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Seasonal prevalence and geographical distribution of ticks of camels (*Camelus dromedaries*) in four states of Great Butana, Sudan

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Abstract
Sudan ranks second, after Somalia, in the world camels' production. Notwithstanding, tick-borne viruses were reported in Sudan however, no research programs were conducted. It is hypothesized that identifying the key tick species and animal hosts as a first step will give better understanding of such viruses lifecycle and fill the currently existing knowledge gaps. Surveys and ticks collections from camels (6 collections/site/year) were conducted in five sites in four states of Butana year-round (November 2014 to October 2015). Regarding the detailed tick species findings during the study period, a total of 828 camels were surveyed in the five sites. A total of 9245 ticks from the genera: *Hyalomma*, *Amblyomma*, *Rhipicephalus* (*Boophilus*), and *Rhipicephalus* were collected and identified. The species composition and prevalence of tick species feeding on camels in descending order was: *Hy. dromedarii* (72.22%), *A. lepidum* (7.74%), *Hy. Rufipes* (7.36%), *Hy. excavatum* (4.12%), *R. guilhoni* (3.31%), *Hy. impeltatum* (2.07%), *Hy. anatolicum* (1.57%), *R.* (*B.*) *decoloratus* (0.81%), *R. camicasi* (0.18%), *Hy. Truncatum* (0.16%), *Hy marginatum* (0.05%), *R. sanguineus* (0.03%). It was able to relate such data to the locations, seasons and animal breed, sex and age. Therefore, such collected information could be useful at least as a first step in the risk analysis of emerging tick-borne diseases in general and viruses in particularly.

Keywords: Ticks, camels, Great Butana, Sudan

Introduction
Sudan sits at the crossroads of sub-Saharan Africa and the Middle East and coastlines bordering the Red Sea and other eight countries. Sudan is rich with fertile lands and abundant livestock. Agriculture and livestock contribute approximately 35 to 40 percent of gross domestic product (World Bank 2009, IGAD, 2013 and FAO 2015) [1-3]. Additionally, the traditional pastoral production systems, small holders and migratory producers constitute around 90% of the country livestock (FAO 2015) [3]. In 2004, the Ministry of Animal Wealth estimated the camel, cattle, sheep and goat population (>130 million heads) at 3.3, 38.3, 48.0 and 42.0 million heads, respectively (FAO 2015) [3]. It seems as the one humped camel's ability to withstand torrid heat and drought is the main paramount factors determining its distribution in Sudan and hence, enabling nomadic people to live in such a difficult environment.

In fact, Sudan has a dominant prevalence of the severe zoonotic diseases in the world. These diseases include malaria, guinea worm disease, river blindness, leishmaniasis, bilharzias, sleeping sickness and viruses. Viruses reported in Sudan such as Ebola (Onyango *et al.* 2007) [4]; mosquito-borne viruses such as Rift Valley virus that affects both animals and humans, is transmitted to humans by mosquito bite and contact with uncooked animal's products or their infected tissues (Hassanain *et al*. 2010 and Hassan *et al.* 2011) [5, 6]; Dengue hemorrhagic fever (Malika *et al.* 2011) [7]. Additionally, tick-borne viruses such as the Crimean-Congo hemorrhagic fever virus (CCHFV) has been reported (Afraa *et al*. 2011; Aradaib *et al*. 2013) [8, 9]. Furthermore, Alkhurma is also a severe tick-borne virus and very closely related virus to Kyasanur Forest disease was first reported in Saudi Arabia (Madani, 2005) [10]. In 2010 the disease was reported in Italian travelers returning from Egypt and tick bite was incriminated as a source of infection while riding on camels. Therefore, the presence of Alkhurma virus in Sudan cannot be excluded. Additionally, the two tick species so far identified as potential vectors of Alkhurma virus (Charrel and Gould, 2010) [11] are there in Sudan. Economically,

It could be therefore, reasonable should such diseases lead to losing billions of dollars also.

