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Prevalence of TickInfestation in Domestic Ruminants and Associated Risk Factors in OmdurmanLocality -Khartoum State -Sudan

معدل انتشار الإصابةبالقراد في المجترات المحلية وعوامل الخطر المرتبطبة به في محلية أم درمان- ولاية الخرطوم- السودان

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DEDICATION

To:

My parents and my sisters

Soul of my grand mother

Soul of my grand father

And my brothers

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First of all, thanks and praise are to ALLAH, The Compassionate and The Most Merciful for His giving me strength and health to make this work possible.

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Abstract

A cross sectional study was conducted from December2017 to May 2018 to investigate the prevalence of tick infestation and to reveal the relationship between tick infestation and factors of age, sex, district, , breed , coat color, predilection sites, season, herd size, housing type, raising system, feeding type, removing of manure, tick control, method of control, in Omdurman Locality, Khartoum State, Sudan.

A total of 185 domestic ruminant, 52 goat, 60 sheep, and 73 head cattle were inspected thoroughly for tick presence in fifth areas namely: Karary, Gandahar, Rudwn, Almowailih, and Alhoda. The result disclosed that tick presence was common in the three species where the prevalence was 28.8% (15 out of 52) in goats and 40.0%(24 out of 60) in sheep while 71.2%(52 out of 73) in cattle.

The results indicated that, three tick genera and seven species were found during the study period, the genera were of *Rhipicephalus*, *Hyalomma* and *Amblyomma*. The tick species included *Rhipicephalus decoloratus*, *Rhipicephalus evertsi evertsi. Rhipicephalus sangiueneus*, *Hyalomma anatolicum*, *H.rufipes*, *H. truncatum* and *Amblyomma lepidum*. The most abundant tick species was *H.anatolicum.* Its number was 528 ticks (69.83) followed by *R.evertsi* 140 ticks (18.39), *A.lepidum* 31 (4.04), *R.decloratus* 22 ticks (2.89), *H.truncatum* 19 (2.49), *R.sangiueneus* 18 (2.36), *H.rufipes* 3 (0.39).

The analysis of risk factors showned association with tick presence under significant level of P-value ≤ 0.05: Concerning goats, positive association was recorded for following factor: District (p-value = 0.000) and predilection site (P-value = 0.000) and feeding type (P-value=0.000) and method of control (P-value=0.001). In relation to sheep, positive association was recorded for predilection site (P-value = 0.000), while in cattle, positive association was recorded for District (p-value = 0.027), predilection sites (p-value = 0.000), breed (p-value = 0.006), age (p-value = 0.000) and method of control (p-value = 0.022).

Tick infestation was prevalent in study area, and become a source of a continuous animal infestation and transmission of disease to animals and had economic impact, and the overall prevalence of ticks infestation in domestic ruminant was higher, and the most abundance tick infestation was *Hyalomma anatolicum* and hence emergence of tropical theileriosism.

ملخص

اجريت دراسة مقطعية في الفترة من ديسمبر2017 الى مايو2018 للتحقق في معدل انتشار القراد وللكشف عن العلاقة بين الاصابة بالقراد وعوامل الخطر المرتبطة به من العوامل الاتية: العمر، الجنس، المنطقة، السلالة، لون الطبقة، مواقع الالتصاق،الموسم، حجم القطيع، نوع الايواء، نظام الرعي، نظام التغنية، ازالة المخلفات، التحكم في القراد و طرق التحكم بمحلية ام درمان، ولاية الحرطوم، السودان.

تم تفتيش ما مجموعة 185 من الحيوانات المجترة المحلية، عدد 52 راس من الماعز، 60 من الاغنام، 73، من الماشية بدقة لوجود القراد في المناطق الخمسة وهي: كرري، الرضوان، قندهار، المويلح، الهدى. وكشفت النتائج ان وجود القراد شائع في الثلاثة انواع حيث يقدر معدل انتشارة ب28.8%(15 من 52) في الماعز و 40% (24من اصل 60) في الاغنام بينما 71.2% (52 من اصل 73) في الماشية .

اشارت الدراسة الى انه تم تحديد ثلاثه اجناس للقراد وسبعة انواع خلال فترة الدراسة. هذه الاجناس هي: *Rhipecephalus, Hyalomma, , Amplyomma,* و شملت انواع القراد *Rhipecephalus decloratus, Rhipicephalus evertsi evertsi, Rhipecephalus sanguieneus, Hyalomma anatolicum, Hyalomma rufipes, Hyalomma truncatum, Amplyomma lipedum.* *وكان اكثر انواع القراد وفرة* *Rhipicephalus evetsi evetsi* بعدد 528 قرادة بمعدل (69.83) يلية *H.anatolicum* 140 (18.39), ثم *Amplyooma lipedum* 31 (4.04), ثم *Rhipicephalus decloratus* 22 (2.89), ثم *Hyalomma truncatum* 19 (2.49), ثم *Rhpicephalus saguieneus* 18 (3.36), و *Hyalomma rufipes* 3 (0.39).

في التحليل الفردي لمعرفة عوامل الخطر المرتبطة بالقراد باستخدام مربع كاي وجدت علاقة معنوية تحت مستوى معنوي اقل من او يساوي 0.05 : فيما يتعلق بالماعز تم تسجيل الارتباط الايجابي للعوامل التالية:المنطقة(القيمة المعنوية=0.000)ومواقع الالتصاق(القيمة المعنوية=0.000) ونوع التغذية(القيمة المعنوية=0.000)وطرق التحكم(القيمة المعنوية=0.001)، فيما يتعلق الاغنام تم تسجيل ارتباط ايجابي(لموقع الالتصاق(القيمة المعنوية=0.000)، بينما في الماشية تم تسجيل ارتباط ايجابي للعوامل التالية: المنطقة(القيمة المعنوية=0.027)، وموقع الالتصاق(القيمة المعنوية=0.000)، والسلالة(القيمة المعنوية=0.006)، والعمر(القيمة المعنوية=0.000)، وطرق التحكم(القيمة المعنوية=0.022).

اظهرت الدراسه ان معدل انتشار القراد سائدا في منطقه الدراسه واصبح مصدرا للاصابه المستمره للحيوانات وانتقال الامراض، وان له تاثير اقتصاديا عليها. واظهرت كذلك ان معدل انتشار القراد في الحيوانات المجترة مرتفعا ، وان اكثر وفره هو القراد من نوع *Hayalomma anatolicum*. ومن هنا ظهور مرض الثاليريا المداريه.

INTRODUCTION

Parasites play an important role in every ecosystem, as one of the regulating mechanisms of population dynamics for species within that system (Begon, 2007).

Parasitic infections in the tropics are responsible for unlimited damages in the meat industry than some other infectious or metabolic disease (Perry and Young., 1995).

Ticks are destructive blood sucking ecto-parasites, found in most if not all the countries of the world, and are of greater economic importance in the tropical and sub-Tropical zones (Siegmund, 1979).

Tick and tick borne disease are major problem to the livestock health in the word and its severity depends on the region, species involved, host population, socioeconomic and technological advances in control measures (Solis, 1991).

Ticks rank first as arthropod vectors of protozoan, rickettsiae, bacteria and viruses causing disease in non human's vertebrates and rank second only to mosquitoes as vectors of pathogens (Zhou *et al.*, 2009).

Tick infestation causes economical loses either directly through tick worry, blood loss, damage to the hides and udders and the injection of toxins, or indirectly by transmission disease by or associated with the ticks (Zhou *et al.*, 2009).

Tick infestation and tick borne disease are the major problem in live-stock production in Sub-Saharan Africa (Jongejan and Ui-lenberg, Mattioli *et al.*, 2000, 1994).

In the Sudan, tick and tick borne disease are wide spread. They represent a threat to domestic, exotic cattle and their crosses in the country causing substantial losses in both animals and their products (Latif, 1994).

Tick and tick borne disease are recognized from all ecoclimatological zones in the Sudan funa desert in the north to the rich savanna in the south (Hoogstraal, 1956).

Tick and tick borne disease are also recognized as a major hindrance to development of animal's production in the Sudan (Osman, 1992).

Ticks infesting livestock in the Sudan are species of the genera *Amblyoma*, , *Hyalomma* and *Rhipicephalus* (Hoogstral, 1956).

Objectives:

The main objectives of this study are:

1. To determine the prevalence of tick infestation in domestic ruminant.
2. To identify the common tick species in the study area.
3. To assess the major risk factors associated with occurrence of tick infestation on the livestock ruminant in the study area.

CHAPTER ONE

Literature Review

1. 1. Ticks Taxonomy:

There are about 900 different species of ticks. Most of which belong to the one of two main established large families, the Argasidae (Soft ticks) and the Ixodidae (Hard ticks) (Barker *et al.*, 2004).

