بسم الله الرحمن الرحيم

SUDAN UNIVERSITY OF SCIENCE AND TECHNOLOGY

College of Graduate Studies

Prevalence and Risk Factors of Tick Infestation in Cattle in River Nile State, Sudan

معدل إنتشار القراد في الأبقار وعوامل الخطرالمرتبطة به بولاية نـهر النيل – السودان

A thesis submitted for partial fulfillment of the requirements of the Master degree in Preventive Veterinary Medicine (MPVM)

By

Hanadi Ahmed Alriah

B.V.Sc. (2003)

University of Khartoum

Supervisor:

Dr. Naglaa Abd El Hakeem Abass

March 2021

DEDICATION

To the soul of my father

To my mother

To my husband

To my sisters

To my brothers

To all who help me in my life.

ACKNOWLEDGEMENTS

First thanks to Almighty Allah for giving me the ability to complete this work. I would like to express my gratitude and appreciation to my supervisor **Dr. Naglaa Abd El Hakeem Abass** for her advices, directions and continuous support.

I would like to thank **Dr. Sara Basher Taha** and **Dr. Limia Alhag Mubarak** for their support in initiating the whole tick project. My thanks extended also to **Prof. Ahmed El Ghali**. for his help in tick identification, and to my colleagues **Iman Ali**,**Hala Ahmed Ibrahim**, **Hiba Khalid** and **Tagreed Mohammed**, who helped me in tick collection period. Also I would like to thank **Dr. Leila Amin** for her help in designing the map of the study area.

I am very grateful to the Ministry of Agriculture, Animal Resources and Irrigation – River Nile State, especially **Dr.Alsaid Mohammed Altaher f**or facilitating my work during the study.

I would like to express my sincere thanks and grateful acknowledgement to my husband **Osman Ahmed**, for his support and encouragement throughout the work. Finally, I would like to thank my mother, sisters and brothers for their support. My appreciation is extended to all who helped me in this study.

ABSTRACT

Ticks are important ectoparasites especially in tropical and subtropical areas, cause direct and indirect damages to animals and leading to great economic losses. Tick and tick-borne diseases are widespread in the Sudan and constitute a major obstacle to livestock production.

In order to determine the prevalence of Ixodid ticks in cattle and to identify the major risk factors for the occurrence of tick infestation in River Nile State, a cross-sectional study was conducted from July to November, 2018 in five localities: Shendi, Al Matama, Eldammar, Atbara and Barber using multistage sampling method. A total of 355 cattle were randomly selected; they were of both sexes, their ages were less than 2 and above 5 years old, different breeds, and they are kept under open, closed and semi closed systems. To identify the potential risk factors associated with tick prevalence, a pretested questionnaire was used and the data of host characteristics (age, sex, breed, coat color, predilection site, and herd size) and farm-related information (location, housing, rearing system, feeding, hygiene and tick control) were recorded.

Out of the 355 examined cattle, 224 were infested. The overall prevalence of tick infestation was found to be (63.1%). In univariate analysis using Chi-square test, the difference in the prevalence of tick infestation was found to be statistically significant between the age groups (x^2 =25.941; *P*= 0.000), sex groups (x^2 =24.185; *P* = 0.000), types of housing (x^2 =17.131; *P* = 0 .000), keeping cattle with or without tick control (x^2 = 46.910; *P* = 0.000), The applied tick control method (x^2 = 50.059; *P* = 0.000) and removing of manure (x^2 = 32.926; *P* = 0.000). However, the difference was not significant between: locality, breed, coat color and herd size groups, and the other factors: raising cattle with other

animal species, feeding type and temporal distribution of ticks throughout the year (P>0.05).

A total of 2,018 ticks were collected during the investigation period including 1148 males (56.9%) and 870 females (43.1%). Two tick genera and six species were identified. *Hyalomma anatolicum* was the dominant tick species 1565 (77.6%), followed by *Rhipicephalus evertsi evertsi* 275 (13.6%), *Rhipicephalus sanguineous* 139 (6.9%), *Rhipicephalus praetextatus* 35 (1.7%), *Hyalomma rufipes* 2 (0.1%) *and Hyalomma truncatum* 2 (0.1%).

One hundred and fifteen cattle were infested in the tail (51.3%), followed by 30 cattle infested in the udder (13.4%), 14 were infested in the ear (6.25%), 7 were found infested in the brisket (3.12%), 4 were infested in the knee (1.8%), 2 were infested in testes (0.9%) and finally only 1 cattle was infested in eye (0.4%). In addition, 51 cattle (22.7%) were found infested in different sites.

The current study showed that ticks are prevalent in cattle in River Nile State where tick-borne diseases (TBDs) are common. Therefore an appropriate control program of ticks and TBDs in River Nile State should be designed and implemented.

ملخص

القراد من اهم الطفيليات الخارجية التي تصيب الحيوان خاصة في المناطق المدارية وشبه المدارية ولها تأثير مباشر وغير مباشر علي الحيوان مسببة خسائر إقتصادية كبيرة وهو منتشر بصورة كبيرة في السودان وينقل العديد من الأمراض التي تشكل عقبة رئيسية لمنتجات الثروة الحيوانية .

حرصا علي تحديد معدل إنتشار الإصابة بالقراد الصلب في الأبقار وتحديد عوامل الخطر المرتبطة به بولاية نهر النيل أجريت دراسة مقطعية في الفترة من يوليو 2018 حتي نوفمبر 2018 في خمسة محليات هي : شندي ، المتمة ، الدامر ، عطبرة ، بربر. وبإستخدام طريقة الجمع متعددة المراحل تم إختيار (355) من الأبقار عشوائيا من كلا الجنسين من أعمار تتراوح من أقل من عامين حتي أكثر من خمس سنوات ، ومختلف السلالات سواء كانت محفوظة في النظام المفتوح أو المغلق أو شبه المغلق .