Furthermore, with expected increase in the world population and growing urbanization and increased income, the demand for animal protein would go up. In fact, the Sudan ranks second, after Somalia, in the world camels' production. However, literature survey revealed that no research programs were conducted on ticks-borne viruses infesting camels in Sudan. literature manifested dispersed reports about ticks belonging to the genera *Amblyomma*, *Rhipicephalus* (*Boophilus*), *Hyalomma* and *Rhipicephalus* on camel in Sudan and very rare tick reports were from Butana that is an important area of camels production in Sudan (Karrar *et al*., 1963; Latif, 1985; Gaafar 2008; ElGhali and Hassan 2009; ElGhali and Hassan 2010) [12,13,14,15,16]. Apparently, climate, geographic region and seasonality affect free-living ticks. In the Sudan the life cycle or developmental period of ticks is affected by temperature and relative humidity (ElGhali and Hassan.2010; El Tigani and Mohammed.2010) [16, 17]. Once again, it is worth noting that, to a remarkable extent, the existence of tick-borne viruses such as CCHF and Alkhurma in Sudan have not been totally excluded. However, few reports presented ticks parasitizing camels anywhere in the Sudan and non-regarding viruses programs. In this regard, in Sudan one of the problems limiting accurate recognition of such vector-borne viruses is the lack of a standardized national vectors surveillance sensitive enough for early diagnostic testing and further investigations. Therefore, in attempt towards understanding of tick-borne viruses in Sudan and to provide background data as a first step for foreseeable future epidemiological investigations of tick-borne viruses in particular this exploratory study was initiated. Targeted surveys are specifically designed to gather data within Butana of Sudan that have large livestock populations. The goal of this aim is to identify and determine the prevalence of tick species on camels as the first step for determining the potential vector species infected with such viruses and their relative abundance. That is because it is hypothesized that identifying the key vector and animal hosts will give better understanding of such viruses lifecycle and fill the currently existing knowledge gaps.

Materials and Methods

Study area:

Great Butana bordered by the Blue Nile, the River Nile, Atbara river, Eritrean and Ethiopian international borders. Butana lies between Latitude 13° 40′ and 17° 50′ North and Longitude 32° 40′ and 36° 00′ east. It is flat with very few mountains such as the Alabaitour, rich in seasonal herbs during the rainy season and Acacia trees. The great Butana encompasses parts of five states: Khartoum, Gezira, Gadaref, Kassala and River Niles. However, the present study performed in the first four states.

Ticks Collection and identification

Five sites in four states were selected for this study. Two known camel markets in Gezira state: Tamboul, the biggest camel market in the Sudan and Wad Nimir. The other three small holders were: Abu Deliag, Khartoum state; Elshowak, Gadaref state and Village 1 Arab (Girba), Kassala state. The duration of the study was from November 2014 to October 2015. Between 30-50 camels were randomly selected in each site for tick collection and such collection was repeated every two month (6 collection a year). Because camels are big animals, all visible ticks were collected from half body collection. All Ticks from each animal were preserved in separate vials containing 70% alcohol and labeled with regard to site name, date and animal's breed, sex and age. Taking into consideration the recent valid names of the genus and species, ticks (males and females) were identified to the species level according to Hoogstraal (1956) and Walker *et al*. (2003) [18, 19].

Data analysis

The present study data was analyzed using SPSS version 16. First, the data was coded appropriately into Microsoft excel spread sheet before being loaded into the SPSS. The prevalence of tick infestation was determined with descriptive statistics. The association between tick distribution and other factors such as location and season, was determined by the chi-square test. The 95% confidence intervals and $p < 0.05$ were set for significance in all cases.

Results and Discussion

Surveys and ticks collections from camels (6 collections/site/year) were conducted in five sites in four states of Butana and over a year (November 2015 to October 2015). Regarding the detailed tick species findings during the study period, a total of 828 camels were surveyed in the five sites. A total of 9245 ticks from the genera: *Hyalomma*, *Amblyomma*, *Rhipicephalus* (*Boophilus*), and *Rhipicephalus* were collected. Therefore, it means around 11 ticks per animal. The data (Table 1) shows the species composition and prevalence of tick species feeding on camels in descending order as follows: *Hy. dromedarii* (72.22%), *A. lepidum* (7.74%), *Hy. Rufipes* (7.36%), *Hy. excavatum* (4.12%), *R. guilhoni* (3.31%), *Hy. impeltatum* (2.07%), *Hy. anatolicum* (1.57%), *R.* (*B.*) *decoloratus* (0.81%),

Table 1: Frequency distribution and percentage of ticks species of camel in season and animal's breed, sex and age and location in Great Butana, Sudan, from November 2014 to October 2015

		Frequency	Percent			Frequency	Percent
Season	Winter	249	30.07	Sex	Male	143	17.27
	Summer	246	29.71		Female	685	82.73
	Autumn	333	40.22		Total	828	100.00
	Total	828	100.00	Age (year)	<5	203	24.52
Breed					5-10	493	59.54
					11-15	106	12.80
	Arabi	705	85.15		16-20	3	0.36
	Butana	45	5.44		>20	23	2.78
	Daali	5	0.60		Total	828	100.00
	Bushari	14	1.69	Location	Shwak	223	26.9
	Rushaidi	4	0.48		Girba	183	22.1
	Anafi	43	5.19		Tamboul	169	20.4
	Kenana	10	1.21		Wad Nimir	143	17.3
	Darfur	2	0.24		Abudeilaig	110	13.3
	Total	828	100.00		Total	828	100.00