Ticks are classified according to their morphological feature into:

Phylum: Arthropoda

Sub phylum: chelicerata (anterior fangs/chelicerae)

Class: Archanidae (Scorpion, Spiders, Harvestmen, Ticks and mites)

Order: Acarina (Parasitifornes, Ticks and Mites)

Suborder: Ixodiodea (Ticks)

Family (1): Argasidae (Soft tick)

Genus: *Argas, Otobius, Ornithodros*

Family (2): Ixodidae (Hard tick)

Genus: *Amblyomma, Hyalomma, Dermacenter, Heamaphysalis, Ixodes, Margroous, Rhipicphalus, and Aponoma.*

Family (3): Nuttaliellidae
Genus: *Nuttalliella*

1.2. Morphology of Ixodidae tick (Hard tick):

Hard ticks contains 684 species under many genera which include, *Aplyomma (130) species ,Ixodes (241) species, Bothriocroton (5) species, Heamaphysalis (162) species, Hyalomma (30)species, Nosoma (1)species, Anomalahimaya (3) species, Dermacenter (33)species, Cosmiomma (1) species, Mograropus (3)species, Rhipicephalus(75)species, Boophilus (5) species, Rhipicenter(2) species* ,(Horak, *et al*, 2002).

The body of a tick is comprised of two main regions, i.e. the gnathosoma and the idiosoma. The gnathosoma include the basic capituli and the mouthparts. The mouthparts of hard ticks consist of a pair of four-segmented palps, a pair of two-segmented chelicerae and a hypostome (Walker *et al.*, 2003). Ticks use the chelicerae to penetrate the epidermis of their host and insert the hypostome with retrograde teeth into the wound. The retrograde teeth on the hypostome, together with cement secreted by the tick's salivary gland enhance attachment of a tick to its host (Sonenshine, 1991). The idiosoma bears the legs, genetal pores and spiracles (Krantz, 1978). The salivary glands of ticks secrete anticoagulants and vasodilators (Sauer *et al.*, 2000), and also secrete immunomodulators, which can suppress the immune system of the host (Barriga, 1999).Ticks have highly efficient sensory organs, which consist of chemosensilla, mechanosensilla, photosensilla and thermosensilla. The tick's sensory organ, the Haller's organ, is situated on the dorsal surface of tarsi of each foreleg and it has both olfactory and gustatory chemosensilla (Sonenshine, 1991). Olfactory chemoreceptors or sensilla perceive volatiles while gustatory chemoreceptors perceive stimulus on contact (McMahon *et al.*, 2003). Carbon dioxide stimulus has been shown to stimulate questing in ticks (Perritt *et al.*, 1993). Also Carroll (1998) reported that aqueous wipes of the metatarsal gland of white-tailed deer elicited an arrestant response in *I. scapularis.* Some of ixodid ticks such as *Hyalomma truncatum* possess eyes equipped with photoreceptors and are capable of perceiving visual signals (Bergermann and Gothe, 1997).The scutum covers the entire dorsal surface in males, but only part of dorsal surface of females, and this characterize them into sexual dimorphism. The mouth part projects forwards and is visible from drosal view. Larvae have three pairs of legs and nymph have four (Hoogstral, 1956). The scutum remains constant during engorgement of females and thus covers a progressively smaller proportion of the dorsum. Eggs, are laid in a single batch of thousands, there is only one nymphal stage, larvae, nymph, and adults feed only once in each stage, and require at least several days to complete engorgement (Soulsby, 1982., Kettle (2000).

1.3. Ticks Biology:

All ticks are blood sucking parasite and found in most part of the world (Oleg Kozhukhov, 2007) and there four stages in the life cycle of the ticks which are, eggs, larvae, nymph, and adult (Bowman, 1999). The life cycle of Argasid ticks species are more different than Ixodides ticks species which have more uniform pattern. Argasids ticks feeding rapidly and female deposit a hundred eggs and in repeated process, the larvae feed on blood with exception of *Ornithodoros* larvae, and then moult to nymphs, and adult, there are 2_7 nymphal stage in the life cycle of Argasid ticks. Male and female copulated outside the host.

The life cycle of Ixodid ticks are classified according to their feeding behavior on number of host blood into three groups which are:

(a) One Host Ticks: in which case moulting occur through stage on the same host such as, *Ripicephalus decloratus* (Walker, *et al*. 2003)

(b) Two Host Ticks: nymphs drop off, moult to adults and attach to a another host such as, *Rhipicephalus e.evertsi and Hyalooma rufipes* (Kettle, 1995)

(c) Three Host Ticks: here ticks require a new host for each developmental stage example, *Amblyomma spp, Rhipicephalus apendiculatus* (Soulsby, 1982).

1. 4. Ticks Ecology:

Ticks are wide distributed throughout the world particularly tropical and subtropical countries, however each species of ticks adapted to different macro and micro climates with same accruing only in warm regions with fair degree of humidity, while others are most active in dry climates (Soulsby, 1982). Ticks are living organism and have their own complex ecology, for most part quite unconnected with animals (Brendan, 1975). The microclimate in layers of vegetation populated by tick is an important factors regulating in abundance of their population, the weather also regulates the period of the year when ticks are active, the seasonal activity of ticks in thus characterized by several cycles of ascending and descending movement in the vegetation, regulated with temperature and losses of water (Balashov, 1972).

Rainfall is another factor which has a significant role in tick and distribution throughout the world, the effect of it on ticks challenge to their host, was investigated at Kyle Recreation Park in Zimbabwe (Mooring *et al*, 1994). They found that adult *Rhipicephalus appendiculatus* infestation on host were 2-3 times more during rainfall, and concluded that ticks burden on host are high during the wet season due to high rainfall(Hassan, 2003).

Ticks vary in their response to temperature, sex, age and host species, Each species has a critical temperature above which the survival of the tick is greatly influenced, this critical temperature varies within different genera, for example it is 32C° for *Ixodes* spp,and 45C° for *Hyalomma* spp, 75C° for *Ornithodors savygni* (Hoogstral, 1956) .Regarding to tick temperature response, Hassan(1997) reported that tick load of host was correlated with host coat color, cattle with the white coat color carried significantly more ticks than brown host, while black cattle carried the least number of ticks. It is possible that ticks picked by cattle with black or brown coat color die or leave the host before attachment, due to relatively raised temperature in the host environment generated by the dark coat color. He also states the high humidity is particularly more required for survival of Ixodid ticks than the Argasid ticks.Ixodid ticks quickly die of desiccation when exposed to humidity below critical equilibrium values. Hence humidity plays an essential role in ticks activities and survival Schulze *et al* (2001) recorded that *Ixodes scapularis* tended to quest earlier and later in day when temperature were low and relative humidity higher. More ever Meyer *et al* (2001) found that *Dermacenter reticulates* and *D.maeginatus* ticks compensated their water losses during the subsequent incubation at 95% relative humidity. Within the Sudan ecosystem ticks occupy a wide range of ecological niches that from climate of the country, (Hoogstral, 1956).

1.5. Tick distribution in Sudan:

Sudan and Southernsudan resemble the geographical region that extend from 4° N latitudes to 22° N and borders nine African countries. There are five major ecoclimatic zones ranging from desert conditions in the north to the wood land savanna with more than 900 mm rainfall in the south. Extensive pastoral land in the east, central, west and south, support different species of livestock (FAO, 1985. It is the largest African country with livestock estimated to be 137 million of which 40 million cattle, 50 million sheep,42.5 million goats, 4 million camels and 0.5 million horses (Anon, 2005). In the Sudan, tick fauna is composed 64 species and subspecies of both Argasid and Ixodid ticks the distribution of these ticks is greatly influence by ecological variations, livestock, birds and wildlife movement .Ticks occupy a wide range of ecological niches that form the climate of the country (Hoogstraal, 1956).The main tick species known to infest animals in the Sudan are *Hyalomma anatolicum, H.marginatum rufipes, H.dromedarii, H. truncatum, H. impressum, H. impeltatum, Rhipicephalus evertsi evertsi, R. sanguineus group, R. appendiculatus, R. Pratextatus group, R annulatus, R. decoloratus, Amblyomma lepidum and A.variegatum* (Hoogstraal, 1956). Karrar *et al*. (1963) stated that tick species infest domestic animals in Kassala, Eastern Sudan are *H.anatolicum, H.excavatum, H. dromedarii, H. impeltatum, H. rufipes, H.truncatum, Rhipicephalus e. evertsi, R.sanguineus, R. praetextatus, R. decoloratus* and *A. lepidum*. Osman (1979) and Osman *et al*. (1982) studied the ecological distribution of ticks in livestock in Kordofan and Darfur regions. They reported several ticks that included *A.lepidum, A. variegatum, H. rufipes, H. truncatum, R. decoloratus, B. annulatus and R. sanguineus spp*, while *R.e.evertsi* was rare. FAO (1983) reported that *H. anatolicum, H. marginatum rufipes, R. e. evertsi* are ubiquitous in Central Sudan, in desert areas. The distribution of the common tick species is correlated with the occurrence of tick–borne diseases of domestic animals (FAO, 1987). Other species found in the Sudan are *B. geigyi, R. camicasi and R. bergeoni* that were recorded for the first time in the Sudan in addition to *R. guilhoni and R.turanicus* in Central Sudan and *R. turanicus and R. guilhoni* in southern Sudan (Jongejan *et al.*, 1987). Latif *et al*. (1994) reported in Khartoum *H. anatolicum, H. truncatum, R. decoloratus, and R. sanguineus. R.praetextatus*. The distribution of *Amblyomma lepidum* in the Sudan is generally concentrated in the central of the eastern part of the country from Torit and Kapoeta in the southern Sudan as far as Kassala in the north, but absent in Northern provinces Osman and Hassan, (2003). (Sowar 2002).Suliman (2004) recorded that *R. guilhoni* is the most predominant species of ticks in Sennar State.Most *Hyalomma spp*. were found only on cattle where *A. lepidum* was found on cattle as well as small ruminants. However, recently Abdalla (2007) confirmed that *A. lepidum* has spread from eastern parts of country to Darfur State, as well as *H. anatolicum* which has been established in the state.Tick species reported in Southern Kordofan include *A. lepidum, A. variegatum, R.decoloratus, R.annulatus, Hyalomma rufipes, H.truncatum, Rhipicephalus* and *Haemaphysalis*

