بسم الله الرحمن الرحيم

Sudan University of Science and Technology

College of Graduate Studies

Distribution and Risk Factors Associated with Tick Infestation in Khartoum Locality, Khartoum State, Sudan

توزيع وعوامل الخطر المرتبطة بمعدل إنتشار الإصابة بالقراد في محلية الخرطوم، ولاية الخرطوم، السودان

A Thesis submitted to the College of Graduate Studies in Partial Fulfillment of the Requirement for the Degree of Master in Preventive Veterinary Medicine (M.P.V.M)

By

Iman Ali Nesam Eldien Alrayah

B.V.Sc (2005) College of Veterinary Medicine, University of Khartoum

Supervisor:

Dr. Sara Basher Taha Mohammed

Assistant Professor of Parasitology

Department of Preventive Medicine and Public Health

College of Veterinary Medicine

Sudan University of Science and Technology

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Dedication

TO:

JOOD❤FARAH

And to all those who helped me, with all my love.

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ABSTRACT

Across sectional study was conducted between November and December in 2017 in Khartoum localities with the aim to; investigate the distribution of tick infestation, and as well as to asses possible risk factors (age, breed, sex, predilection site, coat color, herd size, housing type, raising system, removing of manure, control of tick, method of control and seasonality) that might be associated with infestation.

In total, 1158 ixodid ticks (male: 710; female 448) were collected from 140 animals including 95 cattle, 31 sheep, and 14 goats. Tick collection was carried out in four localities namely Algeraif, Alremaila, Soba project and Saig project.

About (72.9%) of total observed animals were found tick infested with a highest prevalence rate in sheep (77.4%) followed by cattle (73.7%) while the lowest prevalence rate was observed in goat (57.1%).

Based on the locality, Saig showed the highest prevalence of tick infestation (84.1%) followed by Algeraif (78.4%), Alremaila (75%), and the lowest locality was Soba project (57.4%).

The most prevalent tick's species affecting animals *Rhipicephalus eversti* (n= 560, 48.4%) followed by *Hyalomma anatolicum* (n=392, 33.8%) then *Rhipicephalus sanguineus* (n=206, 17.8%). In cattle and goats, *Rhipicephalus eversti* was the predominant species, while *Rhipicephalus sanguineus* was the predominant species in sheep.

Generally, the preferred site of ticks' attachment to infested cattle and goat was tail (63% and 51%, respectively), while ear was the preferred site in sheep (76.7%).

The analysis revealed that there was significant association ($P < 0.05$) between the tick infestation and; animal age ($P = 0.007$), animal sex ($P = 0.013$), raising type ($P = 0.000$), control of tick ($P = 0.037$), remove of manure ($P = 0.005$) and seasonality ($P = 0.000$).

In the other hand, no significant ($P > 0.05$) relation between the tick infestation and; localities ($P = 0.29$), animal breed ($P = 0.136$), coat color ($P = 0.602$), herd size ($P = 0.061$), housing type ($P = 0.427$) and the method of control ($P = 0.163$).

Research result indicated that high tick prevalence in the Khartoum localities therefore, more attention is needed to control and minimize its distribution.

ملخص

أجريت دراسة مقطعية في الفترة بين نوفمبر وديسمبر في عام 2017 في محليات الخرطوم بهدف التحقيق في توزيع الإصابة بالقراد وكذلك تقييم عوامل الخطر المحتملة (العمر , الجنس ,السلالة ,مواقع الالتصاق , لون الجلد , حجم القطيع , نوع الايواء, نظام الرعي , ازالة المخلفات, السيطرة على القراد و الطرق المستخدمة فى السيطرة اضافة الى تاثير الموسم) التي قد تترافق مع الإصابة.

تم جمع عدد 1158 قرادة (710 ذكر ,448 انثى) من 140 حيوان تشمل 95 الابقار ,31 ضان و 14 من الماعز. تم جمع القراد من عدد اربع محليات وهى الرميلة , الجريف , سوبا ومشروع سايغ للالبان.

كشفت النتائج ان حوالى 72.9% من الحيوانات كانت مصابة بالقراد وكان اعلى نسبة انتشارفى الضان (77.4%) تليها الابقار (73.7%) واقل انتشار سجل فى الماعز(57.1%) .

تم تسجيل اعلى معدل انتشار للقراد فى مشروع سايغ (84.1 %) تليها الجريف (78.4%) ثم الرميلة (75%) واخيرا مشروع سوبا (57.4%).

كشفت الدراسة عن انتشار القراد من جنس *رايبيسيفلاس ايفرساي* كنوع سائد (بعدد 560 ونسبة 48.4%), يليه نوع *الهيالوما اناتوليكم* (بعدد392 ونسبة 33.8%) ثم نوع *الرايبيسفلاس سانقوينس*(بعدد 206 ونسبة 17.8%). فى الابقار والماعز, كان القراد من جنس *رايبيسيفلاس ايفرساي* هو السائد بينما القراد من جنس *الرايبيسفلاس سانقوينس* هو السائد الضان.

بالنسبة لمكان الالتصاق فى جسم الحيوان , كان منطقة الزيل هو اكثر الاجزاء اصابة بالقراد فى الابقار والماعز (63% و 51% على التوالى) بينما منطقة الاذن هى الاكثر اصابة بالقراد فى الضان (76.7%).

في التحليل الفردي لمعرفة عوامل الخطر المتعلقة بانتشار القراد كشفت الدراسة عن وجود علاقة ذات دلالة احصائية (القيمة المعنوية اقل من 0.05) بين انتشار القراد و عمر الحيوان (القيمة المعنوية = 0.007), جنس الحيوان (القيمة المعنوية = 0.013), نظام الرعي (القيمة المعنوية = 0.000) , التحكم في القراد (القيمة المعنوية = 0.037) , ازالة المخلفات (القيمة المعنوية = 0.005) و الموسم (القيمة المعنوية = 0.000).

من جهة اخرى لا توجدعلاقة ذات دلالة احصائية بين انتشار القراد والمحلية (القيمة المعنوية= 0.29), السلالة (القيمة المعنوية =0.138), لون الجلد (القيمة المعنوية =0.602), حجم القطيع (القيمة المعنوية =0.061), نوع الايواء (القيمة المعنوية =0.427) و طرق مكافحة القراد (القيمة المعنوية=0.163) .

أشارت نتائج البحث إلى أن ارتفاع معدل انتشار القراد في مناطق الخرطوم يتطلب مزيدًا من الاهتمام للمكافحة وتقليله معدل الانتشار.

INTRODUCTION

Ticks are blood-sucking ectoparasites of mammals, birds and reptiles. More than 800 tick species have been found throughout the world (Barker and Murrell, 2004). They even existed when dinosaurs and primitive birds roamed the Earth. The oldest parasitic form fossil record of a tick was found in New Jersey and was dated back to the late Cretaceous more than 90 million years ago (Klompen and Grimaldi, 2001).