ولتحديد عوامل الخطر المرتبطة بإنتشار القراد تم إستخدام إستبيان تم فيه جمع معلومات تتعلق بالحيوان المضيف تتمثل في : (العمر ، الجنس ، السلالة ، اللون ، مكان وجود القراد بالحيوان ، حجم القطيع) ، ومعلومات تتعلق بالمزرعة تشمل (الموقع ، نوع الأيواء ، طريقة التربية ، نوع التغذية ، إزالة المخلفات ، التحكم والمكافحة و طرق التحكم) .

وجد عدد (224) بقرة مصابة بالقراد وذلك بمعدل إنتشار يعادل (63.1%) .

وعند إجراء التحليل الأحادي لعوامل الخطر وبإستخدام مربع كاي وجد أن هناك علاقة ذات دلالة إحصائية معنوية مع مختلف الفئات العمرية (مربع كاي : 25,941 – القيمة المعنوية : 0,000) ، مجموعات الجنس (مربع كاي :24,185 – القيمة المعنوية 0,000) ، نظام الإيواء (مربع كاي :131، 17- القيمة المعنوية : 0,000) ، التحكم ومكافحة القراد (مربع كاي : 46,910 – القيمة المعنوية 0,000) ، تطبيق مختلف طرق التحكم (مربع كاي : 50,059 - القيمة المعنوية 0,000) و إزالة المخلفات (مربع كاي : 32,926 – القيمة المعنوية : 0,000) .

كما أظهرت الدراسة أنه لا توجد علاقة ذات دلالة إحصائية معنوية بين مختلف المناطق ،السلالة ، اللون وحجم القطيع ، و العوامل الأخري من تربية الأ بقار مع أنواع أخري من الحيوانات ونوع التغذية.

تم جمع عدد (2018) من القراد بها (1148) من الذكور (56,9%) وعدد (870) من الأناث (43,1 %) ، و تم تحديد جنسين وستة أنوع من القراد .

هايلوما أناتوليكم هي الأكثر إنتشارا بالمنطقة 1565 بنسبة (77,6%) ، تليها رايبيسفالس إيفرتساي إيفرتساي 275 بنسبة (13,6%) ، رايبيسفالس سانقوينيس 139 بنسبة (6,7%) ، رايبيسفالس بريتكستيتس 35 بنسبة (1,7%) وأخيرا هايلوما روفيبس 2 بنسبة (0,1%) وهايلوما ترنكاتم 2 بنسبة (0,1%) .

في وجد أن 115 من الأبقار مصابة في الذ يل (31,3%) ، يليها 30 من الأبقار مصابة الضرع (13,4%) ، 14مصابة في الأذن (6,25%) ، 7مصابة في الصدر (3,12%) ،4 مصابة في الأرجل (الركبة) (1,8%) ، 2 مصابة في الخصيتين (0,9%) ، وأخيراً واحدة من الأبقار مصابة في العين (0,4%) . بالإضافة لذلك 51 من الأبقار وجدت مصابة في عدة أماكن في نفس الوقت (22,7%)

وعندما تم إجراء التحليل المتعدد للعوامل المرتبطة بانتشار الإصابة لم تتبين أي علاقة معنوية بينها وبين إنتشار القراد .

هذه الدراسة توصلت إلي أن الإصابة بالقراد في الأبقار منتشرة بمعدلات عالية في المنطقة، مما يؤدي إلي انتشار الأمراض المنقولة بالقراد . لذلك لا بد من تصميم وتنفيذ البرامج المناسبة للتحكم في القراد .

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INTRODUCTION

Ticks are blood sucking parasites that widespread in most parts of the world (Jongejan and Uilenberg, 2004). Tick infestation causes economic losses especially in tropical and sub tropical regions either directly through tick bite, blood loss, damage to the hides and udder and injection of toxins, or indirectly by transmission a wide range of pathogens including zoonotic pathogens (Zhou *et al*., 2009).

Tick infestation is the major health and management problem affecting productivity of livestock in many developing countries (De Castro, 1997). The most commonly known tick-borne diseases (TBDs) are; Theileriosis (tropical theileriosis and malignant ovine theileriosis) , babesiosis, anaplasmosis, cowdriosis, and avian spirochaetosis ,(El Hussein *et al*,. 2002) .

Sudan is the largest African country with an estimated of 31,223 million of cattle, 40,846 million of sheep, 31,837 million goats, 4 million camels and 0.5 million horses, in addition to wildlife and an unknown number of donkeys, dogs and cats (MOAR , 2019).

Total of 63 tick species have been identified in the Sudan, which mainly belong to the genera *Hyalomma*, *Rhipicephalus* and *Amblyomma* (Hoogstraal, 1956; Salih *et al*., 2004). Tick and Tick-borne diseases are wide spread in the Sudan and the economically most important TBDs are theileriosis, babesiosis, ehrlichiosis (heart water) and anaplasmosis (El Ghali and Hassan, 2009).

It is important to investigate tick infestation rate as it directly limit sustainable livestock production (Sultana *et al*., 2015). Furthermore, factors including extensive animal movement, deforestation, desertification and the establishment of large mechanized agricultural schemes have certainly affected the distribution of ticks and tick-borne diseases in the Sudan (Salih *et al*., 2004). A sufficient numbers of published data is available on tick species identified in the country but only few studies were addressed tick infestation prevalence. Within Khartoum State, Ali (2019), Elrayah (2019) and Ibrahim (2020) reported that the prevalence of tick infesting cattle was 71.2%, 73.7% and 92.3% in Omdurman, Khartoum and Khartoum North localities, respectively.