1. 6. Economical Importance of Ticks:

Ectoparasites, mainly ticks, play an important role in all species of domestic animals and pose greater health concerns and about 80 % of world's cattle population is exposed to tick infestation (FAO 1984). Ticks either cause direct losses through tick worry, blood loss, and damage to hides and udders, toxin production and body weight loss (Arthur 1962; Sharma 1984; Scholtz *et al*. 1991; Stachurski *et al.* 1993) or indirectly through transmission of bacterial, viral and protozoan infections, predisposing for secondary disease condition such as screw-worm, myiasis and dermatophytosis (Soulsby, 2006) reduction in milk yield and stunted growth (FAO 2004). A single female engorged tick is imposes a daily loss of 0.5–2 ml of blood, 8.9ml of milk and 1 g of body weight (Minjauw and McLeod 2003; Soulsby 2006).The global economic losses due to tick infestation have been estimated as US $14,000–18,000 million annually and in India it causes annual loss of US $498.7 million (Minjauw and McLeod 2003).Norval *et al*,(1992) stated that about 80% of the world population of 1,200 million cattle is at risk from tick and tick-borne diseases, with global losses amounting to US$ 7,000 million. Bram (1975) cited in Sower (2002) reported that 1600 million head of cattle and sheep were suffering from tick infestation worldwide. Furthermore, tick and tick-borne diseases have become very significant problems in the modern production sector (Osman, 1991). In tropical and temperate areas where they pose a problem, ticks are responsible for hundreds of millions of US dollars loss per year (Soulsby, 1982).

Mukhebi *et al.* (1992) estimated that annual losses due to *T. parva* in Central and East Africa is about US$ 168 million and the annual cost of control and damage caused by tick and tick-borne diseases was estimated by US$ seven billion. Gamal and El Hussein (2003) estimated the financial loss due to the tropical theileriosis in a dairy farm in Eddamer to be 29%. The total cost of tick burden in livestock in Australia alone was estimated at 40 million dollars annually, of which one-third was the cost of tick control and two-third loss in production (Kettle, 2000). In Kenya, the importation of acaricides and drugs for theileriosis control reaches US$ 10 million in 1987. In Zimbabwe, the cost of ticks and Tick-borne disease control was estimated as US$ 9 million during the 1988/89 (Norval, *et al* 1992). In Sudan, Siddig *et al* (2003) reported the total loss due to an outbreak of Theileriosis in a dairy farm in Khartoum State to be about US$ 62000. However, Latif (1994) reported the losses due to *Theileria annulata* in Khartoum to reach 4-6 million dollars annually. Hassan (1997) estimated that feeding of *Amblyomma* species on the udder caused mastitis and teat damage resulting in a highly significant loss in milk yield. Regarding teat damage El-Imam (1999) also found that tick damage to teat reached 19% for one quarter, 3.1% for two quarters, and 0.4% for three quarters. In Eddamer, Northern Sudan, Gamal *et al* (2003) reported that *theileriosis* in the field reduced the expected profitability by 29% of gross profit. Chemical acaricides are considered as the main source of drainage of hard currency in Africa. The annual cost of chemical acaricides per head was estimated in Zimbabwe by Pegram *et al*. (1996) at US$ 963; while in Zambia de Castro et al. (1997) estimated this cost at US$12 per head per year. Worldwide, the cost of control and damage caused by ticks and tick-borne diseases was estimated by McCosker (1979) at US$ 7 billion per year a figure that was later reviewed to be US$ 14 - 18 billion (de Castro, 1997).

1. 7. Important Tick-borne Disease:

Ticks are vectors transmitting a wide spectrum of pathogens causing serious diseases to humans and animals, such as Lyme disease, ticks-borne encephalitis, rickettsiosis (also known as spotted fever), ehrlichiosis, anaplasmosis, theileriosis, or babesiosis (Hajdusek *et al*., 2013).

1.7.1. Tick-borne Protozoan Diseases:

1. 7 .1.1. Thieleriosis:

Theileriosis is a group of tick–borne diseases of cattle, sheep, goats, and buffaloes and occasionally of other wild ruminants caused by species of protozoa in the genus Theileria (Losos, 1986a).There are many species of Theileria that infect domestic animals which are *T.parva,T. annulata, .T. mutans. T. lestoquardi, T.velifera, T.sergenti, T.taurotragi and orientalis* (Kettle, 1995). In the Sudan, six Theileria species have been reported *T.annulata, T.mutans T.lestoquardi, T.velifera and T. ovis*, and *T.parva* which is out of the Sudan after SouthernSudan separation (FAO, 1983).The most pathogenic and economically important are *Theileria parva,* causative agent of East coast fever which transmittesd by efficient tick vector *Rhipicephalus appendiculatus R. zambizeinis* and *Theileria annulata* the causative agent of Bovine Tropical Theileriosis or Mediterranean Coast fever which transmitted by efficient tick vector *Hyalomma anatolicum* (Fujisaki *et al.*1994). Theileria species which infect sheep and goats are *Theileria lestoquardi* causing malignant Theileriosis and Theileria ovis which cause begnin Theileiosis. Ovine or Caprine Theileriosis are both transmitted by their efficient tick vectors *Hylomma anatolicum.* East cost fever caused by *Theileria parva* occurs in southern Sudan where as *T.annulata* and *T.lestoquardi* are found in the northern Sudan. East Coast Fever in southern Sudan was first reported in Kajukaji and Yei River District bordering Uganda (Hoogstraal, 1956). Bovine Tropical Theileriosis caused by *Theileria annulata* had been reported from different areas in northern Sudan , Latiff and Hassan, 1982, FAO, 1983, Hassan, 1987, Siddig, 2002, Bakhiet, and Latif, 2002, and Salih, 2003). Moreover, *Theileria lestoquardi* was reported in Red sea State in eastern Sudan (Mahmmed and Salih, 2003), and it has been reported in River Nile in Atbara and in Khartoum an outbreak by Latif, (1994).

1.7. 1. 2. Babesiosis:

Babesioses are a group of tick-borne diseases caused by several species of protozoa of the genus *Babesia*. These organisms are capable of infecting all species of domestic animals,and are also found in some wild animals, which serve as reservoirs of infection (Losos, 1986b).It is transmitted by various species of Ixodid ticks of which *Rhipicephalus annulatus, R.decoloratus and B.microplus* are predominant tick vectors.The parasite is transmitted by tick through transovarian transmission and by trans-stadial in the two-host tick *R.e.evertsi* (Hall, 1985). Surviving animals remain carriers for variable periods of time (Kettle, 2000).Pre immunity occurs,in most Babesia species, after recovering from natural infection (Blood, *et al*, 1990). In Africa, the vectors *are R. annulatus, R.decoloratus, R.appendiculatus and R.e. evertsi* (Arthur, 1962).Two species are important in the Sudan, *B.bigemina* which transmitted by *B.decloratus* and *B.annulatus* and *B bovis* which only transmitted by *B.annulatus* (Abdella, 1984). An outbreak of Babesiosis due to *Babesia bovis* was reported at Sagadi area of Blue Nile State in 1979 (FAO, 1983). Later, several incidences of Babesiosis were reported in the same area (Jongejan, 1987). An outbreak of Babesiosis in domestic livestock in the eastern region of the Sudan has been recorded by Mohammed and Yagoup, (1990).

1.7. 2 .Tick-borne Rickestial Diseases:

1. 7.2.1. Heartwater(Ehrlichia ruminantium infection):

Heartwater is a tick borne disease caused by an intracellular Rickettsia, Ehrlichia ruminantium, and is transmitted by tick of the genus Amblyomma (Semu, et al., 2001). This disease is a serious economic problem wherever it occurs, in an enormous area covering most of sub-Saharan Africa, its offshore islands, and several islands in the Caribbean.

The disease generally prevents livestock farmers from upgrading their herds to modern high-yielding breeds, as these are more susceptible to infection than traditional stock breeds, which often have a measure of resistance (Simpson,et al,1987).

In the Sudan, the disease is transmitted by *Amblyomma lepidum* in Eastern Sudan and Blue Nile State (Karrar, 1960; Jongejan *et al*., 1984) while *A.variegatum and A. lepidum* were incriminated as the vectors in Western Sudan (Abdel Wahab *et al.*, 1998).