R. camicasi (0.18%), *Hy. Truncatum* (0.16%), *Hy marginatum* (0.05%), *R. sanguineus* (0.03%). According to the site of collection, Table (1) shows that such species were more abundant in descending order as follows: Showak 26.9%; Girba 22.1%; (Rural areas) and Tamboul 20.4%; Wad Nimir 17.3% and Abu deilaig 13.3% (markets), respectively. It declares that the ticks are more abundant on camels of rural areas than camels in the markets. Additionally, it shows that the owners in Abu deilaig are concerned more than those in Wad Nimir and in Tamboul. In the present study, *Hy. dromadarii* was found to be the most abundant species (72.22%), the widely distributed tick species in all studied sites and the rest of the tick species were in lesser number. In fact, all tables show the means (±SE) followed by the same letter in each column are not significantly different at 5% level based on Duncan test. Tables 2A and 2B, showed that there are significant differences between tick sex loaded in camels in the different locations. For instance, *H. dromadarii* males were highly significant at Abu Deilaig (7.63 ±0.68) and Wad Nimir (7.74 ±0.67); less significant at Tamboul (5.41 ±0.45) and Showak (6 ±0.32) and not significant at Girba. While *H. dromadarii* females the biggest significant differences were at Tamboul and Showak on one side with the least significance at the other three sites. However, *Hy rufipes* males showed the highest significant differences at Wad Nimir, less significance at Abu Deilaig and not significant at the other three sites. Additionally, no *Hy rufipes* females nor other ticks' species showed significant differences between collection sites (Tables 2A and 2B). Furthermore, the data show that the ticks infestation increases during short rainy season and decreases during the long dry seasons. Autumn scored the highest record (40.22%), followed by similar or very closed records at winter and Summer with 30.07, 29.71%, respectively. Tables 3A and 3B, showed significant differences between autumn and summer and less significant in winter in case of *H. dromadarii* males while for the females the highest significant differences was at autumn, less significant at summer and least at winter. While non significant differences in case of *H rufipes* females however, in case of *H rufipes* females the highest significant differences was at winter, less at autumn and least at summer. With regard to *Hy. excavatum* males, the highest significant differences was in autumn, less in summer and least in winter however, for females the highest was in autumn and winter and less in summer (Table 3A and 3B).

Regarding the effect of camel's breed on ticks infestation was as follows in descending order; Arabi (85.15%); Butana (5.44%); Anafi (5.19%); Bushari (1.69%); Kenana (1.21%); Daali (0.6%); Rushaidi (0.48%) and Darfur (0.24%) (Table 1). It is worth observing that the effect of the animal breed (Table 4A and 5B) on *Hy. dromadar ii*, the most abundant species, there higest significant differences in Darfur breed and Rashaidi, less in Arabi, Daali, Anafi and Kennana and not significant in Butana and Bushari for Hy dromadarii males. While the load of this species females, the highest significant differences on Darfur breed, less on Arabi, Anafi and Kennana and least on Butana, Daali, Bushari and Rashaidi (Table 5A and 5B). In fact, such results presented the more infected animal's breed by incriminated tick (s) and hence, could indicate the possibility of viruses infection when identifying the vector of a certain virus and would help also in planning for vector control. Additionally, the effect of animal sex on ticks abundance was: animal females (82.73%) and 17.27% for males. This results could alert that in case of virus infection, the virus could be found also in the uncooked milk. Although, there are no significant differences, however, the means of the ticks totals, with exception of *B. decolaratus*, were outnumbered females. Such observation could be due to the fact that fully engorged female tick drops off to the ground to lay eggs while males normally remain on the host longer to continue feeding and mating. The small size of male of *B. decolaratus* may be the reason for not observed during collection (Table 6A and 6B). Furthermore, the recorded effect of the animal age was as followed: 5-10 years (59.54%); <5 years (24.52%); 11-15 years (12.8%); >20 years (2.78%) and 16-20 years (0.36%). There are no significance differences however, Tables 7A and 7B, showed that the animals between 5-10 years old hold more ticks species with the same abovementioned order of ticks' prevalence.