Data about tick prevalence in any specific area is essential for the planning of control measure towards ticks and tick borne diseases.

Objectives:

1. To estimate the tick prevalence among cattle in River Nile State
2. To identify the potential risk factors associated with tick infestation prevalence in cattle in the study area.

CHAPTER I

LITERATURE REVIEW

1.1 Taxonomy

Ticks are members of the phylum Arthropoda, class Arachnida, subclass Acari, order Parasitiformes, suborder Ixodida which comprises three families; Ixodidae (hard ticks), Argasidae (soft ticks) and Nuttallillidae (Sonenshine, 1991). There are approximately 850 species had been described worldwide, from which the family Ixodidae contains more than 650 species and 13 genera (de La Fuente and Kocan, 2006).

The family Ixodidae is characterized by the presence of a tough sclerotised plate on the dorsal body surface, the scutum. The scutum covers the entire dorsal body surface in males and only the one third of the dorsal body region in females, nymphs and larvae. Soft ticks belong to the family Argasidae, lack this scutum, and they characterized by a tough leathery integument (Walker *et al*., 2003).

1.2 Ecology

Ticks affected by the environmental factors like macroclimate components; temperature, relative humidity and rain. Longevity of host seeking . Both high rates of water loss or heat stress are possibly lead to the rapid death of ticks at high temperature (Tukahrwa, 1976; Utech *et al*., 1983). Additional factors such as host density, host susceptibility, vegetation type and host grazing behavior are affected tick regulation and distribution (Tatchell and Easton, 1986).

1.3 Ticks infesting animal worldwide

Ticks are most numerous parasites throughout the world, particularly in tropical and sub-tropical regions, approximately 850 species have been described worldwide (Furman and Loomis, 1984). Each species of tick is adapted to certain macro and microclimates, some ticks occurring only in warm regions with a fair degree of humidity, while others are most active in dry climates (Soulsby, 1982).

According to Punyua *et al*., (1991), the distribution of certain species of ticks is restricted to specific ecological zones. In Africa, ten genera of ticks; three are argasids and seven are ixodids, are commonly infest domestic animals (Walker *et al*., 2003). The main ticks found in Ethiopia belong to the genus *Amblyomma, Boophilus, Haemaphysalis, Hyalomma* and *Rhipicephalus* (Desalegn *et al*., 2015; Ahmed *et al*., 2017).The genus *Dermacentor* is reported in domestic animals in Americas, Europe and Asia and *Dermacentor marginatus* is found on cattle in North Africa (Walker *et al*., 2003).

In Asia, *Rhipicephalus bursa, R. turanicus, R. sanguineus, Hyalomma marginatum, H. anatolicum excavatum, Boophilus annulatus, Haemaphysalis parva, Hae. sulcata, Hae . otophila, and Dermacentor niveus* have been reported in the Kayseri region of Turkey (Ica *et al*., 2007). *Hyalomma anatolicum*, *Rhipicephalus microplus, H. dromedarii* and *R. turanicus* were reported infesting ruminants in Punjab Province, Pakistan (Rehman *et al*., 2017). In addition, *Hyalomma anatolicum anatolicum* was observed on Cattle, Buffaloes, Sheep and Goats of Azad Kashmir (Sultana *et al*., 2015).

1.4 Ticks infesting animal in the Sudan

In the Sudan and South Sudan , a total of 72 tick species have been identified (Hassan and Salih, 2013). Ticks infesting livestock in the Sudan are mainly *Hyalomma anatolicum anatolicum, Hyalomma dromedarii, Hyalomma marginatum rufipes, Hyalomma impressum, Hyalomma impeltatum, Hyalomma truncatum, Rhipicephalus evertsi evertsi, Rhipicephalus sanguineus* group, *Rhipicephalus simus* group, *Rhipicephalus appendiculatus, Rhipicephalus Boophilus decoloratus, Rhipicephalus Boophilus annulatus , Amblyomma lepidum* and *Amblyomma variegatum* (Salih *et al*., 2004). Hassan and Salih (2013) described that animal movement either for trade, nomadism, or migration due to civil unrest, habitat modification such as deforestation, large-scale mechanized cultivation, urbanization, drought and desertification, and global climate change were factors that determine the dynamic changes of tick distribution within the country.

The most significant tick species which infested cattle in the Sudan is *Hyalomma anatolicum*, the vector of *Theileria annulata* and *T. lestoquardi*, the causative agents of tropical theileriosis in cattle and malignant theileriosis in sheep, respectively (Alhaj and Hamid, 2003; Salih *et al*., 2005).