1.7.2.2. Anaplasmosis (Gall sickness):

Anaplasmosis is an acute or sub acute febrile disease of wild and domestic ungulates. It caused by the rickettsia. *Anaplasma marginale, A. centrale* and *A. ovis,* the former being more pathogenic. It is characterized by progressive anaemia and occasionally icterus (Losos, 1986b). Anaplasmosis can be transmitted by twenty species of ticks (Bram *et al.*, 1983), but *Boophilus species* are the most efficient vectors (Blood and Radostis.1990).They transmit the disease trans-stadially and transovarially while biting flies (Tabanids, Stomoxys) play an important role in mechanical transmission beside surgical instruments and injection needles (Uilenberg,1983). Post mortem lesions are enlarged spleen, liver and distended gall bladder, hence the name gall sickness (Hall, 1985).

1.7. 3. Tick-borne Viral Diseases:

1.7.3.1. Louping ill:

Louping ill is an acute encephalomyelitis affecting mainly sheep,but other animals can also be infected. It is a viral disease transmitted by the ticks of species *Ixodes ricinus*. The disease is characterized by fever, abnormal gait, convulsion, and paralysis (Blood and Radostits, 1990, Sheahan *et al*, 2002). The disease is present in southern Europe and northern Africa.

1.7.3.2. Nairobi sheep disease:

Is most pathogenic and a severe disease of sheep and goats in which mortality may reach 90%. It is transmitted trans-staidly and trans-ovarian by Ixodid tick, *Rhipicephalus appendiculatus*. It is characterized by gastroenteritis and paralysis, which in many cases lead to death of the animal (Davies, 1997 and kettle, 2000). In Sudan, Osman, (1997) suspected the occurrence of the disease in southern Sudan bordering, Zaire, Uganda, and Kenya.

1.7.4. Tick-borne Bacterial Diseases:

1.7.4.1. Bovine Farcy:

Bovine farcy is a chronic infectious disease of cattle, in some tropical countries. It is considered as one of the most important mycobacterial infection (Timony *et al*, 1988). The disease was believed to be caused by *Nocordia farcinica*, but now *Mycobacterium farcinogenes* and *Mycobacterium senegalense* were found to be the main causitive agents (Chamoiseau, 1979). The disease clinically shows nodular swelling of lymphatic nodes present at the sites of the attachment of the vector tick *Amblyomma variegatum* (Blood and Radostits, 1990).

In Sudan, Awad and Karib, (1958) reported the relationship between Bovine farcy and Tuberculosis. The disease was found to be 14.6% in condemned carcases in Malakal Abattoir (Awad and Karib, 1958). El-Nasri (1961) noticed the spread of the disease by 15% among Arab herds in the Nuba mountains region. Nonetheless, the disease caused losses among Bargara nomadic tribe cattle in western Sudan (Hamid, 1988, El Hissien, 2001). Recently vaccine development trial against the Bovine farcy was conducted by Eiman, (2003).

1.7.4.2. Dermatophilosis:

Dermatophilosis is an acute, sub acute or chronic disease affecting wide- range of animal species. It is worldwide distributed but more prevalent in the humid, tropics and sub tropics (Zaria, 1993). It is caused by *Dermatophilus congolensis*. Feeding of *Ambylomma vareigatum* ticks on cattle suppress immunity such that any infection with *Dermatophilus congolensis* bacteria in the skin is aggravated to cause very severe *Dermatophilosis* (Latiff and Walker, 2004). In Kenya it has generally been found in the main semi-arid camel rearing areas (Gito, 1993). Similarly in Sudan the disease was reported in Butana region of eastern Sudan affecting camels (Gito *et al*, 1998).

1.7.5. Tick Toxicosis:

1.7.5.1. Sweating Sickness:

The disease affects cattle especially the young calves infested with *Hyalomma truncatum* adult ticks (Dollan, 1980). It is characterized by moist eczema and pale mucous membrane. It is common during the hot-wet season and in area sassociated with heavy rainfall where the vector ticks are abundant Sower,(2002). The disease has no specific treatment. However, the administration of hyperimmune serum obtained from animals which have recovered from the disease will induce immunity against the infection this method is impractical due to possible serum contamination and availability of the donor animals (Spickett *et al,* 1991).

1.7.5.2. Tick Paralysis:

Paralysis usually occurs during rapid engorgement by the adult females Ixodes, but there have been report of it also being caused by large numbers of larval or nymphal ticks (Atwell, 2010). The disease resulting from toxins that are secreted by several species of ticks such as *Ixodes rubicundus,R.evrtsi, Haemaphysalis punctata and Ixodes ricinus* (Doube, 1975, Blood, and Radostis, (1990).

1.8. Tick Control:

Control strategies of ticks depend on ecology, biology and epidemiology of ticks and tick-borne disease. It aims at reducing tick population and infestation levels on animals and to prevent transmission of diseases. Control of ticks and tick-borne disease has started since the early twentieth century. Some countries succeeded in control programs such as USA and parts of Argentina .However, other countries have failed specially in Africa due to lack of financial resources, presence and density of host and eco-climatic factors (FAO, 1984).

1.8.1. Conventional tick control:

The conventional method of controlling ticks is by application of chemical acaicidesds using dip tank, spray race, hand spray, pour on and tick grease. Generally the use of acaricides has been successful; this is possible through correct mixing of the acaricides and strategic application of ticks control measures, considering seasonal variations (Chizyuka *et* *al*, 1990). The other methods of application of acaricide include acaricide impregnated ear tags, tail bands, leg bands, neck bands (Drummond, 1983; FAO, 1984) and acaricide boluses (Miller *et al.*, 2001). Tick species can be controlled by efficient dipping interval which varies from one host tick, two host tick and three host ticks. One host tick requires 2-5weeks interval while two-three host ticks required 5-7days (Sower, 2002). Arsenic compound, the first effective method for controlling ticks and tick-borne diseases, were used in many parts of the world for over 50 years before resistance to chemical became a problem. However, acaricides such as organophosphate, organo-chlorine and synthetic pyrethroid have recently been used in a wide range (Awumbil, 1996, and George, 2000). Moreover, resistance of ticks to these chemicals develops due to long term and indiscriminate use (Pengnet *et al*., 1998). A number of tick species develop resistance to some acaricide (FAO, 2004). In Australia, *Rhipicephalus microplus* developed resistance to D.D.T. (Kettle, 1995).The disadvantages of chemical acaricides use are development of resistance of ticks to various acaricides (Aziz, 2003), beside the environmental pollution among other adverse effects on non target organisms and toxicity to man and animals. Intensive and thus expensive dipping or spraying programs have been largely unsuccessful in eradicating ticks and tick-borne diseases (Jongejan and Uilenberg, 1994).

1.8.2. Host resistance:

Resistance of animals to tick infestation varies according to animal breeds and number of external factors specially season, nutrition status and stresses (de Castro and Newson, 1993). Animals can be either highly resistance which are infested by few numbers of ticks or of law resistance which have carry higher numbers of ticks (Latif and Pegram, 1992). In Africa, it is evident from all reported studies that zebu cattle carry significantly less tick than the exotic breeds of cattle (Latif, 1984). Dolan (1986) reported that resistant animals to one species or one stage of the life cycle of a particular tick can be expected to be resistant to other species. High resistant cattle keep overall total tick populations very low. In contrast, low resistant cattle in the same herd or in the same farm produce higher peaks at certain seasons (Latif and Pegram, 1992). Latif *et al* (1991b) found that *R.appendiculatus* female on zebu cattle in western

Kenya was 10%on higher resistant cattle, 11-40% on low resistant and above 41% on cattle of very low resistance. In the Sudan crossbred B. taurus X B. indicus carried 4.5 times more ticks, than B. indicus (Kenana and Butana) (Latif, 1984). The inclusion of tick-resistance of cattle through a breeding programme will increase the average resistance of cattle within a herd, which can be used for tick control (Jonsson *et al*., 2000).

1.8.3. Biological control:

The biological control of ticks mainly relies on natural enemies, both predacious and parasitoid or pathogens. In nature, many bacteria, fungi, beatles, rodents, ants, birds, and other living things are feeding largely on insects including ticks. This indirectly reduces ticks population (Hoogstraal, 1956, Mwangi *et al*, 1991, Samish and Rehacek, 1999, Samish and Glazer, 2001).

Hassan *et al*. (1991, 1992) reported that domestic chickens play an important role as natural tick predators in a free management system. Other predators are red-billed and yellow billed oxpeckers (*Buphagus erythrorhynchus*) in which ticks constitute the main food components (Norval *et al*., 1991). Re-introduction of Oxpeckers to farming areas was facilitated by reduced acaricide usage and availability of acaricide such as amitraz which do not poison birds (Bezuidenhout and Stutterheim, 1980). Opportunistic predators which include spiders, rodents, toads, ants, lizards, shrews and snakes have been described (Mwangi *et al*., 1991; Hassan, 2003).

Parasitoids for tick control were reported to be successful at first with proven reduction on tick number, but later the ticks were found to increase again (Mwangi *et al*., 1991). The female parasitoid lay eggs in the host tick by piercing the integument with her ovipositor. Engorged adult female of *R.appendiculatus* and *Boophilus species*(Short et al,1989) were occasionally parasitized by the larvae of an identified species of coffin fly(*Phoridae:Diptra*). Ixodiphagus hookei a parasitoid which lays its eggs in nymphs of *A. variegatum* reduce tick load in cattle by about 95% in a trial in Western Kenya (Mwangi *et al*., 1997).