In fact, rare reports presented ticks on camels in Sudan. For instance, Hoogstraal (1954, 1956) [18, 19] collected ticks from 15 localities. Karrar *et al*. (1963) recorded *A. lepidum*, *R. sanguineus* and *Hy. dromedarii* on camels in the area around Atbara river and Gash river in Kassala state, eastern of Sudan. Then, the above mentioned genera were reported as immature stages Latif (1985) [13] and as adults (Gaafar 2008) [14]. In the River Nile State, northern Sudan, the fifth state of the Great Butana area, where this study was conducted in the other 4 states, ElGhali and Hassan (2009) [15] reported the species composition of ticks feeding on camels as *Hy. dromedarii*, *Hy. Impeltatum, Hy. Anatolicum, Hy. Truncatum, Hy. Rufipes*, *R. praetextatus* and *R. sanguineus* group. While El Tigani and Mohammed (2010) [17] recognized *A. lepidum*, *A. variegatum*, *Hy. anatolicum*, *Hy. dromedarii*, *Hy. impeltatum*, *Hy. rufipes*, *Hy. truncatum*, *R.* (*B.*) *decoloratus*, *R. evertsi evertsi* and *R. sanguineus* on camels. Generally, the reported data concur with the present findings. In fact, In the Sudan, climate, geographic region and seasonality affect free-living ticks and their hosts. For instance, the life cycle or developmental period of ticks is affected by temperature and/or relative humidity (ELGhali and Hassan (2010) [16]. Acacia species and seasonal grasses predominate the Butana area. However, the plant cover is constantly changing as a result of variable factors such as annual rainfall and the expansion of agricultural projects. Additionally, overgrazing has depleted most of the highly palatable grasses. FAO report in 2015 [11], recognized that the disruption of migratory patterns because of the lack of pasture in Butana, will likely be continued through to June 2016 (the start of the next rainy season). For instance, during the present study it was observed that the members of the Lahawiyin tribe, where two sites of this study was conducted (Showak and Girba), sustains the animals at their farm on crop residues for the rainy season and moves out during the dry season. However, till the end of August 2015 there were no outbreaks of diseases reported (FAO, 2015). Moreover, in Ethiopia which borders this study area, the distribution and abundance of the most common tick species infesting camels are also vary greatly from one area to another (Pegram *et al*. (1981) [21].

Notwithstanding its population numbers only about 40 million, it has been estimated that Sudan has 140 million domestic ungulates and a large livestock trade is a vital part of the economy. However, dangerous tick-borne viruses are exist in and around Sudan. For instance, Alkhurma hemorrhagic fever is a viral hemorrhagic disease reported mainly in Saudi Arabia (Madani 2005) [10]. The virus was isolated in 1994 from the blood of a butcher with a severe illness in the Jeddah district of Alkhurma (Charrel and de Lamballerie, 2003) [22]. Since 1994, about 40 human cases have been laboratory confirmed according to published reports (Memish *et al*.

2005) [23]. The etiological agent is a Flavivirus genetically belonging to the tick-borne complex that is very closely related to Kyasanur Forest disease virus, a severe tick-borne hemorrhagic disease occurring in India, Karnataka state (Charrel *et al*. 2001) [241]. Up to 2010 the disease has been reported in western Saudi Arabia, in the Makkah and Najran provinces. In 2010 the disease was reported in Italian travelers returning from Egypt (Carletti *et al*. (2010); Ravanini *et al*. (2011) [25, 26]. This clearly indicates that the disease is present in countries outside Saudi Arabia. Since there is a lack of previous work about antibody prevalence in host species and the presence of the virus in arthropods of the Arabian Peninsula and the surrounding countries, it is unknown what the wider distribution of the virus might be. Therefore, due to the large livestock trade of Saudi Arabia with neighboring countries, the spread of such virus from/to other areas and countries cannot be excluded (Sherman *et al*. 2011) [27]. Therefore, and taken into account such diseases severity, the situation needs to be carefully monitored. In general, in such study, the tick species and counts give better understanding of the prevalence of tick infestation and relative tick species composition. For instance, the two tick species so far identified as potential vectors of Alkhurma virus (Charrel *et al*. 2007) [28] are there in Sudan. A second disease, of interest which also meshes well with Alkhurma and RVFV, is the Crimean-Congo hemorrhagic fever (CCHF), a dangerous virus that had been reported in Sudan since 2008 (Aradaib *et al*. 2011) [9]. Although not a pathogen of domestic animals, it is well known that domestic animals are involved in the maintenance of the virus and the tick populations (*Hyalomma* spp.) which are the principal vectors of the virus among the vertebrate reservoir hosts. Direct exposure to infected livestock at slaughter or nosocomial infection from contact with infected humans are the other principle means of such viruses transmission to humans (Afraa *et al*. 2011; Aradaib 2013) [8, 9].

Generally, the current study identified the key tick species and was able to relate such data to the locations, seasons and animal breed, sex and age in Butana. Therefore, such collected information could be useful at least as a first step in the risk analysis of emerging tick-borne diseases in general and viruses in particularly.