In northern provinces of Sudan, Hoogstraal (1956) identified *Amblyomma exornatum*, *Hyalomma dromedarii*, *Hyalomma excavatum*, *Hyalomma impeltatum*, *Hyalomma impressum*, *Hyalomma marginatum*, *Hyalomma scupense* (= *Hyalomma detritum*), *Hyalomma rufipes*, *Hyalomma truncatum*, *Rhipicephalus evertsi evertsi*, *Rhipicephalus praetextatus* and *Rhipicephalus sanguineus*. Karrar *et al*., (1963) reported that *Hyalomma anatolicum* was the predominant tick species in northern and central parts, while *Amblyomma lepidum* is the most common tick species in eastern parts of the country from Torit and Kapoeta in the south to Kassala in the north. Furthermore, the tick species that infest domestic animals in Kassala, Eastern Sudan, were *A. lepidum, H. anatolicum, H. excavatum, H. dromedarii, H. impeltatum, H. rufipes, H. truncatum, Rhipicephalus evertsi evertsi, R .s .sanguineus, R. praetextatus* and *B. decoloratus* (Osman and Hassan, 2003). . In Southern Darfour, ticks reported on cattle were *H.truncatum, H. rufipes, H. impeltatum*, *B. annulatus*, *R. sanguineus sanguineous*, *R. longus*, *R. evertsi evertsi*, *R. simus* and *R. praetxtautus* (Osman, 1978). Osman *et al.*, (1982) found that the most common ticks in Kordofan were *H. rufipes* and *H. impeltatum*. Salih *et al*., (2004) collected *Hyalomma anatolicum* from cattle and *H. dromedarii* from Shendi, Atbara, Eldammar and Barber, as well as *Rhipicephalus* (*Boophilus*) *decoloratus*, *H. impeltatum*, *H. truncatum*, *H. rufipes*, *R. evertsi evertsi*, *R. praetextatus* and ticks belonging to the *R. sanguineus* group from several localities. Similarly, in River Nile State, Ahmed *et al*., (2005) reported that 74% of the ticks feeding on sheep were *H. anatolicum*, 15% were *R. praetextatus*, 9% were *R. sanguineus* group, 2% were *R. evertsi evertsi* and 0.5% were *H. dromedarii*. The predominant tick species feeding on horses in Atbara were *H. anatolicum* (92%) together with *H. dromedarii*, *R. evertsi evertsi* and *R. sanguineus* (Salim, 2008). In the same area, the species composition of ticks feeding on camels were *H. dromedarii* (89%), *H. impeltatum* (7.7%), *H. anatolicum* (3.3%), *H. truncatum* (0.29%), *H. rufipes* (0.25%), *R. praetextatus* (0.30%) and *R. sanguineus* group (0.09%) , (El Ghali and Hassan 2012).

1.5 Life cycle of ticks

Most ticks go through four life stages: the embryonated egg, the larva, nymph and the adult, and the phenotypic difference between males and females is evident only in the adult stage. The development in soft tick species is gradual, with multiple nymphal stages before reaching the adult form (multi-host life cycle), while in the Ixodidae (hard tick species), the development is accelerated, with only one nymphal stage (Latif and Walker, 2004).

Ticks may require more than one host during their life cycle, and accordingly, ticks are classified into three groups.

One host tick, in this group, some tick species prefer to feed on the same host during all life stages such as *Rhipicephalus* spp. (Walker *et al*., 2003). Two host life cycle; the larvae and nymphs feed on the same individual host, while the adults will feed on another host such as *Hyalomma detritum detritum*, *Rhipicephalus evertsi evertsi* and *Hyalomma rufipes* (Kettle, 1995). Finally, three host life cycle; here the ticks need a new host at each stage of their life. Larvae feed once on a host, then drop off from the host and hide in sites such as soil or vegetation before moult to nymphs. Then nymphs attach another host and fed then detach from the host and moult to either female or male such as *Amblyomma* spp. and *Rhipicephalus appendiculatus* (Soulsby, 1982).

1.6 Economic importance of ticks

Ticks are the most important livestock pest that parasitize a wide range of mammals, birds and reptiles throughout the world, cause great economic losses to livestock and have adverse effects on livestock in several ways (Snelson, 1975). In addition, they transmit a wide variety of pathogenic agents than any other group of arthropods (Oliver, 1989).

Ticks generate direct effects in livestock such as irritation due to ticks' bite, damage hides and skins due to the attachment to the host, which is lead to ulceration and sometimes secondary bacterial infection. Ticks feeding cause weight loss and anaemia among domestic animals, especially when they are in large numbers. Moreover, heavy infestation of ticks can also cause severe dermatitis as well as reduction in milk production and weight gain in cattle (FAO, 1983; L´Hostis and Seegers, 2002; Peter *et al*., 2005).

Non-specific symptoms like toxicosis and paralysis are also reported as consequences of tick infestation, as some tick species are capable of releasing toxins in the host while feeding, and affected animal either may die or the paralysis may have relieved quickly if the ticks are removed (Gothe and Neitz, 1991). Tick paralysis is most commonly occurring in late winter and spring when the adult ticks are active, but it can occur at any time if the weather is warm and humid (Stewart and De Vos, 1984). Furthermore, ticks are active vector in disease transmission from host to host during blood sucking (FAO, 1984).

1.7 Risk factors associated with the tick prevalence

Risk factors associated with tick prevalence in specific area have direct impact on the epidemiology of TBDs. Identification of such host and environmental risk factors are essential for the planning of control strategies for ticks and TBDs (Abdul Rehman *et al.,* 2017)**.**

As regards to host characteristics, Hassan (1997) found that tick load of the host was correlated with host coat colour; cattle with white coat colour carried significantly more tick than brown hosts, while black hosts carried the least number of ticks. Latif (1984) assessed the status of three breeds of cattle to natural and artificial tick infestation, and he found that the indigenous *Bos indicus* cattle, Kenana and Butana were able to limit natural *H. anatolicum* and *Rhipicephalus evertsi evertsi* population.

Nutritional status of the animal plays an important role in tick distribution and infestation, as any nutritional deficiency will result in decrease in immunity through decrease phagocytosis and antibody production so leading to heavier tick infestation (Nelson, 1984).