Pathogens were also considered in tick control. Fungi, rickettsia, protozoa, bacteria and viruses or their metabolite products are used to control the target vectors (Calberg, 1986). Results of some isolates of the fungi *Metarhizium anisopliae* and *Beauveria bassiana* have been proved to be pathogens for the ticks, their effects lead to death of ticks and minimize their population level of subsequent generation (Samish et al,1999, Kaya *et al*,1996, Kaya and Hassa, 2000, Bittencourt,2000). Ricketsial pathogen, Ricketsial prowazeki was used to artificially infect females of *D.marginatum and D. albipictus* (Rehacek, 1965). *Wolbachia persicus* is Rickettsia which was successfully put into the gut of *Ornithodoros moubata* where it multiplied and had damaging effect (Weyer, 1973). Nevertheless, Hendry and Rechav,(1981) were able to produce the described clinical signs by injecting common laboratory strains of bacteria species *Salmonella marcescens*, *Klebsiella pneumonia*, *Proteus species*, *Staphylococcus aureus* and *Pseudomonas aeruginosa* into healthy engorged females of *Rhipicephalus decoloratus*. They concluded that ticks become infected with bacteria after detachment from the host; despite the acaricidal action of certain bacteria, they see little prospect for their use as biological control.

1.8.4. Ecological control:

Ecology plays an important role in tick control programmes (Estrada-Pena, 2003). The aim of this method is to minimize success of parasite in finding a passing host, and to interfere with development of engorged ticks. Burning of pasture, bushes, grasses, cultivation of grazing areas, use of mixed farming, removal of manure, pasture spelling, and sealing off cracks and crevices in animal enclosures largely reduce host tick contact and contribute in control of ticks (ElGhali, 1992; Hassan, 2003). Pasture spelling was used in tick control in Australia (FAO, 1984), but this method is not applicable in Africa where there are three-host tick species which might have other hosts to feed on, beside that longevity of unfed adult ticks in pasture might be for two years or more ((Young *et al.*, 1983).

1.8.5. Vaccination against ticks and tick-borne diseases:

In the early 1990s, vaccines were developed that induced immunological protection of vertebrate hosts against tick infestations. These vaccines contained the recombinant *R. microplus* Bm86 gut antigen (de la Fuente J and Kocan KM, 2003., Willadsen, 2006). This vaccine causes damage of gut wall resulting in leakage of bovine erythrocyte in haemolymph. Ingestion of blood containing antibody to Bm86 causes lysis of the gut cells of the ticks. This results in high mortality of feeding ticks, reduction of engorged weight and egg laying capacity causing reduction of tick's population (Hassan 2003). The vaccine is able to control *Rhipicephalus microplus* and other *Rhipicephalus* species (Fragoso, et al 1998, Kalafa-Allah, 1999, Pipano *et al*, 2003). Moreover, it is utilized in vaccination against other ticks species *Hyalomma anatolicum and Hyalomma dromedarii* (De vos S *et al*, 2001). This vaccine is now applied on a large scale against the tick *Rhipicephlus microplus* in Australia since 1996. On the other hand, cell culture vaccine for tropical theileriosis was established in Israel (Pipano and Tsur, 1966) and successfully applied in many countries such as Iran (Hashemi-Freshaki, 1998), Schizont cell culture vaccine provided immunity against *T. annulata* for at least 6 months (Beniwal *et al*., 2000; Khatri et al., 2001). Beside that tissue culture vaccine against *T.annulata* has been established in Sudan by isolation and attenuation of two strain Atbara and Hantub Shariff *et al*,.(2006). Furthermore laboratory experiments was conducted on cross breed and pure Frisian by evaluation and quality control studies Elhag (2010), field vaccination trails have been also conducted on calves from two weeks to six months Elhag (2013) un published data.

In Sudan, the vaccine is currently been evaluated against *Hyalomma a.anatolicum and Hyalomma dromedarii* (Hassan, 2003). Rabbit immunity against *Hyalomma a.anatolicum* using larval antigens was proved (Ochi, 2004).

CHAPTER TWO

Materials and Methods

1. Study area:

The current study was carried out in Khartoum State. Khartoum, the national capital of the Republic of Sudan, is located at the confluence of the White Nile and the Blue Nile between latitude 15° 32.799´N and longitude 32° 32.0166´ E in an area about 22.122 square kilometers. Khartoum divided into seven localities: Khartoum, Jabal Awlia, Karay, Umbada, Omdurman, Bahri and East Nile. Khartoum features a semi-desert climate with average annual temperature ranging between 22.7° C and 37.1° C with a mean annual rainfall of 156.8 mm. The livestock in Khartoum State comprises of 250,566 cattle, 442,672 sheep, 642,927 goats and 6,472 camels (Anon, 2011).

2. Study design and sample size:

A cross-sectional study was conducted to investigate the prevalence of ticks infesting livestock in the study area. The sample size was calculated according to Thrusfield (2007) with a 95% confidence interval, 5% desired absolute precision and by considering the expected prevalence to be 50%.Accordingly a total of 185 ruminants was examined in five areas in Omdurman locality, which possess large numbers of animals, were selected for sampling, 73 cattle, 60 sheep, and 52 goats. A multistage sampling method was used to select study animals from selected areas.

3. Collection of ticks and Questionnaire survey:

During the study period, total body collections of tick specimens were collected from 185 of cattle, goats, and sheep. The following predilection sites: ears; brisket, withers, knees, udder in the case of females, testes in males and tail was targeted for specimens collection. ticks were removed manually from the attachment sites of the animal body by a rotating manner to retain their body parts for identification (Wall and Shearer, 2001), and transferred to Eppendorf tubes containing 70% ethanol, labelled with specific ID,including the herd ID, host species and body attachment.Ticks of each predilection site were collected into separate tube. The areas which had been visited in Omdurman locality for tick's collection include, Karary, Alrodwan, Gandahar, Almowailih, and Alhuda.

A questionnaire was designed to provide information about potential risk factors hypothesized to be associated with tick's infestations in domestic ruminants. Prior to sample collection, the questionnaire was completed for every visited farm in an interview with the owner.

4. Investigation of risk factors:

For each specimen, host related factors comprising; species, sex, age, breed and predilection sites and other factors including: raising one or more livestock species within the herd, high tick infestation period in the year, method (s) to control ticks, feeding type and method, presence of natural predators in the herd and housing type was recorded in predesigned form.

5. Identification of ticks:

Each tick specimens was examined under stereoscopic dissecting microscope on the Central Lab for Veterinary Research in Suba, Khartoum, Sudan, and tick samples was morphological identified to the species level according to taxonomic keys described by (Hoogstraal, 1956).

6. Statistical analyses:

The collected data was entered and managed in Microsoft excel sheet and the analysis was done using statistical package for the social sciences (SPSS), version 16 software program. The prevalence of tick was determined and expressed as percentages. Chi-squared test was used to assess whether tick infestation prevalence differed significantly between the levels of selected risk factors. A p-value ≤ 0.05 was considered significant.