Ticks and tick-borne diseases are major obstacles to livestock management in many regions of the world especially in the tropics and subtropics areas (Uilenberg, 1995). Tick-borne diseases such as Theileriosis, Babesiosis, Anaplasmosis and Cowdriosis as well as a direct effect of ticks infestation, are the major health and management problems affecting the productivity of livestock in many developing countries especially in Asia, Africa and Latin America (Perry *et al.* 2002; Minjauw and McLeod, 2003; De Castro, 1997).

Sudan is one of the largest countries in African with livestock estimated to be 137 million of which 40 million are cattle, 50 million sheep, 42.5 million goats, 4 million camels and 0.5 million horses, in addition to wildlife and an unknown number of donkeys, dogs and cats (Abdallah, 2007).

Numbers of tick species have been reported in Sudan. They mainly belongs to the genera *Amblyomma, Boophilus, Hyalomma* and *Rhipicephalus* (Hoogstraal, 1956).

In Sudan, ticks and tick-borne diseases are widespread and constitute substantial constraints to the development of meat and milk production (El Hussein *et al*., 2004). According to Gamal and El Hussein (2003) ticks are transmit a number of diseases to indigenous and exotic cattle in Sudan and cause a large economic losses in productivity. They mainly transmitted Theileria, Babesia, Anaplasma, and Cowdria spp, which are considered as a restrictive factor of the international movement of animals (Cahn and Line, 2005).

The prevalence and the distribution of ticks have not been studied extensively in Khartoum State. Moreover, the factors could be associated with this distribution have not been studied.

The main objectives of this study were to:

1/ Identify ticks species which are distributed in Khartoum region (Khartoum and Gabal awliya localities).

2/ Estimate the prevalence of ticks in Khartoum region (Khartoum and Gabal awliya localities).

3/ Determine the possible risk factors associated with the distribution of Ixodid ticks.

CHAPTER ONE

Literature Review

1.1 Biology of ticks:

Ticks are ectoparasitic arthropods, which have jointed legs, a segmented body, and a chitinous exoskeleton. They belong to the class of Arachnids. Ticks are classified into the subclass Acari, which include three families; Argasidae (soft ticks, 186 species), Ixodidae (hard ticks, 692 species) and Nuttalliellidae (monotypic) (Nava *et al*., 2009).

1.2 Taxonomy of ixodid ticks:

Phylum: Arthropoda

Class: Arachnida (Atif *et al*., 2012).

Subclass: Acari (Atif *et al*., 2012).

Order: Ixodida (Atif *et al*., 2012).

Family (1): Argasidae (Atif *et al*., 2012).

Genera: Argas, Ornithodoros and Otobius (Horak *et al*, 2002)

Family (2): Ixodidae (Atif *et al*., 2012).

Genera: The major ones are Rhipicephalus (Boophilus), Amblyomma, Dermacentor, Hyalomma, Haemaphysalis, Ixodes, Margaropus and Rhipicentor. (Horak *et al*., 2002)

Family (3): Nuttalliellidae (Horak *et al*., 2002)

1.3 Morphology of ticks:

Tick body is comprised of three major segments: capitulum, idiosoma (body), and legs. Capitulum includes chelicerae, palps, and hypostome.

Ventral side of the hypostome is covered by rows of recurred teeth that help to penetrate the epidermis of the host during blood feeding. Idiosoma contains legs, genital pore, and internal organs. Adults and nymphs had four pairs of legs, while larvae had only three pairs.

In hard ticks of the family Ixodidae, dorsal side in adults is covered by scutum. In female ticks, scutum covers the anterior third of the dorsal side, while in males the scutum it extends over the entire dorsum of the idiosome (Sonenshine and Roe, 2014).

1.4 The life cycle of ticks

Ticks are hematophagous parasites have a wide range of host including animals, man, reptiles and birds (Hoogstraal, 1956). Generally, ticks are not very specific host, although some species may show a particular preferable host or definite adaptation to certain hosts (Soulsby, 1982).

Ticks start feeding on their hosts, the period of feeding var from several days to weeks, according to some factors such as host type, stage of tick, and ticks species. Female of hard tick has a cuticle, which grows during feeding to accommodate the large volume of ingested blood, which in adult ticks may expand from 200 to 600 times compare with unfed adult female ticks (Sonenshine, 1991).

After feeding, the female secretes one or more types of pheromones, which attract males (FAO, 1984). After engorgement, the female drops off to the ground and lays eggs between 100 -20,000 eggs according to the tick species and then dies (Soulsby, 1982). On the other hand, males continue attachment to the hosts for a longer time and may mate with other females.

Following hatching, immature stages (larvae and then nymphs) detach from their hosts after each blood meal before molting to the next stage during few days until cuticular changes occur.

Classification of the tick life cycle, according to the number of hosts:

1.4.1 One host ticks:

Ticks spend all three developmental stages; larva, nymph and adult engorge on the same host. *Rhipicephalus (Boophilus) decoloratus* and *Rhipicephalus (Boophilus) annulatus* are an example of arcades take place on the same host (Walker *et al*., 2003).

1.4.2 Two host ticks:

The larvae and the nymph engorge on the same host and drop to the ground to molt. The adult feeds on a second host. An example of two host tick is *Rhipicephalus evertsi evertsi* and *Hyalomma rufipes* (Kettle, 1995).

1.4.3 Three host ticks:

Ticks require three hosts for every developmental stage, which drops off the host after engorging and then molts on the ground: e.g. Ixodes ricinus and *Amblyomma spp* (Soulsby, 1982).