Many previous studies investigated the prevalence of the tick fauna and associated risk factors in numerous part of the world. Host factors like age, sex, breed, animal species, body condition and coat colour were considered as well as different environmental factors like geographical location, housing system, husbandry practices, existence of tick control programme and season. Sultana *et al*., (2015) concluded that age, sex, and season are the risk factors for tick distribution. Likewise, in a survey among domestic ruminants of Haramaya District, Ethiopia, Desalegn *et al*., (2015) reported significant statistical difference in the prevalence of tick infestation between species and age. From Punjab, Pakistan, Abdul Rehman *et al*., (2017) stated that animal species, gender, age, breed, the absence of rural poultry, not performing acaricide treatments, traditional rural housing systems and grazing were important characteristics that determined the intensity of tick infestation.

1.8 Tick–borne diseases in the Sudan

As ticks and tick-borne diseases are wide spread in the Sudan, tick-borne diseases are considered a major health problem and constant threat to the development of animal production in the country (Osman, 1992).

1.8.1 Theileriosis

Theileriosis is a group of diseases that caused by members of species in the genus *Theileria*. (Losos, 1986a) (Ali *et al*., 2017) .The disease is considered as an obstacle in animal improvement worldwide particularly in tropical and subtropical countries (Hashemi- Fesharki, 1998). Six *Theileria* species have been reported in the Sudan; *T. parva, T. annulata* , *T. mutans, T. lestoquardi* , *T. velifera* and *T. ovis* (FAO, 1983). Salih et *al*., (2009) reported that the highest seroprevalence of *T. annulata* was in Atbara and Eldammar, Northern Sudan.

Bovine tropical theileriosis, is an infectious, virulent, non-contagious disease caused by *T. annulata* that transmitted by several *Hyalomma* species (Robinson, 1982). The disease causes severe economic losses due to mortality, drop of milk production, abortion and sometimes infertility and cost of anti-Theileria drugs as well as cost of prevention and control measurements (Latif, 1994).

Elhussein *et al*., (2004) described the Malignant Ovine Theileriosis (MOT) as an important emerging cause of morbidity and mortality among sheep in the Sudan. *Theileria lestoquardi* antibodies were detected from sheep grazing areas. In addition, Hammad, (2009) found *Theileria lestoquardi* in North Darfur State.

1.8.2 Babesiosis

Babesiosis is tick-borne disease caused by *Babesia* species and transmitted by species of *Rhipicephalus Boophilus, Dermacentror, Haemaphysalis, Ixodes,* and *Rhipicephalus* (Kettle, 1995). Babesia infection occurs in domestic animals including cattle, sheep, goats, horses, dogs, cats, and pigs. The disease is very common in small ruminants (Theodoropoulos *et al*., 2006). This disease threatens around half a billion cattle across the world (Saad *et al*., 2015). The infection causes severe economic losses to sheep farmers in tropical and sub-tropical regions (Phillip and Peter, 2015).

In the Sudan, important *Babesia* spp. of cattle are transmitted by *Boophilus decoloratus* and *Boophilus annulatus* (Abdalla, 1984). *Babesia bovis* and *B. bigemena* in cattle and *B. caballi* in equines, *B. motasi* in sheep have been reported from various regions of the Sudan (El Hussein *et al*., 2004).

1.8.3 Anaplasmosis

This is caused by a rickettsial bacterium, usually *Anaplasma centrale* or *A. marginale*, which infect red blood cells and a severe anaemia may be caused. Transmission is by ticks of many species particularly R. *Boophilus* and this involves development within the tick. Anaplasma can also be transmitted mechanically by biting flies and contaminated needles (Uilenberg, 1983) (Atif , 2015)

In the Sudan *Anaplasma marginale* and *A. centrale* were diagnosed in cattle. However though, bovine anaplasmosis due *to A. marginale* was reported all over the country (Elhussein *et al*., 2004), the incidence of the disease in traditionally managed cattle was very low (1.5%) in northern Sudan (Abdallah, 1984). The prevalence of *Anaplasma* spp. infection in Khartoum State was reported by Suleiman and Elmalik, (2003). Awad *et al*., (2011) reported that the prevalence of *Anaplasma marginale* in cattle in northern Sudan was 6.1%, and the highest number of *A. marginale* positive samples was reported in River Nile area.

1.8.4 Crimean-Congo hemorrhagic fever

This is caused by a virus of the same name and of the family Bunyaviridae. The disease occurs in humans and is characterized by severe hemorrhage with kidney and liver failure. The virus is transmitted by several species of ticks, commonly *Hyalomma marginatum marginatum and H. m.* rufipes (Jongejan and Uilenberg, 2004)

Multiple Crimean-Congo hemorrhagic fever (CCHF) virus lineages are circulating in the Kordofan region of Sudan and were associated with outbreaks of the disease (Aradaib, 2011). Adam *et al*., (2013) reported that the infection of CCHF was high among cattle in North Kordofan State.

1.8.5 Ehrlichiosis (heartwater)

This is caused by a rickettsial bacterium, *Ehrlichia ruminantium*. This is transmitted to sheep, goats and cattle by *Amblyomma species*, mainly *A. variegatum* and *A. hebraeum*. The bacteria multiply in the endothelial cells of blood vessels, especially in blood vessels of the brain. Acute infection causes severe oedema especially into the pericardium and brain (Latif and Walker, 2004)

A study was conducted to determine the prevalence of *Ehrlichia ruminantium* in ruminants in Al Gezirah State (central Sudan) using PCR technique. Out of 170 blood samples, a prevalence of 3.0% among sheep was recorded and no one of goats, cattle and camels was positive for *E. ruminantium* (Ibrahim *et al*., 2013).

