animal coat colour									
	Black (108)	0.51±0.2b	2.35±0.5a	2.23±0.6a	2.22±0.4a	0.31±0.1a	5.52±0.3a	1.96±0.6a	2.48±0.5a
	Brown (233)	0.87±0.2a	2.12±0.3a	2.21±0.4a	2.60±0.3a	0.40±0.1a	7.02±0.6a	3.45±0.9a	1.64±0.2a
	White (528)	1.06±0.1a	3.13±0.3a	1.75±0.2a	3.17±0.2a	0.48±0.1a	6.51±0.3a	3.11±0.6a	1.48±0.1a

Figures in parentheses are numbers of animals.

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

Table (3) Mean (± SE) number of ticks seasonally collected from cattle in localities of South Darfur during 2004 - 2005

Month	*A. lepidum*	*A. variegatum*	*B. annulatus*	*B. decoloratus*	*H. dromedarii*	*H. rufipes*	*H. impeltatum*	*H. truncatum*
Nyala			.					
February	0.03±0a+	0.03±0.c	0.63±0.6b	0.23± 0.1c	0.30± 0.2a	7.17± 1.2a	11.20± 2ab	2.83±0.6a
April	0.13± 0.1a	1.10± 0.7c	0.17± 0.1b	1.20± 0.5bc	0.70± 0.5a	6.47± 0.3ab	7.77± 2.5b	0.70± 0.3c
May	0.03±0a	0.23± 0.1c	0.00± 0b	0.07± 0.1c	0.67± 0.4a	2.13±0.7b	26.93± 4.6a	0.33± 0.1c
July	0.00±0a	6.70± 1.6a	0.00± 0.b	0.03± 0. c	0.30± 0.2a	2.87± 0.9b	13.70± 3.5b	0.40± 0.2c
September	0.03±0a	2.01± 0.6b	1.70± 0.7b	2.00± 0.7b	0.67± 0.2a	4.47± 1.0ab	1.43± 0.5c	2.67± 0.8ab
December	0.43±0.3a	0.07± 0.1c	8.60± 2.4a	5.20±1.1a	0.20± 0.1a	7.47± 1.0a	0.20± 0.1c	0.93± 0.3bc
Edd-alferrsan								
January	2.10±0.6b	0.10±0.1b	0.63±0.4a	3.20± 1.0bc	0.43± 0.2bc	4.33± 0.9bc	0.00± 0a	0.20±0.1b
March	6.90± 1.1a	0.70± 0.2b	0.33± 0.2a	3.83± 0.7ab	1.73± 0.3a	6.83± 0.9ab	0.03± 0a	1.23± 0.3a
April	1.63± 0.5b	0.17± 0.5b	0.00± 0a	3.13± 0.7abc	0.53± 0.4c	12.13±1.5a	0.00± 0a	0.33± 0.2b
July	2.77± 0.5b	15.80± 2.6a	0.10± 0.1a	2.17± 0.9c	1.77± 0.3a	8.63± 1.4abc	0.00± 0a	1.60± 0.5a
November	3.23± 0.7b	0.17± 0.1b	0.27± 0.2a	6.07± 1.2a	0.26± 0.2c	4.13± 1.0c	0.00± 0a	0.73± 0.3ab
Tulus								
January	0.13±0.1b	0.20±0.1b	9.37±1.4a	10.37± 2.3a	0.10± 0.1b	8.03± 1.3abc	0.37± 0.1c	0.77±0.4ab
March	0.20± 0.1b	0.70± 0.2b	3.80± 0.8bcd	1.27± 0.4b	0.23± 0.1b	7.40± 1.8ab	1.57± 0.4b	0.63± 0.3ab
April	0.16± 0.1b	0.58± 0.2b	1.71± 0.4cd	5.06± 1.1a	0.74± 0.3ab	6.23±1.0abc	0.10± 0.1c	0.10± 0.1b
July	1.23± 0.4a	13.17± 2.6a	1.07± 0.4d	1.30± 0.5b	1.33± 0.5a	17.80± 3.5a	24.70± 8.1a	1.43± 0.4a
September	0.10± 0.1b	0.27± 0.1b	4.20± 0.7abc	3.87± 0.8a	0.13± 0.7b	3.53± 0.7bc	0.07± 0.1c	0.53± 0.3ab
November	0.20±0.1b	0.30± 0.2b	7.20± 1.3ab	3.93±0.8a	0.10± 0.1b	4.10± 1.0c	0.10± 0.1c	0.37± 0.3b

Number of observations = 30 in each locality at two monthly intervals.