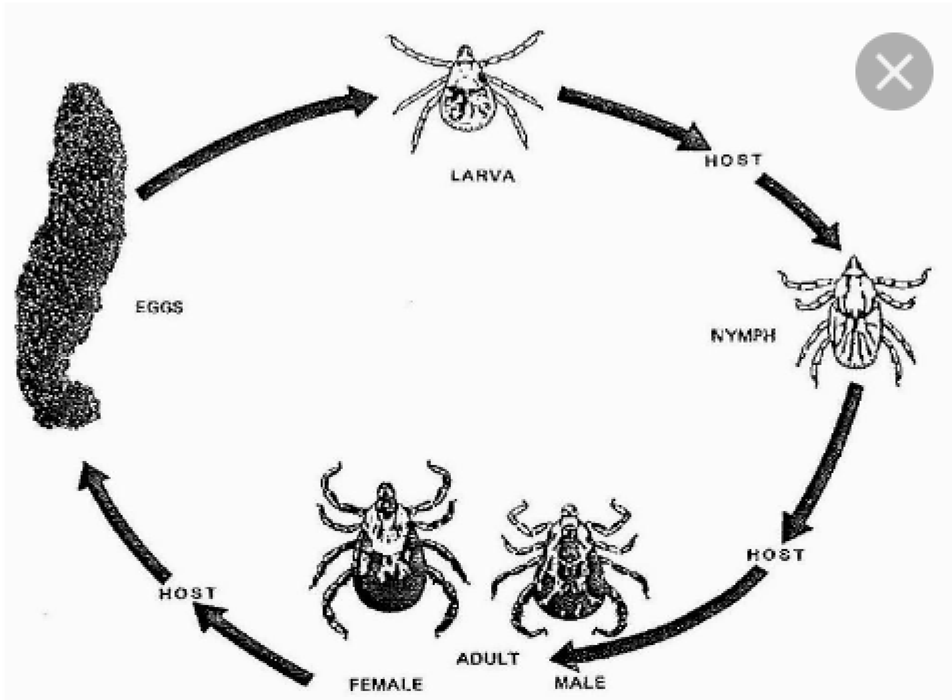

Figure 1: Live Cycle of Tick

1.5 Ecology and Epidemiology of tick:

Approximately 850 tick species have been described worldwide, particularly in tropical and subtropical countries. However, any species of tick prefer specific types of macro and microclimates (Soulsby, 1982). Ticks distribution is influenced by a variety of environmental factors such as temperature, relative humidity and rainfall, availability of the host, susceptibility of the host, vegetation type and host grazing behaviour (Tatchell and Easton, 1986).

1.5.1 Vegetation:

Reduction in vegetation may decrease the tick population (Osman and Hassan, 2003). As vegetation prevents ticks from the adverse situation by providing it with an optimum humidity (Hassan, 2003).

1.5.2 Temperature:

Each species of ticks survive at a range of temperature and it has a critical temperature, which varies within different species. For example, the critical temperature for Ixodes spp. is 32°C while it is 45°C for *Hyalomma spp.* (Hoogstraal, 1956). High temperatures increase mortality rates and reduce fertility. Moreover, high temperatures inhibit host-seeking activity, which could indirectly increase tick mortality rates by reducing host finding success (Rebecca *et al*., 2017).

1.5.3 Humidity and rainfall:

Tick distribution influenced by the rainfall, and humidity of the soil and air. Unfed tick can restore its water deficit by absorption of atmospheric water, while the engorged tick obtains water from the ingested blood meal (Hoogstraal, 1956). Therefore, low humidity is lethal for ticks, and they need humidity in which they can re-hydrate (Rebecca *et al.*, 2017).

As an example, *Hyalomma dromedarii* presents in areas with an rainfall below 250 mm annually and may be found in desert and semi-desert areas, while *Amblyomma variegatum* is present in areas with annual rainfall of 400-700 mm (Hoogstraal, 1956).

The effect of the rainfall on tick infestation was investigated at Kyle Recreational Park in Zimbabwe (Mooring *et al.*, 1994*).* They found that the duration of the feeding of the *Rhipicephalus appendiculatus* during the wet season was 2-3 times more than another season. Estrada–Pena (2001) found that the seasonal effects had also an important influence on the transmission dynamic of tick-borne pathogens.

1.5.4 Availability and susceptibility of the host:

The availability of vertebrate hosts is a major determinant of the occurrence of ticks and tick-borne zoonoses in natural and anthropogenic ecosystems (Tim *et al*., 2017). On the other hand, the host immune status considers as another factor as any decrease in immunity plays an important role in tick infestation through decreased antibody production and phagocytosis so that leading to heavier tick infestation (Nelson, 1984).

1.6 Tick borne diseases (TBD):

Ticks transmit a greater diversity of viral, bacterial, and protozoan diseases than any other arthropod vector on earth. Tick-borne diseases are widely distributed throughout the world, particularly in the tropics and subtropics areas. They represent an important proportion of all animal diseases affecting the livelihood of poor farmers in developing countries (Minjauw and McLeod 2003; De Castro 1997). Although ticks are transmitted a number of diseases, some of them economically is considered as the most important.

1.6.1 Heartwater:

Is a tick-borne rickettsial disease of domestic and wild ruminants and caused by *Cowdria ruminantium*. The disease is transmitted by ticks of the genus *Amblyomma* and widespread in sub-Saharan region (Camus *et al*., 1996; Semu *et al*., 2001; Ilemobade; 1991). In Sudan, Heartwater was reported in Blue Nile State, Eastern and western Sudan which is transmitted by *Amblyomma variegatum* and *Amblyomma lepidum* respectively (Karrar, 1960; Jongejan *et al*., 1984; Abdel Wahab *et al*., 1998)

1.6.2 Anaplasmosis:

Is a disease caused by *Anaplasma spp* and transmitted mainly by *Boophilus* (Blood *et al*.1990). The disease can be also transmitted by other species of ticks (Bram *et al*.1983). Anaplasmosis affects both domestic and wild ruminants and it is widespread throughout the tropic region (Wanduragla and Ristic, 1993). In Sudan, *Anaplasma marginale* and *A. centrale* were reported in cattle (Abdallah, 1984), whereas A. marginale was regularly observed in the blood smear of healthy cattle in the Blue and White Nile State (Jongejan *et al*., 1987). Moreover, the prevalence of Anaplasmosis was estimated to be 11.6% in Khartoum State using IFA test (Suleiman and Elmalik, 2003).

1.6.3 Babesiosis:

Babesiosis is a protozoan parasitic disease caused by *Babesia spp* and transmitted by ticks of the genus *Boophilus* The disease is widespread throughout the tropics and subtropical areas, and causing heavy losses especially in non-resistant animals (Soulsby, 1982).

1.6.4 Theileriosis:

Theileriosis is considering as one of the most important tick-borne diseases of cattle, which transmitted by the genera of *Rhipicephalus, Hyalomma and Amblyomma.* Theileriosis is caused by the species of Theileria; *T. parva*, causes East Coast fever (ECF), while *T. annulata* causes tropical theileriosis, (Norval *et al*., 1992; Irvin, 1985). Since the beginning of the last century, Theileriosis was reported in Sudan, (Abdallah, 2007). It is causes high mortality rate especially in calves, exotic and crosses breeds (Latif and Shawgi, 1982)

1.7 The economic impact of tick-borne diseases

Tick-borne diseases consider as important restrictions factors to successful animal production. They cause high morbidity and mortality rate, decreased in meat and milk production (Ilemobade, 1991). Mukhebi estimated that the annual losses due to *T. parva* in Central and East Africa are about US$ 168 million per year (Mukhebi *et al*., 1992). In addition, the cost of control and restrictions on animal movements (Norval *et al* .,1991). Moreover, the annual cost of chemical acaricides per head was estimated to be US$ 963 in Zimbabwe (Pegram *et al*., 1996).