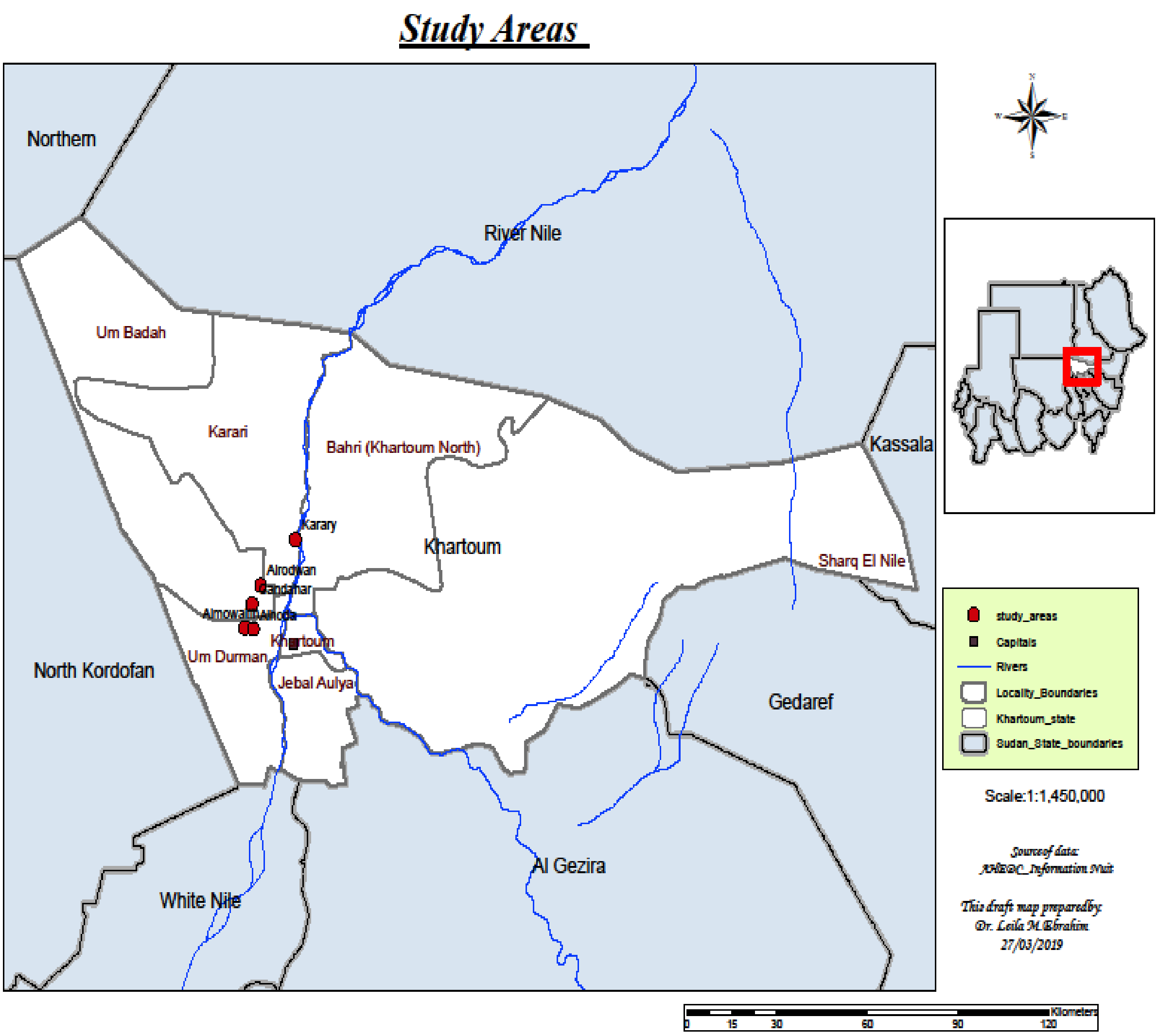

Fig (1) study area

CHAPTER THREE

Results

1. Tick survey:

Three tick genera and seven species were identified during the survey period. These were the genera *Rhipicephalus*, *Hyalomma* and *Amblyomma*. The tick species included *Rhipicephalus decoloratus*, *Rhipicephalus evertsi evertsi Rhipicephalus sanguanus*, *Hyalomma anatolicum*, *H.rufipes*, *H. truncatum* and *Amblyomma lepidum*, Fig (2).

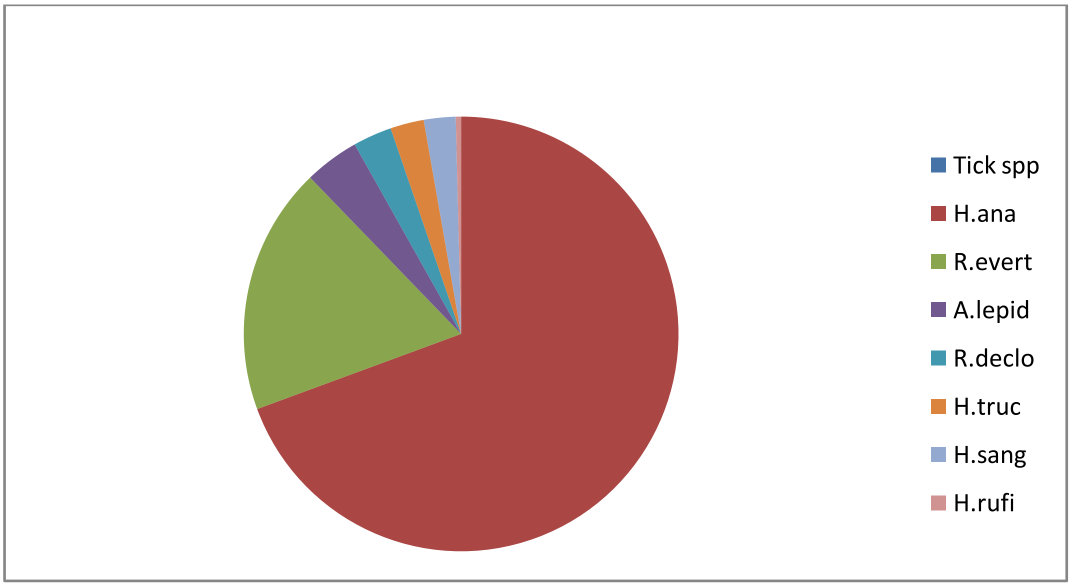

Fig (2) tick survey

2. Prevalence of tick infestation:

Of total 185 examined domestic ruminants in fifth areas in Omdurman between December 2017to Maye 2018, 49.4% were infested by one or more tick species. The corresponding percentage of infestation in cattle, sheep and goat was 71.2%, 40% and 28.8%, respectively (table 1).

Table (1).**An overall prevalence of tick's infestation in different animal species**

Species	No	Infested	Non infested	Prevalence %
Cattle	73	52	21	71.2
Sheep	60	24	36	40
Goat	52	15	37	28.8
Total	185	91	95	49.4

Overall of total 761 ticks collected 514 males (67.54%), 247 females (32.45%) from 73 cattle, 60 sheep, 52 goats, from total count *Hyalomma anatolicum* was the dominant tick species (69.38%) and *Hyalomma rufipes* (0.39%) was the least. table (2).

Table (2) **Overall prevalence of tick infestation in domestic ruminants:**

Tick species	Male %	Female %	Total %
Hyalomma anatolicum	382(50.2)	164(19.18)	528(69.38)
Rhipicephalus evertsi evetsi	81(10.64)	59(7.75)	140(18.39)
Rhipicephalus sangunas	13(1.7)	5(0.65)	18(2.36)
Hyalomma rufipes	3(0.39)	-	3(0.39)
rhipicephalus decloratus	-	22(2.89)	22(2.89)
Hyalomma turncatum	6(0.78)	13(1.7)	19(2.49)
Amblyomma lepidium	29(3.81)	2(0.26)	31(4.04)

Among distribution of ticks genera and species with their predilections site in domestic ruminants and male to female ratio, The male to female ratio of *Hyalomma rufipes* was not possible to figure-out, because there were no any female ticks identified in the counting. The result indicated that there were more males than females in all the ticks except in *R. decoloratus* which had females only. Each tick species tended to prefer a site of attachment on the animal body. The most favorable predilection site for *Hyalomma anatolicum* was udder, tail, testes, brisket, and ear, *Hyalomma rufipes* was collected from tail, and *R.evertsi* was collected from tail, ear, eye, and *H.truncatum* from tail, testes, brisket, and *Rhioicephalus decloratus* from testes, brisket, ear, and *Amblyomma lipedum* from tail, testes, brisket, and *R.sanguanus* was collected from tail, ear, table (3).

Table (3) **Distributions of tick's species with predilections sites:**

Host	Tick species	No. of ticks	Male	Female	Male to female ratio	Predilection sites
Cattle	*H.anatolicum*	439	320	119	2.6.8	Udder,tail,testes,brisket
	R.e evertsi	26	17	9	1.8:8	Tail
	H.truncatum	18	5	13	0.3:8	Tail, tests, brisket
	H.rufipes	3	3	-	-	Tail
	A.lepidum	28	-	2	1.3:0	Tail, testes, brisket
	R.decloratus	11	22	11	-	Testes, brisket
Sheep	*H.anatolicum*	81	57	24	2.3:7	Udder, tail, ear, brisket
	H.truncatum	2	2	-	-	Testes
	R. e evertsi	63	99	34	0.5:8	Tail, ear, eye
	R. sangunas	17	13	4	3.2:5	Tail.ear
	A.lepidium	3	3	-	-	Testes
	R.decloratus	11	-	11	-	Testes, ear

Goat	*H.anatolicum* *R.e evertsi* *R. sangunas*	10 49 2	7 33 -	3 16 1	2.3:3 2.0:6 -	Udder, tail, ear Tail, ear Ear

The data with regards to tick predilection site on host body of domestic ruminant revealed that mixed infections (udder tail) (49.54%) is the highest infested site of tick infestation followed by tail (7.62), testes (4.6%), brisket (4.204%), udder (3.54%) in cattle. In sheep the highest infested site is ear (9.85%) and lowest was eye (0.26%). In goat the highest site was tail (5.51%) followed by ear (2.231%) and udder (0.131%) table (4).

Table (4) **Distribution rate (%) of tick infestation in different predilection sites of examined animals:**

Predilection site	Cattle %	Sheep %	Goats %
Udder	27(3.54)	27(3.54)	1(0.131)
Tail	58(7.62)	25(3.82)	42(5.51)
Testes	35(4.6)	8(1.051)	-
Brisket	32(4.204)	7(0.919)	-
Ear	-	75(9.85)	17(2.231)
Knee	-	-	-
Wither	-	-	-
Mixed	377(49.54)	28(3.68)	-
Eye	-	2(0.26)	-

Regarding tick burden in different domestic ruminant, in total of (73) cattle are infested by Ixodid ticks, there were 27 animals (37%) infested by (1-10) ticks, 16 (22%) infested by (11-20) ticks, and 9 (12.3%) infested by (21-30) ticks. And in total of (60) sheep are infested by Ixodid ticks, there were 18 animals (30%) infested by (1-10) ticks, 4 (6.6%) and 2 (3.3%) were infested by (11-20), and (21-30) respectively. And in total of (52) goats there were 14 animals (27%) were infested by (1-10) Ixodid ticks, and 1 (1.9%) were infested by (11-20) ticks.