+ Analysis was based on values transformed to $\sqrt{(\log 10 (x+1) + 0.5)}$

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

Table(3) (Cont.) Mean (± SE) number of ticks collected seasonally from cattle in localities of South Darfur during 2004 – 2005

Month	*A. lepidum*	*A. variegatum*	*B. annulatus*	*B. decoloratus*	*H. dromedarii*	*H. rufipes*	*H. impeltatum*	*H. truncatum*
Reheidalberdi								
January	0.20±0.1b+	0.40±0.2c	0.27±0.1bc	3.23± 0.7abc	0.17± 0.1a	8.13± 1.0a	0.00± 0a	4.23±0.9a
February	0.10± 0.1b	0.33± 0.1c	2.33± 0.6a	6.13± 1.8ab	0.33± 0.2ab	5.47± 1.1ab	0.00± 0a	0.43± 0.3b
March	0.60± 0.4ab	1.00± 0.4c	3.67± 1.8ab	2.60± 1.0c	0.23± 0.1ab	11.13±2.0a	0.07± 0.1a	0.83± 0.3b
June	0.33± 0.1ab	11.93± 1.3a	0.13± 0.1c	2.70±0.6abc	0.27± 0.1ab	7.97± 1.8ab	0.00± 0a	1.00± 0.4b
August	0.83± 0.2a	6.33± 1.1b	0.43± 0.2bc	1.47± 0.3bc	0.90± 0.4a	4.93± 1.1ab	0.00± 0.a	2.83± 0.6a
November	0.10±0.1b	0.33± 0.1c	3.63± 0.8a	5.03±1.0a	0.03± 0.0b	5.93± 1.9b	0.03± 0.0a	0.23± 0.1b
Umdafug								
January	0.23±0.1c	0.27±0.1c	0.40±0.2c	0.73± 0.3b	0.00± 0b	5.17± 0.9bc	0.00± 0b	3.50±0.9b
March	0.27± 0.1c	0.37± 0.1c	2.13± 0.8ab	1.20± 0.4b	0.07± 0.1ab	5.08± 0.9ab	0.00± 0.b	3.00± 1.0bc
April	1.37± 0.3b	0.53± 0.3c	1.60± 0.4a	3.37± 0.8a	0.00± 0.b	4.27±0.8bc	0.07± 0.1b	1.40± 0.7c
June	3.17± 0.9a	14.04± 1.7a	0.64± 0.3abc	2.54± 1.0ab	0.21± 0.2b	12.86± 1.9a	0.00± 0b	11.07± 1.6a
August	0.17± 0.9c	3.13± 0.6b	0.93± 0.6bc	1.23± 0.7b	0.30± 0.1a	2.10± 0.4c	0.63± 0.2a	2.37± 0.4b
November	0.20±0.1c	0.03± 0.0c	0.07± 0.1c	0.77±0.3b	0.00± 0.b	2.17± 0.4c	0.00± 0.b	1.50± 0.3bc

Number of observations = 30 in each locality at two monthly intervals.

+ Analysis was based on values transformed to $\sqrt{(\log 10 (x + 1) + 0.5)}$.

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

Table (4) Correlation analysis between abundance of total parasitic ticks in Nyala with monthly climatic factors during 2004 - 2005

Climatic factors	***A. lepidum***	***A. variegatum***	***B. annulatus***	***B. decoloratus***	***H. dromedarii***	***H. rufipes***	***H. impeltatum***	***H. truncatum***
Temperature	-0.12ns	-0.11ns	-0.38***	-0.37***	0.09ns	-0.12ns	0.38***	-0.07ns
R.H	-0.09ns	0.39***	-0.10ns	-0.09ns	0.01ns	-0.22**	-0.03ns	0.02ns
Rainfall	-0.08ns	0.50***	-0.14ns	-0.16*	-0.03ns	-0.18*	0.03ns	-0.09ns

R.H = Relative humidity, * $P \leq 0.05$. ** $P \leq 0.01$. *** $P \leq 0.001$. ns = non-significant.