Generally, tick infestation causes local irritation, which results in wounds. These wounds play as a predisposing factor to infect by blowflies, screwworms, and bacterial (Soulsby, 1982). Feeding of Amblyomma species on the udder is predisposed to mastitis and teat damages which result in a significant high loss in milk yield (Hassan, 1997).

Ticks cause a direct blood loss to their hosts due to their blood-sucking habits. A single adult female can suck between 0.5–2.0 mL of blood and several thousand ticks can cause daily blood loss of several hundred millilitres (Rechav *et al*., 1994). On the other hand, ticks transmit a wide variety of pathogenic agents than any other group of arthropods such as babasiosis, anaplasmosis, theileriosis, heartwater, Q. fever, Rocky Mountain spotted fever, Taularaemia, Relapsing fever and Louping ill (Oliver, 1989; Anon, 1979).

1.8 Ticks in Sudan:

1.8.1 Distribution of the tick in Sudan:

In Sudan, there are more than 70 species of ticks (Anon, 2005). *Hyalomma anatolicum, Hyalomma excavatum, Hyalomma dromedarii,* *Hyalomma impeltatum, Hyalomma rufipes, Hyalomma truncatum, Rhipicephalus eversti evertsi, Rhipicephalus sanguineus, Rhipicephalus praetextatus, Rhipicephalus (Boophilus) decoloratus* and *Amblyomma lepidum* were observed on domestic animals in Kassala State (Karrar *et al.*, 1963).

Whereas in Southern Kordofan, *Amblyomma lepidum, Amblyomma variegatum, Boophilus decoloratus, Boophilus annulatus, Hyalomma rufipes, Hyalomma truncatum, Rhipicephalus and Haemaphysalis spp* were identified (Sowar 2002).

Osman reported that *Hyalomma impeltatum* was the most common tick of sheep in the arid area in Kordofan (Osman *et al*.,1982). While in Khartoum State the presence of *Hyalomma anatolicum, Hyalomma truncatum, Boophilus decoloratus, and Rhipicephalus sanguineus* was documented by (Latif *et al*. (1994).

ElImam (1999) found that *Hyalomma impeltatum* was the most dominant species of tick in Kosti province, while the most predominant species of ticks in Sennar State is *Rhipiciphalus guilhoni* according to Suliman (2004).

Later, Abdalla (2007) confirmed that some other species of tick such as *Amblyomma lepidum* has spread from eastern parts of the Sudan to Darfur State as well as *Hyalomma anatolicum,* which has established in Darfur state.

Rhipicephalus camicasi, Rhipicephalus bergeoni, Rhipicephalus guilhoni, Rhipicephalus turanicus, Rhipicephalu sturanicus and *Rhipicephalus guilhoni* were also identified in a different part of Sudan (Jongejan *et al*., 1987).

1.8.2 The economic impact of tick in Sudan:

Livestock in Sudan is estimated to be 30 million of cattle, 37 million of sheep, 33 million of goats and 3 million of camels. About 80% of the livestock population consider as a traditional sector (Anon 2005). These population effects by ticks and tick borne diseases, which is causes high mortalities rate in Sudan especially cattle (FAO, 1983). In addition, tropical theileriosis and malignant ovine theileriosis are reported as the main restrictive of animal production improvement in Sudan (Latif and Shawgi, 1982; Imam, 1995).

1.9 Control:

In order to achieve proper control of any tick species, enough information about ecological and biological behaviour of ticks must be available. This includes life cycle, population dynamics and host-seeking behaviour (King *et al*., 1988)

1.9.1 Physical Control

Modification of the environment may decrease the population of the ticks (Wall and Shearer, 2001). For example, increasing the sunlight and lower humidity reduce the suitability of ectoparasites habitats (Kirby, 2004). Moreover, grazing practices such as pasture spelling reduce the tick–host contact, which in turn reduce the ticks' population (Wall and Sheare, 2001). Enhancing of quarantine biosecurity measures with restricted animal movement are strongly recommended in order to control the tick infestation (Vorster and Mapham, 2012).

1.9.2 Biological Control:

Birds especially chickens consider the most important predators animal, which picks ticks from cattle (Hassan *et al*., 1991). Some opportunistic predators such as toads, snakes, rodents and lizards play also a role in tick control (Mwangi *et al*., 1997). According to Wall and Sheare (2001), there are other organisms can be used as biological controls such as parasites, competitors and pathogens of the ectoparasite.

1.9.3 Chemical Control:

The acaricidal treatment considers a most effective method to reduce production losses from tick infestation and tick-borne diseases according to Walker (2014). The direct application of acaricides considers the most widely used method for the effective control of ticks by using the following options which described by Minjauw and McLeod (2003) and George *et al.*, 2004):

i. Dip-tanks.
ii. Spray races.
iii. Hand-spray
iv. Pour-ones and spot-ones.
v. Hand-dressing.

George *et al.,* 2004) and Minjauw (2003) were classified acaricide into groups (organophosphates, carbamates , pyrethroids and amidines).

There are some side effects of using acaricides, such as high direct costs, an increase of tick resistant, the risk of jeopardize enzootic stability, the production losses due to the animals handling and to the withdrawal periods of acaricides (Abbas *et al*., 2014; Peter., 2005).

Generally, the achievement of effective control of ticks and tick borne diseases is best through a combination of tick control, prevention of disease and treatment of clinical cases (De castro 1997).

CHAPTER TWO

Materials and Methods

2.1 Study area:

Khartoum city is located in the middle of the populated area in Sudan at the confluence of the White Nile and the Blue Nile, between latitude 15–16° north and longitude 31–32° east .

The state is bordered by Aljazeera state to the south, River Nile state to the north, Algadarif state to the east and Kordofan North state to the west.

Generally, Khartoum has an arid climate. The annual mean temperature in Khartoum is 37.1 and the average annual rainfall is 135 mm (Figure 1**):**