Table 2A: Means and standard errors of ticks species of camel in six locations in Great Butana, Sudan, from November 2014 to October 2015

Location	HdrmM	HdrmF	HrufM	HrufF	HexcM	HexcF	HanatM	HanatF	HimpM	HimpF	HmargM	RBdecM	RBdecF
Abu Deliag	7.63 ±0.68 a	4.76 ±0.39 c	1.55 ±0.17 b	1.6 ±0.29	0	0	0.78 ±0.41	1.71 ±0.45	1.46 ±0.26	1.84 ±0.47	0	0.41 ±0.33	1.84 ±0.56
Tambul	5.41 ±0.45 b	2.36 ±0.18 a	2.43 ±0.34 ab	2.54 ±0.3	1.87 ±0.3	3.79 ±0,51	2.46 ±0.42	0	0	0	0	5 ±0	0
Wad Nimir	7.74 ±0.67 a	4.51 ±0.36 c	3.33 ±0.5 a	1.55 ±0.35	0	0	1.4 ±0.68	0.6 ±0.24	2.37 ±0.39	1.41 ±0.36	0	1.14 ±0.49	1.92 ±0.42
Showak	6 ±0.32B	2.72 ±0.19 a	2.22 ±0.31 ab	1.55 ±0.29	1.67 ±0.66	1.33 ±0.21	0	0	0	0	1.66 ±0.33	0	0
Girba	6.44 ±0.25 ab	3.6 ±0.23 b	2.35 ±0.33 ab	2.71 ±0.74	5.53 ±0.83	1.53 ±0.19	2.66 ±0.6	1.66 ±0.66	0	0	0	0	0
Total	6.53±0.2	3.47±0.12	2.38±0.17	1.89±0.16	4.1±0.57	2.9±0.35	1.96±0.27	1.43±0.3	1.91±0.23	1.62±0.29	1.7±0.33	0.96±0.33	1.88±0.34

Means (±SE) followed by the same letter in each column are not significantly different at 5% level based on Duncan test. Means for groups in homogeneous subsets are displayed.
Male = M and Female= F
Hyalomma dromedarii (Hdrm), *Hyalomma Rufipes* (Hruf), *Hyalomma excavatum* (Hexc), *Hyalomma anatolicum* (Hanat), *Hyalomma impeltatum* (Himp), *Hyalomma marginatum* (Hmarg), *Rhipicephalus* (*Boophilus*) *decoloratus* (RBdec),

Table 2B: Means and standard errors of ticks species of camel in six locations in Great Butana, Sudan, from November 2014 to October 2015

Location	RevsM	RevsF	RgulM	RgulF	RcamiM	RcamiF	AlepM	AlepF	HtruncM	HtruncF	RsngM	RsngF	Nymph
Abu Deliag	0.25 ± 0.25	0.25 ± 0.25	3.11 ±0.32	1.82 ±0.88	0	0	3.17 ±0.55	3.75 ±0.53	1.29 ±0.61	0	0.25 ±0.25	0.5 ±0.29	2.17 ±0.32
Tambul	0	0	0	0	0	2.33 ±0.33	2.25 ±0.73	0	0	0	0	0	0
Wad Nimir	4.16 ± 1.14	0.5 ± 0.34	5.25 ± 0.92	1.13 ± 0.21	0	0	4.36 ±0.66	2.12 ±0.36	0	0	0	0	6.33 ±2.82
Shwak	1 ±0	1 ±0	1.6 ±0.41	1.44 ±-0. 24	1.33 ±0.33	1.5 ±0.28	1.75 ±0.18	2 ±0.49	0	0	0	0	0
Girba	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	2.23±0.72	0.45±0.21	4.2±0.71	1.38±0.28	1.33±0.33	1.85±0.26	3.31±0.34	2.73±0.28	1.87±0.78	0	0.25±0.25	0.5±0.28	4.31±1.48

Means (±SE) followed by the same letter in each column are not significantly different at 5% level based on Duncan test.
Male = M and Female= F
Rhipicephalus evertsi evertsi (Hevs), *Rhipicephalus guilhoni* (Rgul), *Rhipicephalus camicasi* (Rcami), *Amblyomma lepidum* (Alep), *Hyalomma Truncatum* (Htrun), *Rhipicephalus sanguineus* (Rsang).

Table 3A: Means and standard errors of ticks species of camel in three seasons in Great Butana, Sudan, from November 2014 to October 2015

Season	HdrmM	HdrmF	HrufM	HrufF	HexcM	HexcF	HantM	HantF	HimpM	HimpF	HmargM	RBdecM	RBdecF
Winter	8.41±0.51 b	4.39±0.29 c	2.26±0.28	1.02±0.16 a	6.03±0.87 c	1.63±0.29 a	1.55±0.35	1.15±0.29	1.89±0.27	1.54±0.32	1.66±0.33	0.84±0.34	1.95±0.36
Summer	5.15±0.24 a	3.56±0.17 b	2.63±0.32	3.71±0.53 c	2.11±0.31 b	3.84±0.53 b	2.43±0.49	1±.	0	0	0	0	0
Autumn	6.18±0.24 a	2.61±0.13 a	2.33±0.25	2.28±0.23 b	1.46±0.33 a	1.16±0.16 a	2±0.57	3.33±0.67	2±0.31	2.4±0.24	0	2.5±1.5	1±0
Total	6.52±0.2	3.47±0.12	2.38±0.17	1.89±0.17	4.1±0.57	2.9±0.36	1.96±0.27	1.43±0.3	1.91±0.23	1.62±0.29	1.67±0.33	0.96±0.33	1.88±0.34