1.9 Diagnosis of tick-borne diseases

Diagnosis of tick-borne diseases is very important for control strategies of such diseases. There are some ways for diagnosis of those diseases which includes; history, clinical signs, postmortem findings and knowledge of disease and vector distribution (OIE, 2000). Laboratory diagnosis is more accurate and confirmatory, so several techniques for detection of tick-borne diseases have been developed.

The microscopic techniques for diagnosis of tick-borne diseases are still considered as the “gold standard” technique, for example, *Theileria* spp. can be easily detected under microscope in blood smear, lymph node biopsy smear and post mortem impression smear that are stained by Giemsa´s stain (Norval *et al*., 1992).. However, the detection of piroplasms in blood smears in the absence of clinical assessment and lymph node biopsy are difficult to interpret, as piroplasms of *T. annulata*, *T. parva*, *Theileria mutans* and *T. lestoquardi* are difficult to differentiate based on the morphology (Norval *et al*., 1992). In case of Anaplasmosis and Babesiosis in cattle, the detection is based on clinical finding and identification of intra erythrocytic organisms and the most commonly used method to confirm diagnosis is Giemsa stained blood smears from cattle with clinical signs (Palmer, 1991). Usage of microscopic examination in the diagnosis of tick-borne haemoparasitic diseases has several limitations; extremely labor intensive particularly with large number of samples, trained technicians are required for accurate diagnosis and not useful when haemoparasites are morphologically similar or too small to be missed or infection is very low (Salih *et al*., 2015).

Indirect serological tests either used for detection of antibodies or antigens are also used to diagnose TBDs. The enzyme linked immune sorbent assay (ELISA) is increasingly being used for detection of parasite specific antibodies, antigens and immune complexes (Kachani *et al*., 1992). ELISA based on schizont antigen functioned well in the case that cellular fraction was enriched from the soluble fraction (Manuja *et al*., 2000). Gao *et al*., (2002) developed an ELISA for diagnosis of *Theileria* spp. infection in sheep using piroplasm antigens that were obtained from experimentally infected sheep with parasitemia, however, they found cross-reactions with *Babesia ovis.* Salih *et al*., (2005) reported that ELISA is a useful test for the diagnosis of *T. annulata* infection in cattle under field condition.

The most commonly method for diagnosis of *T. annulata* and *T. parva* is the indirect fluorescent antibody (IFA) test (Burridge, 1971; Burridge *et al*., 1974; OIE, 2004 and 2005). The test is very useful in epidemiological studies in different countries of Africa including the Sudan (FAO, 1983; Alani *et al.,* 1987). Complement fixation test (CFT) has been used for diagnosis of *Babesia, Theileria, Toxoplasma* and *Trypanosoma* (Salih *et al*., 2015).

Molecular diagnostic tools have been developed for diagnosis of tick borne diseases (Figueroa and Buening, 1995). Polymerase chain reaction test (PCR) has been used to detect *Babesia* spp. such as *B. ovis*, *B. crassa* and *B. motasi* (Almeria *et al*., 2001). All TBDs were diagnosed using PCR.

1.10 Tick control

Control strategies of ticks depend mainly on ecology, biology and epidemiology of ticks and TBDs, and all these strategies aim reduction of tick population and infestation levels on animals and prevention of transmission of diseases. Control of ticks and TBDs has started since the early twentieth century, and 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). Intervention to reduce the tick burden can be achieved by using a combination of more than one method such as chemical acaricides, rotation of pasture, natural predators and disease control by treatment of infected animals. (Chizyuka *et al*., 1990)

1.10.1 Chemical control

The use of acaricides has been a major component of integrated tick control methods. This method is represented the treatment of animals by dipping or spraying with acaricides, spraying can be performed using motorized spray-races or hand-sprays. Acaricides are often inappropriately used, have residual effects in milk and meat products, and are not environmentally friendly and being responsible for the increase of acaricide-resistant ticks (Domingos *et al.,* 2013). Furthermore, intensive and thus expensive dipping or spraying programs have been largely unsuccessful in eradicating ticks and tick-borne diseases (Jongejan and Uilenberg, 1994) (Walker 2014).

1.10.2 Ecological control

Better understanding of the ecology and behavior of tick that focus on non-parasitic phase particularly when undergoing development or host seeking. Offer the best promise for their management (Hassan, 2003). Fully engorged ticks could easily be removed by hands during milking , hand detecting has been a method of tick control practiced by farmers in West Africa (Dipeolu *et al*., 1992). Habitat modification such as reduction in bushes and vegetation may effectively reduce tick population. Similarly, prescribed burning of vegetation and heavy grazing (Norval *et al*., 1992) destroy breeding sites of ticks. Removal of manure and burning litter kill a large number of engorged ticks, larvae and nymphs found on the ground. Punyua and Hassan, (1992) demonstrated that cattle restricted from grazing a part of a day carried significantly less tick than freely grazing one.

1.10.3 Biological control

The most important predators of tick are birds specially chickens, where they found to pick ticks consistently from cattle (Hassan *et al*., 1991). When chickens existed in close to tick infested cattle there was reduction in tick load by 47% (Hassan and Odhiambo, 1996). Some opportunistic predators play a role in tick control such as toads, snakes, rodents and lizards. 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).

1.10.4 Host resistance

For many years, acquired resistance to ixodid ticks has been recognized as a possible biological control method (Trager, 1939). This acquired resistance after repeated infestations by ticks, is immunologically mediated (Allen, 1989). Acquired immunity is expressed by a reduction in the number of ticks which attach to the host, reduced engorgement weights, and reduced egg and larval production, which resulting in significantly reduced in tick populations (Willadsen, 1980). The acquisition of this type of resistance varies with the tick species and the type of breed, and between individuals, probably depending on natural selection of animals exposed to the tick in question over many generations. Jonsson *et al*. (2000) reported that the 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.