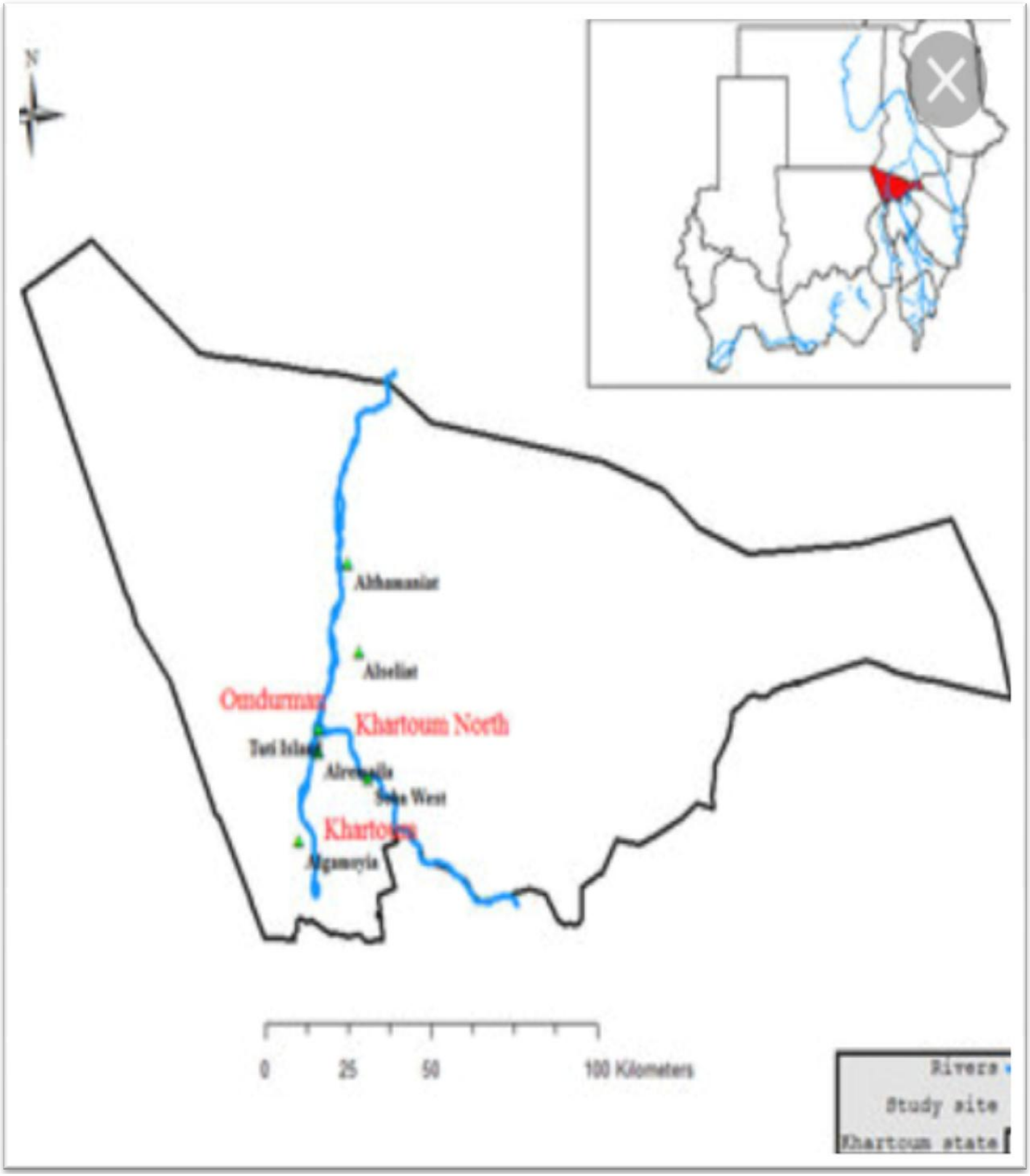

Figure 2:Study area, Khartoum State

2.2 Study design and sample size:

A cross-sectional study was conducted from November to December 2017 in Khartoum city to investigate the prevalence of tick infestation in livestock and to determinethe risk factors could be associated with the tick infestation.

The sample size was calculated according to the formula described by Thrusfield (2005):

$$\mathbf{n} = (\mathbf{1.96})^{\mathbf{2}}\mathbf{.\ Pexp\ (1\text{-}Pexp)}/\boldsymbol{d}^{\mathbf{2}}$$

n= sample size

P_{exp} = expected prevalence. The expected prevalence of ticks infestation was assumed to be 50%

d = desired absolute precision (d=0.05)

Tick specimens were collected from four districts (Algeraif, Alremaila, Soba Agricultural Project, Saiyg Dairy project). Ticks were counted and collected from 140 animals; including 95 cattle, 31 sheep and 14 goats.

2.3 Tick collection:

Total body ticks were collected using a blunt steel forceps (Soulsby, 1982). They were transferred into a tube containing 70% ethanol. Each tube was labelled with a unique sample ID including the district, animal number, animal species and the predilection site (tail, udder, ear, knee, brisket, testes).

2.4 Investigation of risk factors:

Data regarding the characteristics of the individual animal (age, sex, breed and coat colour), management factors (racing type, control of tick, removing of manure, herd size, housing type and methods of control) and seasonality were obtained and recorded in a questionnaire.

2.5 Tick identification:

The collected ticks were transported to Central Laboratory for Veterinary Researches - Ministry of animal resources and fisheries and identified under a dissecting microscope according to the methods described by Walker (Walker et al., 2003)

2.6 Statistical analysis:

The collected data were analyzed using the statistical package for Social Science (SPSS version 24). The Chi-squared and logistic regression tests were used to assess the significant association between the selected risk factors and tick infestation. If the p-value is less than 0.05, the analysis will be considered statistically significant.

CHAPTER THREE

Results

3.1 Prevalence of tick infestation in relation to districts

Among different localities, Saiyg showed the highest prevalence of tick infestation (84.1%) followed by Algeraif (78.4%), Alremaila (75%), and the lowest district was Soba project (57.4%). There were no significant differences among the districts was observed (P = 0.29) (**Table 1**).

Table 1: Prevalence of tick infestation in relation to districts

District	Examined	Infested (%)	X	p-value
Alremaila	12	9 (75%)	9.050	0.29
Algeraif	37	29 (78.4%)		
Soba	47	27 (57.4%)		
Saig	44	37 (84.1%)		

3.2 Prevalence of tick infestation in relation to animal species:

A total of 140 ruminants (95 cattle, 31 sheep and 14 goats) were examined on 20 livestock farms. The overall prevalence of tick infestation was found to be 72.9% (102 out of 140). The highest prevalence of tick infestation was observed in sheep 77.4% (24 out of 31), followed by cattle 73.7% (70 out of 95) and the lowest prevalence was reported in goat 57.1% (8 out of 14) (**Table 2**). No significant difference (P =0.349) was observed between different animal species.

Table 2: Prevalence of tick infestation in relation to animal species

Animal species	Examined	Infested (%)	X	p-value
Cattle	95	70 (73.7%)	2.107	.349
Sheep	31	24 (77.4%)		
Goat	14	8 (57.1%)		
Total	140	102 (72.9%)		

3.3 Tick species:

In total, 1158 ixodid ticks (male: 710; female 448) were collected from 140 animal. They belonged to three species. *Rhipicephalus evertsi* (n= 560, 48.4%), which was the most common species, followed by *Hayalomma anatolicum* (n=392, 33.8%), and *Rhipicephalus sanguineus* (n=206, 17.8%)(Table 3).