Table (5) Ticks (Males/ Females) collected in very low numbers from localities of South Darfur during 2004 - 2005

Tick species	Nyala	Edd-alferrsan	Tulus	Reheid alberdi	Umdafug	Total
R. e. evertsi	190/120	29/17	7/5	3/0	0/0	229/142
R. sanguineus	3/1	2/1	12/25	23/31	28/45	68/103
R. praetextatus	0/0	0/0	0/0	24/14	4/0	28/14
R. guilhoni	0/0	0/0	0/0	7/3	14/4	21/7
R. muhsamae	0/0	4/14	7/79	19/31	29/10	59/134
H. impressum	19/0	0/0	4/0	90/2	172/24	285/26
H. anatolicum	80/92	0/0	0/0	0/0	1/0	81/92

Discussion

The present study revealed fifteen tick species infesting cattle in five localities in South Darfur. The ticks were observed to increase in the rainy season and this was due to the suitable environmental conditions for their development and survival. However, it was noticed that in some localities tick abundance decreased during continuous heavy rains in August. This could be due to water flushing of different tick stages from their microhabitats. Tatchell and Easton (1986) pointed out that heavy rains usually wash larvae from their questing positions at the tips of grass blades and thus hindering host finding. Population density of the species in the five localities was variable. This difference may be attributed to cattle density in Tulus in the dry and wet seasons and to the vegetation cover along the banks of Tulus Stream. Some of the tick numbers were higher in some areas and lower in others. *H. impeltatum*, for instance, was abundant in Nyala, while it was rare in Edd-alferrsan. This might be due to the fact that sheep are intensively reared around Nyala. Similarly, Osman (1978) recorded this tick species in South Darfur from areas where sheep were reared. *Boophilus* spp. were also higher in Tulus and lower in Nyala and Umdafug. It could be attributed to the favourable environmental conditions prevalent and other factors such as vegetation, host density and climate which determine ticks distribution (Tatchell and Easton, 1986).

Amblyomma spp. were found in all localities with a variation in their total numbers. In the Sudan, *A. lepidum* was found abundant in eastern parts of country from Torit and Kapoetea in the south as far as Kassala State in the north (Osman and Hassan, 2003). In the current study, *A. lepidum* was identified in all the localities. Males of *A. lepidum* were prevalent throughout the year, while females were usually present at the end of the dry hot months and reached peaks during the rainy seasons. Thereafter, they started to decrease and became absent in the dry hot season. This finding coincides with that of Osman *et al*. (1982) who observed in Kordofan that *A. lepidum* reached a peak in the rainy season. Walker *et al*.

(2003) reported that *A. lepidum* occurs in a wide variety of climatic zones, from temperate highlands to savanna and desert, but it is common in the arid habitats with rainfall of 250 – 750 mm. In Darfur, Osman (1978) found males only in his collection from three localities. This indicates that this species has spread from eastern Sudan to the far western parts and has established and widely distributed in Darfur. It is alarming that this tick species which was confined in eastern parts of the African continent (Walker and Olwage, 1987) may reach West African countries in the near future. This would aggravate and complicate the situation of heartwater and dermatophilosis in West Africa. *A. variegatum* was similar to *A. lepidum* in its seasonal dynamics. *A. variegatum* was more numerous than *A. lepidum* in South Darfur compared to Kordofan (Sowar, 2002) and Blue Nile (Mohamed, 2002). It is not known as per current survey whether this species exists in Northern Darfur. In the month proceeding rainfall, large numbers of *A. variegatum* males were found, but with small numbers of females. In the following rainy season, a slight increase in males occurred with a sharp increase in numbers of females.

The pattern of *Boophilus* spp. was similar to that of *A. variegatum*. *B. decoloratus* and *B. annulatus* were found in all localities, with a high mean number during wet and dry cool seasons. Osman (1978) recorded *B. annulatus* only from two localities, while in the current survey they were reported in all localities. This could be as a result of their continuous spread out due to animal movement from Bahr El Ghazal humid region of Southern Sudan to Darfur region. This is also an indication and confirmation that *B. annulatus,* is steadily spreading on the north direction. These species are more active in cool relatively dry period (Hoogstraal, 1956; Osman *et al*., 1982). On the other hand, although *B. geigyi* was reported in Central Republic of Africa (Walker *et al.,* 2003), however, it was not found in this survey. It is difficult to explain its absence in this region despite the fact that animal cross the borders to and from Chad for the sake of water and pasture. This species has been reported in the Sudan only on one occasion among ticks collected from

Southern Sudan (Jongejan *et al*., 1987), probably due to an accidental introduction from Uganda where this species is prevalent.