Means (±SE) followed by the same letter in each column are not significantly different at 5% level based on Duncan test.
Male = M and Female= F
Hyalomma dromedarii (Hdrm), *Hyalomma Rufipes* (Hruf), *Hyalomma excavatum* (Hexc), *Hyalomma anatolicum* (Hanat), *Hyalomma impeltatum* (Himp), *Hyalomma marginatum* (Hmarg), *Rhipicephalus* (*Boophilus*) *decoloratus* (RBdec),

Table 3B: Means and standard errors of ticks species of camel in three seasons in Great Butana, Sudan, from November 2014 to October 2015

Season	RevsM	RevsF	RgulM	RgulF	RcamiM	RcamiF	AlepM	AlepF	HtruncM	HtruncF	RsngM	RsngF	Nymph
Winter	2.23±0.73	0.45±0.21	4.2±0.71	1.38±0.28	1.33±0.33	1.5±0.28	3.89±0.45	2.85±0.32	1.87±0.78	0	0.25±0.25	0.5±0.28	4.31±1.48
Summer	0	0	0	0	0	2.5±0.5	1.9±0.31	1.57±0.36	0	0	0	0	0
Autumn	0	0	0	0	0	2±	1.88±0.31	2.2±0.73	0	0	0	0	0
Total	2.23±0.73	0.45±0.21	4.2±0.71	1.38±0.28	1.33±0.33	1.85±0.26	3.31±0.34	2.73±0.28	1.87±0.78	0	0.25±0.25	0.5±0.28	4.31±1.48

Means (±SE) followed by the same letter in each column are not significantly different at 5% level based on Duncan test.
Male = M and Female= F
Rhipicephalus evertsi evertsi (Hevs), *Rhipicephalus guilhoni* (Rgul), *Rhipicephalus camicasi* (Rcami), *Amblyomma lepidum* (Alep), *Hyalomma Truncatum* (Htrun), *Rhipicephalus sanguineus* (Rsang).

Table 4A: Means and standard errors of ticks species on eight camel breeds in Great Butana, Sudan, from November 2014 to October 2015

Breed	HdrmM	HdrmF	HrufM	HrufF	HexcM	HexcF	HantM	HantF	HimpM	HimpF	HmargM	RBdecM	RBdecF
Arabi	6.43±0.21 b	3.22±0.12 b	0.21±0.21	0.17±0.17	4.07±0.64	3.09±0.4	2.08±0.29	1.26±0.34	1.87±0.27	1.78±0.33	1.66±0.33	0.75±0.28	1.7±0.38
Butana	9.76±1.27 ab	5.44±0.62 ab	2±0.44	0.7±0.33	4.75±1.67	1.25±0.25	1.5±1.19	2±0.57	2.12±0.78	2.12±1.07	0	1.5±1.5	3.25±0.94
Daali	3±0.57 b	4.75±2.17 ab	0	0	3±.	1±.	0	0	0	0	0	0	1±.
Bushari	8.66±2.07 ab	4.91±1.47 ab	2.25±0.85	1±0	0	3.5±2.5	1±1	3±.	1±.	0	0	2.5±2.5	1±.
Rashaidi	14.75±4.67 a	5±1.08 ab	1±.o	1±1	0		0		2.33±0.33	0	0	0	0
Anafi	3.71±0.33 b	3.79±037 b	1.88±0.3	4±4	0	1±.	0	0	0	1±.	0	0	0
Kenana	5.44±1.19 b	4±1.02 b	1±0	0	1±0	2±	0	0	0	0	0	0	0
Darfur	13±8 A	8±6 a	2±0	0	0	0	0	0	5±	0	0	0	0
Total	6.52±0.2	3.47±0.12	2.38±0.17	1.89±0.16	4.1±0.57	2.9±0.35	1.96±0.27	1.43±0.3	1.91±0.23	1.62±0.29	1.66±0.33	0.96±0.33	1.88±0.34

Means (±SE) followed by the same letter in each column are not significantly different at 5% level based on Duncan test.
Male = M and Female= F
Hyalomma dromedarii (Hdrm), *Hyalomma Rufipes* (Hruf), *Hyalomma excavatum* (Hexc), *Hyalomma anatolicum* (Hanat), *Hyalomma impeltatum* (Himp), *Hyalomma marginatum* (Hmarg), *Rhipicephalus* (*Boophilus*) *decoloratus* (RBdec),

Table 4B: Means and standard errors of ticks species on eight camel breeds in Great Butana, Sudan, from November 2014 to October 2015