Table 3: The prevalence of the tick species and their sex

Tick species	Total No of tick	Sex	
		Male (%)	**Female (%)**
Hyalomma anatolicum	392 (33.8%)	234 (59.7%)	158 (40.3%)
Rhipicephalus eversti	560 (48.4%)	346 (61.8%)	214 (38.2%)
Rhipicephalus sanguineus	206 (17.8%)	130 (63.1%)	76 (36.9%)
Total	1158	710 (61.3%)	448 (38.7%)

3.4 Distribution of tick in different animal species:

3.4.1 Cattle:

In total, 897 ixodid ticks were collected from cattle, the predominant tick species was *Rhipicephaus evertsi* 54.6% (490/897) followed by *Hayalomma anatolicum* 42.5% (381/897) and *Rhipicephalus sanguineus* 2.9% (26/897) (Table 4(a)).

3.4.2 Sheep

In total, 210 ixodid ticks were collected from sheep, the predominant tick species was *Rhipicephalus sanguineus* 74.8% (157/210) followed by *Rhipiciphalus evertsi* 20.9% (44/210) and the lower tick infestation was *Hayalomma anatolicum* 4.3% (9/210) (Table 4(a)).

3.4.3 Goat

In total, 51 ixodid ticks were collected from goat, the predominant tick species was *Rhipicephalus evertsi* 50.98% (26/51) followed by *Rhipicephalus sanguineus* 45.09% (23/51) and *Hayalomma anatolicum* 3.9% (2/51) (Table 4(a)).

Table 4 (a): Distribution of tick infestation in different animal species

Animals	**Total No of tick**	**Distribution of ticks/species**		
		Hayalomma Anatolicum	**Rhipicephalus eversti**	**Rhipicephalus sanguineus**
Cattle	897	381	490	26
Sheep	210	9	44	157
Goat	51	2	26	23
	1158	392	560	206

Among all tike species, we observed that the prevalence of male ticks was higher than female ticks (Table 4(b)).

Table 4(b): Distribution of tick infestation/ sex in different animal species

Animals	Tick species	No of ticks		
		Total	Male	Female
Cattle	Hayalomm Anatolicum	381	225 (59%)	156 (41%)
	Rhipicephalus evertsi	490	297(60.6%)	193 (39.4%)
	Rhipicephalus sanguineus	26	14 (53.8%)	12 (46.2%)
Sheep	Hayalomma Anatolicum	9	8 (88.9%)	1 (11.1%)
	Rhipicephalus evertsi	44	32 (72.7%)	12 (27.3%)
	Rhipicephalus sanguineus	157	98 (62.4%)	59 (37.6%)
Goat	Hayalomma Anatolicum	2	1 (50%)	1 (50%)
	Rhipicephalus evertsi	26	17 (65.4%)	9 (34.6%)
	Rhipicephalus sanguineus	23	18 (78.3%)	5 (21.7%)

3.5 Predilection sites of tick infestation:

In cattle, the most infested part was tail (n=565) followed by udder (n=305), ear (n=10), Brisket (n=7) and knee and testes (n= 5 of each). Meanwhile, in sheep the most infested parts were the ear (n=161) followed by the tail (n=46), udder (n=2) and brisket (n=1).

In goat, the tail was the highest infested part (n=26) followed by ear (n=21) and udder and brisket (n=2 of each) (Table 5).

Table 5: Distribution rate (%) of ticks' infestation in different body parts of examined animals.

Body part	Animal Species		
	Cattle	**Sheep**	**Goat**
Udder	305 (34%)	2 (.9%)	2 (4%)
Tail	565 (63%)	46 (21.9%)	26 (51%)
Ear	10 (1.1%)	161 (76.7%)	21 (41%)
Brisket	7 (0.8%)	1 (.5%)	2 (4%)
Knee	5 (0.55%)	-	-
Testes	5 (0.55%)	-	-
	897	210	51

Generally, the predilection sites of *Hayalomma anatolicum* were tail, udder, brisket, knee, testes and ear. While the predilection sites of *Rhipicephalus evertsi* were tail, udder, knee, ear and brisket. For *Rhipicephalus sanguineus*, the predilection sites were tail, udder, ear and brisket (Table 6 (a)).

Table 6 (a): Distribution of tick species in relation to the predilection sites

Host	Tick spp	Predilection sites
Cattle	Hayalomma anatolicum	Tail, udder, brisket, knee, testes.
	Rhipicephalus evertsi	Tail, udder, knee, ear.
	Rhipicephalus sanguineus	Tail, udder, ear
Sheep	Hayalomma anatolicum	Tail, udder, ear
	Rhipicephalus evertsi	Tail
	Rhipicephalus sanguineus	Tail, ear, brisket
Goat	Hayalomma anatolicum	Tail
	Rhipicephalus evertsi	Tail, udder, brisket
	Rhipicephalus sanguineus	Udder, ear

The Chi-squared reveled that there was a significant relation between the tick infestation and predication site whereas the highest infested part was tail (Table 6 (b)).

Table 6 (b): Chi-squared analysis of predilection site of tick infestation in 140 examined animal.

Predilection site	No of animal(%)	X	P
Udder	4 (3.9%)	140	.000
Tail	32 (31.4%)		
Ear	18 (17.6%)		
Udder +tail	26 (25.5%)		
Udder +brisket	1 (1%)		
Tail +ear	10 (9.8%)		
Tail +brisket	1 (1%)		
Tail +testes	2 (2%)		
Udder+tail+ear	2 (2%)		
Udder+tail +brisket	1 (1%)		
Udder +tail+knee	2(2%)		
Udder+ear+Brisket	1(1%)		
Tail + ear +brisket	1(1%)		
Udder + tail +ear + knee	1(1%)		
Total	**102**		

3.6 Prevalence of tick infestation in relation to the host characteristics (age, breed, sex and coat colour)

The animals were classified into three age groups, young animal(< 2 years in cattle and < 6 months in sheep and goat), adult (2-5years in cattle and 6 months - 3 years in sheep and goat) and old animal (> 5 years in cattle and > 3 years in sheep and goat). The results revealed that tick infestations were significantly higher (p=0.007) in old animal (85.7%) 30

compared with the adult animal (83.7%) and young animal (60.9%). Moreover, the infestation rate was significantly higher (P=.013) in female (79.2%) compared with male (59.1%) (**Table 7**).

Although the tick infestation was higher in the local breed (81.4%) than crossbreed (69.1%), this different was statistical not significant (P=.138). Similarly, the coat colour had also no influence on the tick infestation

(P=.602), where the prevalence was higher in black followed by mix colour, white and brown (80%, 75.8%, 71.4% and 65.7% respectively) (**Table 7**).

Table 7: The effect of host characteristics in the prevalence of tick infestation

Risk factor	Examined	Infested (%)	X	p-value
Animal age				
Young	69	42 (60.9%)	9.921	0.007
Adult	43	36 (83.7%)		
Old	28	24 (85.7%)		
Animal sex				
Male	44	26 (59.1%)	6.149	.013
Female	96	76 (79.2%)		
Animal breed				
Local	43	35 (81.4%)	2.288	.138
Cross	97	67 (69.1%)		
Coat colour				
White	42	30 (71.4%)	1.861	.602
Black	30	24 (80%)		
Brown	35	23 (65.7%)		
Mix color	33	25 (75.8%)		

3.7 Prevalence of tick infestation in relation to management factors (herd size, housing type, racing type, control of tick and the method of control).