Table (5) **Tick burden of animal species:**

Number of ticks	Cattle %	Sheep %	Goat %
1- 10	27 (37)	18 (30)	14 (27)
11-20	16 (22)	4 (6.6)	1 (1.9)
21-30	9 (12.3)	2 (3.3)	0 (0)

3. Risk factors analysis:

Table (5-1) **Summary of univariate analysis for risk factors associated with tick infestation in Omdurman locality, Sudan (n=73 cattle) using the Chi-squared test**.

Risk factor	No. examed	No. infested (%)	df	x^2	p- value
Age					
Young < 2 year	29	12 (41.4%)	2	21.196	0. 000
adult 2-5 year	30	28(93.3%)			
Old > 5 year	14	12 (85.7%)			
Sex					
Female	35	23(65.7%)	1	0.999	0.317
Male	38	29 (76.3%)			
District					
Mowelih	15	15(100.0%)	4	10.955	0.027
Gandahar	8	7(87.5%)			
Huda	6	4(66.7%)			
Karary	15	10(66.7%)			
Rudwan	29	16(55.2%)			
Breed					
Local	15	15 (100.0%)	1	7.624	0.006
Cross	58	37(63.8%)			

Coat color					
White	26	17(65.4%)	3	1.210	0.751
Brown	20	16(80.0%)			
Black	14	10(71.4%)			
Mixed	13	9(69.2%)			
Predilections site					
Tail	15	15(100.0%)	5	64.089	0.000
Udder	3	3(100.0%)			
Brisket	2	2(100.0%)			
Testes	6	6(100.0%)			
Knee	1	1(100.0%)			
Mixed	23	23(100.0%)			
Season					
Dry hot	52	37(71.2%)	2	0.094	0.954
Wet cold	15	11(73.3%)			
Unknown	6	4(66.7%)			
Herd size					
Big	12	7(58.3%)	1	1.166	0.280
Small	61	45(73.8%)			
Housing type					
Open	5	4(80.0%)	2	0.250	0.882
Closed	32	23(71.9%)			
Semi closed	36	25(69.4%)			
Raising system					
Mixed	35	21(60.0%)	1	4.140	0.042
One species	38	31(81.6%)			
Methods of control					
Acaricide	29	25(86.2%)	1	5.265	0.022
Mixed	44	27(61.4%)			

Table (5-2) **Summary of univariate analysis for risk factors associated with tick infestation in Omdurman locality, Sudan (n=52 goat) using the Chi-squared test**.

Risk factor	No. examed	No. infested (%)	df	x^2	p- value
Age					
Young 1-6 moth	16	5 (31.2%)	2	0.104	0.949
Adult 6mth-3year	28	8 (28.6%)			
Old > 3 year	8	2 (25.0%)			
Sex					
Female	25	8(32.0%)	1	0.233	0.629
Male	27	7 (25.9%)			
District					
Mowelih	9	7(77.8%)	1	23.634	0.000
Gandahar	15	6(40.0%)			
Huda	3	2(66.7%)			
Karary	15	0			
Rudwan	10	0			
Breed					
Local	28	8 (28.6%)	1	0.002	0.962
Cross	24	7(29.2%)			
Coat color					
White	9	3(33.3%)			
Brown	8	3(37.5%)	3	0.640	0.887
Black	14	4(28.6%)			
Mixed	21	5(23.8%)			
Predilections site					
Tail	7	7(100.0%)	1	52.000	0.000
Mixed	8	8(100.0%)			

Season Dry hot Wet cold Unknown	 28 2 22	 4(50.0%) 1(14.3%) 10(45.5%)	 2	 6.285	 0.043
Herd size Big Small	 5 47	 2(40.0%) 13(27.7%)	 1	 0.335	 0.563

Housing type Closed Semi closed	 29 23	 6(20.7%) 9(39.1%)	 1	 2.125	 0.145
Feeding type Mixed Rouphage	 45 7	 9(20.0%) 6(85.7%)	 1	 12.745	 0.000
Removing manure Weekly Monthly No	 18 4 30	 6(33.3%) 3(75.0%) 6(20.0%)	 2	 5.472	 0.65
Tick control No	 29	 11(37.9%)	 1	 2.63.6	 0.104

Yes	23	4(82.6%)			
Method of control Acaricides Mixed No	 30 15 7	 8(26.7%) 1(6.7%) 6(85.7%)	 2	 14.694	 0.001

Table (5-3) **Summary of univariate analysis for risk factors associated with tick infestation in Omdurman locality, Sudan (n=60 sheep) using the Chi-squared test**.

Rick factors	No. examed	No. infested %	df	x^2	p- value
Age Young 1-6month Adult 6month-3year Old > 3 year	 13 28 19	 4(30.8%) 10(35.7%) 10(52.6%)	 2	 1.939	 0.379
Sex Female Male	 26 34	 12(46.2%) 12(35.3%)	 1	 0.724	 0.395
District Moweli Gandahar Huda Karary	 15 32 8 5	 5(33.3%) 15(46.9%) 14(50.0%) 0(.0%)	 3	 4.575	 0.206
Breed Hamary Kabashi	 32 28	 16(50.0%) 8(28.6%)	 1	 2.867	 0.091
Coat color					

White Brown Black Mixed	16 26 3 15	2(12.5%) 14(53.8%) 2(66.7%) 6(40.0%)	3	8.007	0.046
Predilection site Udder Tail Testes Ear Mixed	 4 3 2 3 12	 4(100.0%) 3(100.0%) 2(100.0%) 3(100.0%) 12(100.0%)	 4	 60.000	 0.000
Season Dry hot Wet cold Unknown	 17 14 29	 8(47.1%) 7(50.0%) 9(31.0%)	 2	 1.908	 0.385
Herd size Big Small	 21 39	 11(52.4%) 13(33.3%)	 1	 2.063	 0.151
Housing type Open Closed Semi closed	 10 13 37	 4(40.0%) 6(46.2%) 14(37.8%)	 1	 0.277	 0.871
Raising system One species Mixed	 26 34	 11(42.3%) 13(38.2%)	 1	 0.102	 0.750
Feeding type Mixed Roughage	 45 15	 20(44.4%) 4(26.7%)	 1	 1.481	 0.181
Removing manure Weekly Monthly	 34 13	 12(35.3%) 6(46.2%)	 2	 0.724	 0.696

No	13	6(46.2%)			
Tick control No Yes	17 43	7(41.2%) 17(39.5%)	1	0.0104	0.907
Method of control No Acaricides	42 18	18(42.9%) 6(33.3%)	1	0.476	0.490

According to age factor, higher infestation rate was detected in adults cattle (93.3%) followed by old (85.7%) and finally young (41.4%). Significant association was observed (x^2=21.196; *P* = 0.000). In goat higher infestation rate was detected in young (31.2%) followed by adults (28.6%) and finally old one (25.0%). (x^2=0.724; *P* = 0.395). In sheep higher infestation rate was detected old (52.6%) followed by adults (35.7%) and finally (30.8%). (x^2=1.939; *P* = 0.379).

In relation to gender, male animals had higher prevalence rate (76.3%) than females (65.7%), (x^2= 0.999; *P* = 0.317) however the infestation rate was higher in female in goat than male (32.0% female) and (25.9% male), (x^2=0.104; *P* = 0.949). Also in sheep (46.2% female) and (35.3% male). (x^2=0.724; *P* = 0.395).

Herd size were concerned in this study, infestation rate in cattle was (58.3%), (73.8%) in big and small herd size respectively, on the other hand, the infestation rate in goats and sheep was as follow, (40.0% in big herd size) and (27.7% in small herd size) in goats while (52.4% in big herd size) and (33.3% in small herd size) in sheep respectively.

In the Chi-squared test, the result showed that there was no association between ticks infestation and the herd size observed in cattle(x^2= 1.166; *P* =0.280), similar results obtained from goat(x2=.335) (P=0.563) and sheep(x2= 2.063) (0=p.151) respectively.

Concerning districts of examined animals, the rate of infestation was in Mowelih, Gandahar, Huda, Karary and Rudwan (100.0%), (87.5%), (66.7%), (66.7%) and (55.2%) respectively. Significant association was found between the infestation with ticks and districts of the study (x^2=10.955; *P* = .027) (Table.5. 2). Alongside, Mowelih recorded higher infestation rate in goats(77.8%) followed by Alhoda (66.7%), Gandahar (40.0%) and finally Rudwan and Karary with infestation rate (0%) whereas in sheep the higher infestation rate scored by Huda (50.0%) followed by Gandahar (46.9%), Mowelih (33.3%) and finally Karary with infestation rate(.0%). significant association was observed between District and Goats species (X^2=23.634) (p=0.000) while no association was observed between sheep and district(X^2=4.575)(p=0.206).

Regarding housing type, 4(80.0%), 23(71.9%) and 25(69.4%) animals were found infested in open, closed and semi closed respectively. Chi –squared was (x^2=.250; *P*= 0.882.). Furthermore, the semi closed system recorded higher infestation rate in goats (39.1%) and the lower prevalence recorded by closed system (20.7%), Chi –squared was (x^2=2.125; *P*=0.145). In sheep the results was (46.2% in closed), (40.0% in open) and (37.8%) in semi closed. Chi –squared was (x^2=0.277; *P*= 0.871).