1.10.5 Tick vaccines

Tick vaccines were developed in the early 1990s; it was induced immunological protection of vertebrate hosts against tick infestations. These vaccines contained the recombinant R. (B.) microplus Bm86 gut antigen (Willadsen, 2006; De La Fuente and Kocan, 2003). Two vaccines using recombinant Bm86 were consequently registered in Latin American countries and Australia (Tick GARD) during 1993–1997 (De La Fuente *et al*., 2007). These vaccines reduce the number of engorging female ticks, their weight and reproductive capacity. Thus the greatest vaccine effect was the reduction of larval infestations in subsequent generations. After more than a decade, the two commercial tick recombinant vaccines are still being used in some countries such as Cuba, Australia and Mexico, however not worldwide due to commercial and technical constrains. These vaccines, still, when used in field trials, showed very positive results on tick and tick-borne diseases (TBD) reduction, improving cattle production and reducing dependency on acaricides. In parallel, they also showed to be a cost-effective and environmentally safe strategy, to tick control (Domingos *et al.*, 2013).

CHAPTER II

MATERIALS AND METHODS

2.1 Study area

River Nile State is one of the 18 States of Sudan, it has an area of 122,123 km² and an estimated population of 1,212,000. The State is located to the north of Khartoum State, which is the capital of the republic of Sudan. River Nile State lies between latitudes 16-22° North and longitude 30-32° East. The rainfall ranges from 25 mm in the north to 150 mm in the south and the temperature range from 8-47°C with semi desert climatic conditions.

The State is made up of seven localities; Shendi in the south of the State, Al Matama, Eddammar, Atbara, Berber , Abu Hamed and Al buhaira in the north. There are a total of 107,677 head of cattle in the area (MOAR, 2017).

2.2 Study design and sampling method

A cross-sectional study was carried out from July-November 2018 in five localities: Shendi, Al Matama, Eddammar, Atbara and Barber. These localities were purposively selected due to the presence of cattle population (Figure 2.1) and the cattle were selected randomly, using multistage sampling method.

The sample size was determined according to the formula described by Thrusfield (2007) using 50% expected prevalence and 95% level of confidence interval (CI) with 5% desired absolute precision, so 355 cattle selected .

2.3 Study population and questionnaire survey

355 cattle comprised of both sexes, all ages ranged between less than 2 and above 5 years old, different breeds including; local (Butana), pure (Friesian) and cross bred (Friesian and Butana) and cattle kept under open, closed and semi closed systems were investigated during this survey.

To identify potential risk factors associated with tick prevalence, a pretested questionnaire was used. All the information required like host characteristics (age, sex, breed, coat color, predilection site and tick infestation) and farm-related information (location, housing, rearing system, feeding, hygiene and applied tick control method) were collected.