Table (8) revealed that tick infestations significantly differed in relation to the racing type (P=.000), apply control measures of tick (P=.037) and the frequency of removing the manure. As infestation rate was significantly higher in one species system (87.3%) than mix species system (58%). Moreover, the infestation rate was higher in the farm did not apply any control measures for tick (88.9%) than farm apply control measures for tick (69%). Infestation rate was also significantly higher in the farm removing the manure once per month

(88.6%) compared with the farm removing the manure once every two weeks (73.9%), and the farm removing the manure once per week (61.2%).

The herd size was classified into 3 categories; small size (1-50 animal), medium size (51 -100) and large size (101 – 150). Although the herd size has no influence on the tick infestation (P= 0.061), the prevalence of tick infestation was highest in medium herd size (83%) compared with the large herd size (77.8%) and small herd size (63.6%). Similarly, there was no significant variation in the tick infestation between housing types (P = 0.427), where the highest prevalence of tick infestation was reported in semi-close house (75.7%), followed by a close house (69.7%) (Table 8).

Regarding the method of control, there was no significant difference in the prevalence of the tick infestation in relation to the methods using to control ticks (P= 0.163). Whereas the highest infestation was observed in the farm using both natural and acaricide method (80%) followed by farm using only acaricide (68.7%), and farm using natural predators only (65%).

Table 8: The effect of management factors in the prevalence of tick infestation

Risk factor	Examined	Infested (%)	X	p-value
Racing type				
One	71	62 (87.3%)	15.25	.000
Mix	69	40 (58%)		
Control of tick				
No	27	24 (88.9%)	4.348	.037
Yes	113	78 (69%)		
Remove of manure				
Weekly	67	41 (61.2%)	10.42	.005
Two week	23	17 (73.9%)		
Monthly	50	44(88%)		
Herd size				
Small	66	24 (63.6%)	5.603	.061
Medium	47	39 (83%)		
Large	27	21 (77.8%)		
Housing type				
Close	66	46 (69.7%)	.631	.427
Semi close	74	56 (75.7%)		
Method of control				
Acaricide	83	57 (68.7%)	5.126	.163
Natural	20	13 (65%)		
Both	10	8 (80%)		

3.8 Prevalence of tick infestation in relation to season

As shown in table (9), there was significant variation (p=0.00) in the prevalence of tick infestation between summer, and autumn, where the prevalence of tick infestation was higher during summer (85.7%) than autumn (47.9%).

Table 9: The effect of the season in the prevalence of tick infestation

Risk factor	Examined	Infested (%)	X	p-value
Season				
Autumn	48	23 (47.9%)	22.99	.000
Summer	63	54 (85.7%)		

3.9 logistic regression

The logistic regression test showed that there was a significant relation between the tick infestation and animal age, racing type, control of tick removing of manure and season table (10).

Table 10: Multivariate logistic regression analysis of the risk factors

Factor	B	Sig	Exp B	95% C.I. for Exp(B)	
Animal age		.035		**Lower**	**Upper**
Animal age (1)	-1.632-	.016	.196	.052	.739
Animal age (2)	-1.384-	.071	.251	.056	1.126
Animal sex (1)	.081	.892	1.084	.337	3.490
Racing type (1)	1.284	.081	3.612	.855	15.265
Control of tick (1)	1.763	.062	5.828	.915	37.124
Remove of manure		.495			
Remove of manure (1)	-.213-	.748	.808	.219	2.978
Remove of manure (2)	-.950-	.239	.387	.080	1.879
Season		.003			
Season (1)	-2.197-	.000	.111	.034	.361
Season (2)	-1.614-	.054	.199	.038	1.030
Season (3)	-1.584-	.0257	.205	.013	3.167
Constant	-1.134-	.143	.322		

CHAPTER FOUR

Discussion

Although in the present study, the difference in the prevalence of tick infestation among the districts was not significant. Saiyg Dairy Project showed the highest prevalence rate (84.1%) followed by Algeraif (78.4%), Alremaila (75%), and Soba Agricultural Project (57. 4%). This result in agreement with(Guma *et al*.,2015) who found that El Jabalain district in White Nile state has the highest mean of ticks burden followed by Kosti , El Gezira Aba, Rabak, El Getaina, Kenana and the lowest prevalence was found in El Dowaim district. This variation is referring to the environmental factor such as such climate (Estrada-Pena., 2009)

In the present study three species were collected from cattle, *Rhipicephalus evertsi* (54.63%), which is the predominant one, *Hyalomma anatolicum* (42.5%) and *Rhipiciphalus sanguineus* (2.6%). This result is in line with previous work conducted by Mohamed *et al*., (1998) who was collected *Hyalomma spp* and ticks of the *Rhipiciphalus* group from exotic cattle in Khartoum State. Moreover, Sajid (2007) reported that cattle were infested with *Hyalomma anatolicum* and *Rhipcephalus Sanguineus* in Pakistan. On the other hand, our result is disagreement with the study performed by Ahmed, who did not identify *H. anatolicum* (Ahmed *et al*., 2012).

In sheep, the predominant tick species was *Rhipicephalus sanguineus* (74.8%) followed by *Rhipiciphalus evertsi* (20.9%) and *Hayalomma anatolicum* (4.3%). This finding is in agreement with Osman (1999) who collected *Hayalomma anatolicum, Rhipicephalus evertsi evertsi* and

Rhipicephalus sanguineus from sheep in the farm of Khartoum University. Taha (2000) also reported a similar finding, whereas *Rhipicephalus* species were collected from sheep. In contrary, Khan *et al*., (1993) were recorded the highest prevalence of *Hyalomma anatolicum* (15%), followed by *Rhipicephalus sanguineous* (4%) and *Boophilus microplus* (3.3%) in sheep in Faisalabad, Pakistan.

In the present study, *Rhipicephalus evertsi* was the predominant tick species in goat (50.98%) followed by *Rhipicephalus sanguineus* (45.09%) and *Hayalomma anatolicum* (4%). This result is in disagreement with Sajid *et al.* (2008) who found that the prevalence of *Hyalomma anatolicum* in goats was higher (42.7%) than *Rhipicephalus spp*. (37.6%).

Generally, the predominant tick species in this study was *Rhipicephalus evertsi,* which is similar to the results of Walker *et al*. (2000) who reported that *Rhipicephalus evertsi evertsi* can be widely present in the area with average annual rainfall between 1200 mm and 2600 mm.