Hyalomma anatolicum was found only in Nyala. Osman (1978) collected only one male *H. anatolicum* in Darfur from a donkey. This species has established in Nyala, but has not yet spread to other localities. Introduction of this species into Darfur was due to the recent introduction of Friesian cattle and their crosses from *H. anatolicum* infested area such as Khartoum and Central Sudan into South Darfur region. This species was not found in other localities with the exception of Umdafug where only one male was found. Introduction of *H. anatolicum* that could be infected with *Theileria annulata* into a non tropical theileriosis endemic area such as South Darfur is alarming. Similar to *A. lepidum, H. anatolicum* is steadily spreading from its ever known distribution zone of Eastern and Central Sudan (Jongejan *et al*., 1987) to western parts of the country. It will not be surprising for this economically important tick species to reach in the near future the far West African countries carried by animals that cross the international borders to Chad, Niger and Nigeria.

Hyalomma rufipes was the most dominant tick in all localities throughout the year followed by *H. impeltatum* which was found throughout the year in Tulus and Nyala, while in other localities it was only found in wet seasons. These findings may be due to adaptability of *H. impeltatum* to dry zones. Similarly, *H. dromedarii* was found in large numbers in Tulus and Nyala in the dry hot months and lower numbers in dry cool months, while in other localities it was in low numbers. This might be due to cattle contact with camels and sheep in Nyala and Tulus. El Ghali (2005) found that the main tick species infesting camels in Northern Sudan was *H. dromedarii* (89%) followed by *H. impeltatum* (7.7%). Osman *et al.* (1982) reported that *H. impeltatum* was the most common ticks of sheep in the arid zone of Kordofan. The presence of *H. truncatum* and *H. impressum* in high numbers in Umdafug may be attributed to the favourable climatic conditions, whereas in Nyala this could be due to the high density of livestock brought from different localities for trade including south west of the region. The fact that *H. impressum* is prevalent in all the localities

and not reported in central and eastern parts of the Sudan (Jongejan *et al*., 1987; Mohamed, 2002.; El Ghali, 2005) indicates that this West African tick species is not spreading to the eastern parts of the country. On the other hand, *Hyalomma detritum* was not found in the current survey although Hoogstraal (1956) reported this species in this area. Osman (1978) also did not find this tick species in Darfur. Probably, it has disappeared due to some climatic changes.

Rhipicephalus species were found in low numbers. The species reported in this survey were *R. e. evertsi*, *R. muhsamae* and *R. sanguineus sanguineus,* with low numbers of *R. guilhoni* and *R. praetextatus.* This coincides with the finding of Osman (1978) in South Darfur in the case of *R. e. evertsi*, *R. guilhoni* and *R. s. sanguineus* which were collected from sheep, goats and dogs. *R. sulcatus* and *R. turanicus* were not found in this study, but some species that belong to *R. simus* group *(R. muhsamae* and *R. praetextatus*) were reported. The prevalence of West African tick species *R. muhsamae* in relatively large numbers is an indication that it is spreading on the eastern direction. With the exception of *R. e. evertsi* and *R. s. sanguineus* which were found in all localities, other *Rhipicephalus* species were restricted to the borders of localities, and this might be attributed to the fact that cattle come into contact with those from West African countries owing to the pastoralists migration system in the dry seasons.

Young calves carried low numbers of ticks than old in all localities. This finding is in line with those of Rechav (1991), Hassan (1997) and El Imam (1999). This might be attributed to different management systems whereby young calves spend all year grazing nearby homesteads while old cattle come in contact with ticks in communal grazing areas where ticks are abundant (Punyua and Hassan, 1992). On the contrary, Latif *et al*. (1991) found no difference between numbers of ticks carried by yearling calves (12 – 18 months old) and old cattle. Similarly, cattle with black coat colour were infested by the lowest number of ticks. These findings were similar to those reported by Hassan (1997) who found that animals with white coat colour carried higher tick numbers followed by

animals with brown coat colour, while animals with black coat colour carried the lowest tick numbers. This could be attributed to the relatively raised temperature of the host's skin environment generated by dark coat colour. However, de Castro *et al*. (1991) found no correlation between tick load and animal coat colour in Boran bulls infested by *Boophilus microplus*.

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