Considering raising system of examined animals, mixed system had lower prevalence (60.0%) than unmixed (one species) (81.6%) in cattle, in chi-squared (x=24.140; P=.042). (Table.5.1). Similar results were obtained from sheep (38.2% mixed) and (42.3% one species), in chi-squared (x=0.102; P=0.750). In goats all farm sample was mixed.

According to species, 185animals were examined, 73 cattle, sheep 60 and goats 52 with prevalence rate (71.2%), (40. %) and (28.8%) respectively. Highly significant association was observed in species investigation (x^2= 23.893; *P* = 0.000) (Table.1).

Coat color was investigated, the results obtained as follow: in cattle brown color had higher infestation with ticks, black, white and mixed color (80.0%), (71.4%) (65.4%) and (69.2%). (x^2= 4.442; *P*=.217). In goats brown color was higher (37.5%) followed by white (33.3%), black (28.6%) while mixed color scored (23.8%) (X^2=0.640: p=0.887). In sheep black was higher infestation (66.7%) followed by brown (53.8%) and white (12.5%) while mixed color scored (40.0%). (X2=8.007: p=.046).

In this study, predilection site was concerned, in cattle and goat, tail and mixed sites, recorded highest prevalence rate (100%), significant association was observed. Chi-squared in cattle was (X2=64.089: p=0.000), while in goat was (X2=64.089: p=0.000). In sheep ticks infested all site with 100%. (X2=60.000: p=0.000).

Season was examined in our questionnaire: our result showed (73.3%) (71.2%) of cattle infested with ticks in wet cold and dry hot respectively while (66.7%) of owner answered by unknown. (x^2= 0.094; *P* = 0.954). (50.0% in wet cold) (47.1% in dry hot), (31.0%) un known, infestation rate of ticks according to questionnaire answer for sheep owner(X2=1.908: p=0.385), while (50.0% in September) (14.3% in May) and (45.5%) unknown, infestation rate of ticks for goat. (X2=6.285: p=0.043)

Our study revealed numerous of cattle owners practiced tick control periodically (100.0%) while (17.4%), (39.5%) of goat and sheep owner practiced tick control respectively. No association was observed in all species.

(86.2%) of owner use Acariside in order to control ticks while (61.4%) of them use mixed methods for controlling ticks concerning cattle owner while (26.7%) of goat owners use Acaricide and (6.7%) of them use mixed methods while (85.7%) of owner have not control methods. Furthermore, (33.3%) of sheep owners use Acaricide and (42.9%) don’t practiced any control methods. Significant association was observed between methods of control and goats species(X^2= 14.694: p= 0.001).

In the present study, significant association was observed between type of feed and ticks infestation in goats (X2=12.745: p= 0.000) unlike cattle and sheep no association observed between type of feed and ticks control.

The current study revealed (70.5%) of cattle owners removed manure monthly and (66.7%) removed weekly beside (87.5%) don’t practiced removal of manure. On other hand (75.0%) and (46.2%) of owner of goat and sheep removed monthly respectively, while (33.3%) and (35.3%) of them removed weekly whereas (20.0%) of goats owners and 46.2% of sheep owners don’t practiced removal of manure.

Chapter four

Discussion

Tick infestations cause substantial blood losses from livestock and can also transmit severe diseases such as theileriosis and babesiosis.

In the current study, the infestation rate of ticks in different animal species revealed that the overall infestation rate was (49.4%) with highest rate in cattle (71.2%) and this finding lower than results which has been reported by (Bekele *et al*, 2017) in Guba-korich District west Hararghe zone, east Ethiopia and this due to different ecological zone, followed by sheep (40%) and this lower than 49.5% , and goats (28.8%) higher than 20.17% which reported by Yagoub *et al*, (2014) and this may be due to different distribution and climate area. The observed overall prevalence is generally high (49.4%) which would result in high economic losses through decreased production and productivity, deaths of the animal and damages of the skin demanding an immediate attention and professional intervention.

Significant association was observed in species investigation (x2 = 23.893; P = 0.000), the difference in the prevalence rate between species might be due to the geographical difference, genetic resistance, season of the study periods management condition and control strategies in the study sites. Also this may be due to continuous shearing of fleece in goats and sheep which practiced by owners.

Our study showed that in relation to gender, cattle males animals had higher prevalence rate (76.3%) than females (65.7%),(x^2 = 0.999; *P* = 0.317) however the infestation rate was higher in female in goat than male (32.0% female) and (25.9% male), (x^2 =0.104; *P* = 0.949). Also in sheep (46.2% female) and (35.3% male). (x^2=0.724; *P* = 0.395).These results are disagreed with the works of Asmaa *et al*. (2014), Rony *et al*. (2010) and Sarkar (2007) where both reported a significantly higher prevalence of ecto parasitic infestations in female than the male cattle and in line with reports by Hitcheock (1993) who reported that males are more infested with ticks than female cattle. In sheep and goats this results may be associated with male animals which were kept properly in the house with good management system for meat purpose whereas, female animals grazing on field all day may be exposed to tick infestation.

In this study, higher prevalence was observed in Mowelih and Gandahar comparing to another's districts in cattle and sheep while goat was Alhuda district, this finding due to high Population densities (animal marketing) in Mowelih and Gandahar more than any districts in Khartoum state, furthermore most of animal in Mowelih and Gandahar brought from east Sudan in which the ecology is favored by tick populations, survival and development.

The study showed that ticks have specific preferred sites of attachment on their hosts, in cattle and goat, tail and mixed sites, recorded highest prevalence rate (100%), This finding is possibly due to the easiness for ticks to acquire blood for nourishment, may be attributed to the fact that the attachment of the tick depends on the temperature and the thickness of the skin of the animal unlike sheep ticks infested all site with 100%(Sajid, 2007).

Tick species identified in this study were generally similar to those reported by Hoogstraal (1956), Karrar (1963), Osman *et al*. (1982) and Jongejan *et al*. (1987).

Hyalomma anatolicum recorded highest prevalence (69.38) in this study and this finding was agreed with result has been reported by (Mohamed,*et al*.2004) in Khartoum District , followed by *R. evertsi* (18.39) which lower, *R.sangiunus* (2.38),and *Rhipicephalus decloratus (2.89)* higher than which reported by (Mohamed,*et al*.2011) in Gadarif State, and this could be to different climate condition. while *A.lepidium* comprising *(4.7)* and this finding disagreed with results reported by (Ibrahim, *el al*. 2012) in Alkadaro Quarantine Station, Khrtoum State, and this could be to varied in their species and origins, *H.trunatum (14.49)*, agreed with result which had been reported by salih (2008) in Central Equatoria State, *H.rufipes* (0.039) were recorded in very low numbers, this may be due to the unfavorable climatic conditions as this tick is usually regulated or governed by the humidity, vegetation types and the length of the rainy season (Hoogstraal, 1956).

The number of male ticks was higher than the number of females in *H.anatolicum, H.rufipes, H.lepidium, R.evertsi* and *R.Sangunas* unlike *H.truncatum* and *Rhipicephalus decloratus* where the females was higher than males and this probably due to the small size of the male which could not be seen. This might be one of the contributory factors for missing males.

The effect of coat color on ticks' loads showed that animals with brown and black coat color infested by the highest number of ticks. These finding is contradicted with Hassan (1997) and Abdalla (2007) who found that animals with white coat color usually were infested by high tick numbers followed by the animals with brown coat color, while animals with black coat color carried the lowest tick numbers and he concluded: this could be attributed to the relatively raised temperature of the host's skin environment that generated by dark coat color.

Husbandry practices are also correlated with tick abundance and distribution, in this context, mixed grazing of different animal species on the same pasture and/or mixed housing provides maximum opportunity to ticks to infest a large population at one time. In this study, prevalence of infestation was so high and highly significant in un mixed (68.9 %) this may be due to animal sheds which are made of bricks and stones with mud which provides cracks and crevices that is suitable for the nidiculous questing behavior of ticks (Soulsby, 1982).

The infestation rate in all species was higher in big herd size flocks because those animals are kept under big size could have picked up ticks from a wide range of flocks individual.

The proportion of tick infestation was higher in old and adults ages in groups categories in all species may be due to outdoor management and long distant movement of adult and old animals to search for food and water compared to younger animals, so the chance of exposure is higher.

Conclusion and recommendation

In conclusion, tick infestation was prevalent in study area, and the study showed that ticks are prevalent throughout the year indicating that they become a source of a continuous animal infestation and incriminated in transmission of disease to animals and had economic impact due to reduction in milk production and the overall prevalence of ticks infestation in domestic ruminant was higher, and the most abundance tick infestation was *Hyalomma anatolicum* and hence emergence of tropical theileriosism.

Recomidation:

- strongly investigations are needed to find out the relationship between tick infestation and presence of tick borne disease in dairy farms
- Conduct further surveys in the other states in order to accurately determine tick infesting domestic livestock throughout the country, appropriate control measures for tick need to be employed for high animal production especially for cattle.
- Study tick distribution and population dynamics in other parts of the state.
- Lastly in order to remapping tick prevalence and distribution reported by Hoogstraal (1956), large scale and systemic survey must be conducted including collection from all livestock and wildlife animals in the Sudan.

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