Generally, the variation in the tick species among the area and also between the animal species was affected by many factors such as geographical and claimed condition and availability of the host (Tatchell and Easton, 1986).

In the current study, the majority of collected ticks were males (61. 3%) followed by females (38.7%). Another plausible found that the number of tick males more than tick females (Suad, 2009). This is due to that males are remaining for a long period on the host than females (Solomon *et al.,* 2001).

In this study, we observed that the predilection sites of tick infestation on their hosts were tail, udder, ear, brisket, testes and knee. This is in agreement with work conducted by Atif who found that the most infested sites were perineum, udder and external genitalia (Atif *et al.,* 2012). This finding is possibly due to the fact that the attachment of the tick depends on the temperature and the sickness of the skin and the easiness for ticks to engorge blood for feeding. Other factors such as density and season may play also a role in the determination of the attachment site (Seyoum., 2005; Kettle *et al.*, 1995).

The statistical analysis was revealed a significant association between age and tick infestation (P=0.007) whereas young animals were infested lower than adult and old. This result is in agreement with previous studies conducted by Yakhchali and Hasanzadehzarza. They are reported that the highest tick infestation rate in adults animals compared with young (Yakhchali and Hasanzadehzarza, 2004). This could be due to the fact that older animals were exposure to tick for long period compared with the young animal (Tadesse *et al.*, 2012).

Based on the breed, the tick infestation was higher in the local breed (81.4%) than crossbreed (69.1%). This is in agreement with previous work where they observed the higher prevalence rate of tick infestation in local breed (44.96%) than cross breeds (15.83%) (Belew and Mekonnen (2011). In contrary, Tessema was observed the higher prevalence of tick infestation in cross breed than local breeds (Tessema and Gashaw (2010). This variation might be due to a high infestation rate which was observed in the local breed of sheep in the current study.

The Chi-square result showed a significant association between the prevalence of tick infestation and animal sex (P=0.013) whereas female had a higher prevalence than male. Gedilu *et al*., (2014) reported a similar finding where the tick prevalence was higher in females (76.7%) than males (70.2%). Male animals are used mainly for draught and breeding purposes throughout the year, and for meat production. Therefore, they receive more attention, like frequent grooming including the manual removal of ticks, which would result in low tick burdens (Rehman *et al*., 2017).

In the current study, there is no significant difference in the prevalence of tick infestation between animals according to the coat colour. This might be due to high infestation in local sheep and goats in the study. The obtained result was opposite with that reported by Guma, Hassan and Mohammed, who found that the coat colour had a significant influence in the prevalence of the tick infestation (Guma et al., 2015; Hassan, 1997; Mohammed and Hassan, 2007).

Husbandry practices are also affected in tick abundance, in this study the racing type had significantly influence (P=0.000) in the prevalence of tick infestation, whereas the prevalence was higher in one species farm (87.3%) than mix farm (58%). Moreover, the prevalence in the farm that did not use control measures was higher (88.9%) in comparison with farms use control measures (69%) (P=0.037). The result was in coinciding with that reported by Bedada (2014) found that the overall prevalence of tick in the uncontrolled area was significantly higher than the controlled area in Ethiopia. In addition, the frequency of manure removing had a significant influence in the prevalence of tick infestation (P=0.005). It is well known that the tick has a free-living stage on the ground, which becomes more susceptible to many factors such as acaricidal treatment hygiene measure, which in turn reduce the population of the tick.

Although there is a variation in the prevalence of tick infestation among the herd size, this variation was statistically not significant. In contrast, Below found that the higher prevalence of ticks in cattle kept under extensive production system (45.40%) than a prevalence on cattle kept under semiintensive farming system (10.06%) (Below *et al*., 2011). These differences might be due to variations in the other management processes on the farm.

In the present study, the prevalence of tick was higher in semi-close system (75.7%) compare with close system (69.7%). This might be due to the movement of animals from one place to another and picked up the ticks from another contact animal. This explanation was confirmed by Cumming (2009) and Abdalla *et al*., (2010). They were reported that animal movement from one zone to another resulting in tick introduction into a new ecosystem. Furthermore, Rehman *et al*., (2017) observed the higher tick prevalence in farms that adopted grazing practice than these farms adopted stall feeding system.

Although there was no significant relation between the tick prevalence and the method used to control the tick (P=0.163), the prevalence of tick was higher in farm apply both method of tick control (acaricide and natural) than farm applies only one method. It is clear when we apply two different strategies to control an organism the achievement will become better (FAO, 1983). In addition, the effects of natural predators especially chicken in tick control were confirmed in different studies (Hassan *et al*., 1991; Hassan, Dipeolu and Munyinyi, 1992; Dreyer, Fourie and Kok, 1997).

The effect of seasonality in the prevalence of tick infestation showed that there is a significant increase in the tick infestation during summer (85.7%) than autumn (47.9%). This observation is in agreement with the previous report, which showed that the prevalence was significantly higher during the summer season compared with winter and wet season (Rony *et al.*, 2010). In contrast, Stuti *et al*., (2008) and Sanjay *et al.*, (2007) showed that the animals were infested with ticks during the rainy season more than summer and winter. Climate variations by season or geographical location influence the spread of tick. The pattern of the tick infection is not expected to be similar in arid or semi-arid regions and in high rainfall savannah, because the biology of tick and their different developmental stages is greatly promoted or demoted by ambient temperature and relative humidity (shuaib *et al.*, 2015).

CONCLUSION

The objectives of this study were to investigate the tick infestation and the risk factors could be associated with in Khartoum localities. The study revealed that the highest tick infestation was observed in sheep, followed by cattle and the lowest infestation was reported in goat.

Also result revealed that three tick species was founded during this study *Rhipicephalus evertsi* was the most common species, followed by *Hayalomma anatolicum* and *Rhipicephalus sanguineus*.

The analysis revealed that there was a significant association between the tick infestation and animal age, animal sex, raising type, control of tick, remove of manure and season.

RECOMMENDATIONS

1. Study tick infestation and risk factors associated with it in another seasons and states to accurately determine tick infesting domestic livestock throughout the country.
2. Need to labouring proper control measures for high animal production especially dairy cattle and goat.

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Appendix

The overall prevalence of tick infestation in different farms

During this study, 20 livestock farms were investigated (cattle farm, sheep farm, goat farm and mixed). The overall prevalence of tick infestation was found to be 90.3%. The highest prevalence was observed in sheep farms (100%), followed by cattle farms (90%) and the lowest prevalence was reported in goat farms (75%) (Table).

Table: Prevalence of tick infestation in different farms

	Cattle	**Sheep**	**goat**	**Total**
No of infested farm (%)	18 (90%)	7 (100%)	3 (75%)	28 (90.3%)
No of non-infested farm (%)	2 (10%)	0 (0%)	1 (25%)	3 (9.7%)
Total	20	7	4	31