Breed	RevsM	RevsF	RgulM	RgulF	RcamiM	RcamiF	AlepM	AlepF	HtruncM	HtruncF	RsngM	RsngF	Nymph
Arabi	2.3±0.91	0.37±0.18	3.51±0.54	1.14±0.18	1.33±0.33	2±0.25	3.25±0.4	2.75±0.33	1.83±1.04	0±0	0±0	0.33±0.33	2.71±0.33
Butana	4±0.	2±.	5.4±2.37	1.09±0.31	0	1±0.	3.72±0.85	2.8±0.82	2±1	0±0	1±.0	1±.0	3.37±1.19
Daali	0	0	0	2±.0	0	0	3±0	1±0	0	0	0	0	1±0
Bushari	0	0	0	0	0	0	1.6±0.67	1.8±1.06	0	0	0	0	5.5±3.5
Rushaidi	1±.0	0	13±11	7.5±7.5	0	0	5.5±3.22	5±2.04	0	0	0	0	27±26
Anafi	0	0	0	0	0	0	3±1	2±0	0	0	0	0	1±0
Kenana	0	0	0	0	0	0	0	0	0	0	0	0	0
Darfur	1±0	0	3±0	2±0	0	0	3±0	1±0	0	0	0	0	0
Total	2.23±	0.45±	4.2±0	1.38±0	1.33±0	1.85±	3.31±	2.73±	1.87±	0	0.25±0	0.5±0	4.31±

Means (±SE) followed by the same letter in each column are not significantly different at 5% level based on Duncan test.
Male = M and Female= F
Rhipicephalus evertsi evertsi (Hevs), *Rhipicephalus guilhoni* (Rgul), *Rhipicephalus camicasi* (Rcami), *Amblyomma lepidum* (Alep), *Hyalomma truncatum* (Htrun), *Rhipicephalus sanguineus* (Rsang).

Table 5A: Means and standard errors of ticks species on sex of camel in Great Butana, Sudan, from November 2014 to October 2015

Sex	HdrmM	HdrmF	HrufM	HrufF	HexcM	HexcF	HantM	HantF	HimpM	HimpF	HmargM	RBdecM	RBdecF
Male	6.91±0.55	3.75±0.31	2.71±0.52	1.5±0.25	4±0.75	2.21±0.45	1.33±0.55	1.66±0.61	2.31±0.41	1.38±0.67	0	1.88±0.65	1.57±0.78
Female	6.44±0.21	3.41±0.13	2.28±0.16	2.03±0.21	4.14±	3.1±0.43	2.08±0.3	1.35±0.35	1.78±0.28	1.7±0.32	1.66±0.33	0.5±0.34	2±0.38
Total	6.52±0.2	3.47±0.12	2.38±0.17	1.89±0.16	4.1±0.57	2.9±0.35	1.96±0.27	1.43±0.3	1.9±0.23	1.62±0.29	1.66±0.33	0.96±0.33	1.88±0.34

Means (±SE) followed by the same letter in each column are not significantly different at 5% level based on Duncan test.
Male = M and Female= F
Hyalomma dromedarii (Hdrm), *Hyalomma Rufipes* (Hruf), *Hyalomma excavatum* (Hexc), *Hyalomma anatolicum* (Hanat), *Hyalomma impeltatum* (Himp), *Hyalomma marginatum* (Hmarg), *Rhipicephalus* (*Boophilus*) *decoloratus* (RBdec),

Table 5B: Means and standard errors of ticks species in sex of camel in Great Butana, Sudan, from November 2014 to October 2015

Sex	RevsM	RevsF	RgulM	RgulF	RcamiM	RcamiF	AlepM	AlepF	HtruncM	HtruncF	RsngM	RsngF	Nymph
Male	1±0	0.5±0.5	2.9±0.83	1.36±0.56	2±.0	0	3.82±0.81	2.5±0.38	1.66±1.2	0	0	0	7.9±5.09
Female	2.6±0.92	0.44±0.24	4.53±0.85	1.39±0.33	1±0	1.85±-	3.12±0,36	2.84±0.38	2±1.14	0	0.25±0.25	0.5±0.28	2.88±0.405
Total	2.23±0.72	0.45±0.21	4.2±0.71	1.38±0.28	1.33±0.33	1.85±0	3.31±0.34	2.73±0.28	1.87±0.78	0	0.25±0.25	0.5±0.28	4.31±1.48

Means (±SE) followed by the same letter in each column are not significantly different at 5% level based on Duncan test.
Male = M and Female= F
Rhipicephalus evertsi evertsi (Hevs), *Rhipicephalus guilhoni* (Rgul), *Rhipicephalus camicasi* (Rcami), *Amblyomma lepidum* (Alep), *Hyalomma Truncatum* (Htrun), *Rhipicephalus sanguineus* (Rsang).

Table 6A: Means and standard errors of ticks species in five age groups of camel in Great Butana, Sudan, from November 2014 to October 2015

Age	HdrmM	HdrmF	HrufM	HrufF	HexcM	HexcF	HantM	HantF	HimpM	HimpF	HmargM	RBdecM	RBdecF
<5	5.77±0.36	3.06±0.22	2.86±0.34	1.81±0.21	2.3±0.74	3±0.74	2.41±0.46	2±0.57	1.73±0.43	2.53±0.65	0	2±2	1±0
5-10	7.13±0.29	3.76±0.18	2.10±0.16	1.88±0.24	4.96±0.79	2.94±0.45	1.91±0.39	1.06±0.34	1.89±0.28	1.17±0.28	1±0	0.88±0.33	1.95±0.36
11-15	5.61±0.37	3.17±0.22	2.9±0.99	2.06±0.52	3±1.26	2.91±1.07	1.66±0.47	4±0	5±0	7±0	0	0	0
16-20	6.66±3.48	1.5±0.5	0	0	0	0	0	0	0	0	0	0	0
>20	4.85±0.61	2.72±0.44	2.66±1.31	3±0	2±1	1.5±0.5	1±0	1±0	0	0	2±0	0	0
Total	6.52±0.2	3.47±0.12	2.38±0.17	1.89±0.16	4.1±0.57	2.9±0	1.96±0.27	1.43±0.3	1.9±0.23	1.62±0.29	1.66±0.33	0.96±0.33	1.88±0.34

Means (±SE) followed by the same letter in each column are not significantly different at 5% level based on Duncan test.
Male = M and Female= F
Hyalomma dromedarii (Hdrm), *Hyalomma Rufipes* (Hruf), *Hyalomma excavatum* (Hexc), *Hyalomma anatolicum* (Hanat), *Hyalomma impeltatum* (Himp), *Hyalomma marginatum* (Hmarg), *Rhipicephalus* (*Boophilus*) *decoloratus* (RBdec),

Table 6B: Means and standard errors of ticks species in five age groups of camel in Great Butana, Sudan, from November 2014 to October 2015

Age	RevsM	RevsF	RgulM	RgulF	RcamiM	RcamiF	AlepM	AlepF	HtruncM	HtruncF	RsngM	RsngF	Nymph
<5	1.5±0.5	0	2.57±0.78	1.37±0.32	0	1±0	3.16±0.64	2.25±0.55	4±0	0	0	1±0	1±0
5-10	2.36±0.85	0.5±0.22	4.82±0.89	1.42±0.38	1.33±0.33	2±0.41	3.39±0.4	2.89±0.33	1.4±1.16	0	0.33±0.33	0.33±0.33	4.43±1.62
11-15	0	0	2.33±0.88	0.33±0.33	0	2±0	3.63±1.83	0	2±1	0	0	0	4±1
16-20	0	0	0	0	0	2±0	0	0	0	0	0	0	0
8	0	0	1.33±0.33	1.75±0.47	0	0	1.5±0.5	1±0	0	0	0	0	0
Total	2.23±0.72	0.45±0.21	4.2±0.71	1.38±0.28	1.33±0.33	1.85±0.26	3.31±0.34	2.73±0.28	1.87±0.78	0	0.25±0.25	0.5±0.28	4.31±1.48

Means (±SE) followed by the same letter in each column are not significantly different at 5% level based on Duncan test.
Male = M and Female= F
Rhipicephalus evertsi evertsi (Hevs), *Rhipicephalus guilhoni* (Rgul), *Rhipicephalus camicasi* (Rcami), *Amblyomma lepidum* (Alep), *Hyalomma Truncatum* (Htrun), *Rhipicephalus sanguineus* (Rsang).

Conclusion

With expected increase in the world population, the demand for animal protein would go up globally. In fact, the Sudan ranks second, after Somalia, in the world camels' production. However, no research programs were conducted on ticks-borne viruses infesting camels in Sudan. Towards understanding of Sudan viruses, bearing in mind the aforementioned information, the program attempt to address these objectives by deliberately adopting a holistic, ecologically grounded approach to viruses' research, surveillance, outbreak response, and public health program implementation including: surveillance and control, molecular research in vectors and viruses, vaccines research, diseases burden, outbreaks and bioterrorism preparedness and training and extension activities. Therefore, such collected information would be useful at least as a first step in the risk analysis of emerging tick-borne diseases. In this regard and as a future work for better understanding of the ecology and transmission dynamics of tick-borne diseases in general and viruses in particular, beside blood specimens collection, more precise ticks collection from animals and from the field (vegetation and ground) using also standard flagging method for collecting all stages of hard and soft ticks beside chemical ecological studies and new vector management measures would be planned for.

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