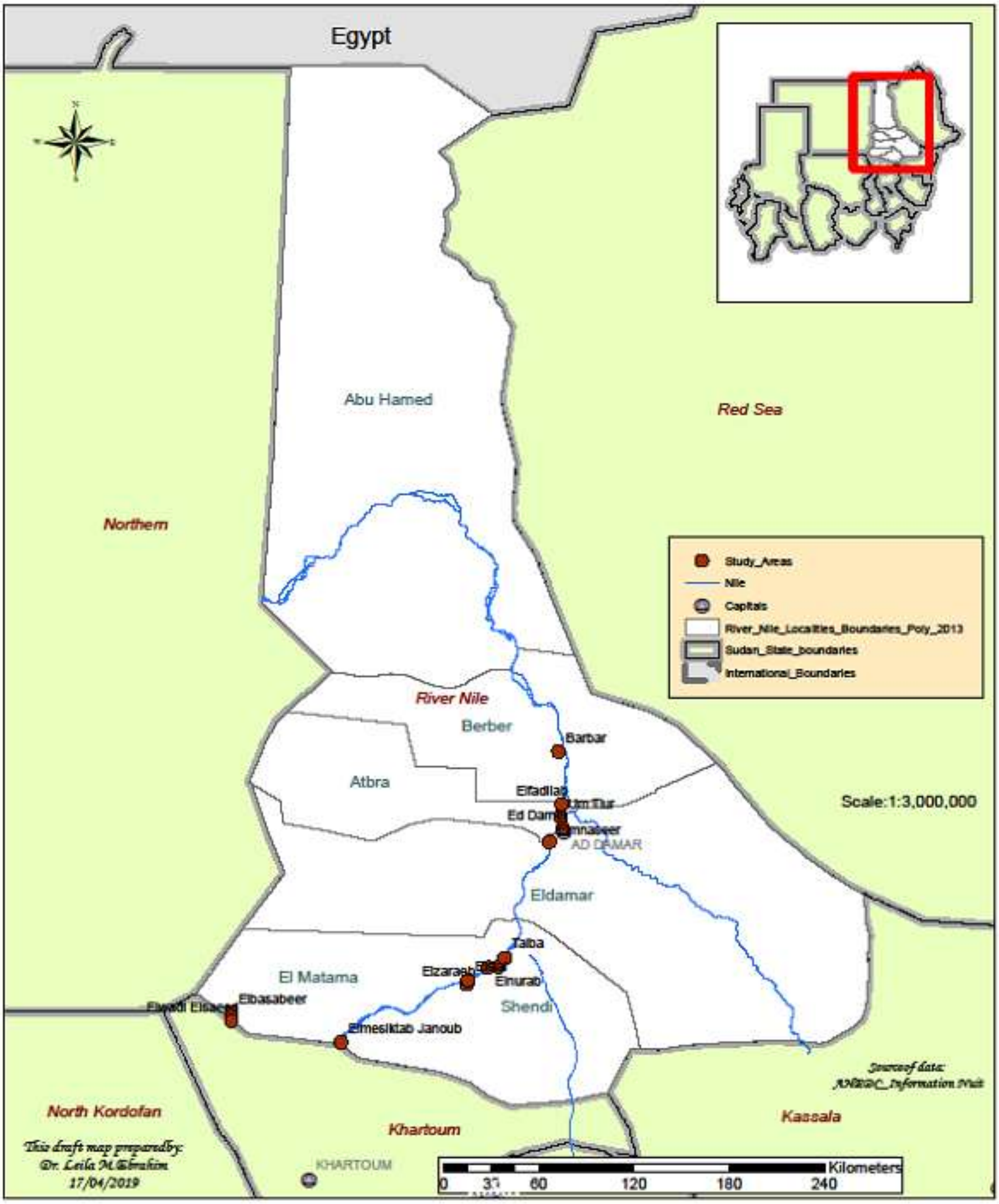

Figure 2.1: Study area-River Nile State

2.4 Collection of ticks

After the animal properly restrained, the body surface of the animal was examined thoroughly for the presence of ticks and all visible adults were collected carefully and gently from the whole of the body. Ticks were collected by using forceps, smeared around the tick to loosen attachment of the tick from the host body surface, put in clean tubes containing 70% ethanol and labeled properly with the number of cattle, date of collection and predilection site.

2.5 Identification of ticks

Under a dissecting microscope, ticks were morphological identified to the species level according to taxonomic keys described by Hoogstraal (1956) and Walker *et al*. (2003). Identification of collected ticks was conducted in the Department of ticks and ticks borne Diseases-Central Veterinary Research Laboratory in Suba, Khartoum, Sudan.

2.6 Statistical analysis

The collected data were stored in Microsoft Excel sheet and then analyzed using statistical software program for Windows (SPSS version 20).

The overall prevalence of tick was determined by dividing the number of infested animals by the total examined cattle and was expressed as percentage. Descriptive statistics were used also to calculate herd prevalence and identified ticks. Association between hypothesized risk factors and tick infestation status of the animal was determined using Chi-square test and a P-value<0.05 was considered statistically significant. Factors with P-value < 0.025 were considered in the final logistic regression model.

CHAPTER III

RESULTS

3.1 Prevalence of tick infestation

A total of 355 cattle were examined between July to November 2018 and 224 were found infested by one or more tick species. The overall corresponding percentage of infestation in cattle in the five localities of River Nile State was 63.1% (Table 3.1). The difference in the prevalence of tick infestation was found to be not statistically significant among the investigated localities within the study area (x^2 = 6.232; P = 0.182).

3.2 Risk factors analysis

In cattle >5 years old, high tick infestation rate was detected (74.8%), followed by adult cattle with 2-5 years old (68.9%), and finally young cattle with ages < 2 years old (46.7%). The result of Chi-square test showed that there was significant association between tick infestation prevalence and different age groups (x^2 =25.941; P= 0.000) (Table 3.2).

About sex factor, higher tick infestation prevalence was detected in females (70.1%) than males' cattle (40.5%) and the intensity of infestation was significantly different between two sex groups (x^2 =24.185; P = 0.000) (Table 3.2).

In terms of breed, tick infestation rate was 100%, 72.2% and 61.9%in pure, local and cross breeds, respectively. The difference in the prevalence of tick infestation was not significant among different breeds (x^2 = 2.052; P =0.358) (Table 3.2).

71.6%, 66.7%, 63.9% and 52.7% tick infestation prevalence percentages were recorded in cattle with brown, mixed, black and white coat color respectively, with no significant different among these coat colors (x^2 = 7.368; *P* = 0 .061) (Table 3.2).

Herd size was not considered as a risk factor associated with prevalence of tick infestation among examined cattle (x^2 =2.487; *P* = 0. 288) since the higher infestation rate was detected in small herds (70.5%), then medium (61.4%) and finally large ones (58.5%) (Table 3.2).

Table 3.1: An overall prevalence of tick infestation in cattle in different localities of River Nile State

Locality	**No. of examined cattle**	**No. of infested cattle**	**Prevalence %**
Shendi	136	92	67.6%
Al Matama	98	60	61.2%
Eldammar	71	37	52.1%
Atbara	21	14	66.7%
Barber	29	21	72.4%
Total	**355**	**224**	**63.1%**

Investigation of housing type showed that high infestation rate of ticks was detected in open type (62.7%), followed by semi closed (49.6%) and lastly the closed type (40.0 %). Accordingly, there was high significant association between housing type and prevalence of tick infestation (x^2 =17.131; *P* = 0 .000) (Table 3.2).

High tick load was detected in cattle raised with other animal species (70.0%) compared with those raised alone (62.0%), with no significant different among the two systems (x^2 = 1.585; *P* = 0.453) (Table 3.2).

Concerning feeding type, there was no association between the tick infestation percentage and feeding cattle either mix or roughages (x^2 = 3.591; *P* = 0.058) (Table 3.2).

High tick infestation seen among cattle kept without tick control (96.2%) compared with those kept with application of different control methods (53.8%). There was significant difference in tick prevalence between the two categories (x^2 = 46.910; *P* = 0.000). Regarding the method of tick control, owners of 55.3% of infested cattle reported acaricides use, 37.5% reported using of both acaricides and natural predators and 33.3% of infested cattle, their owners used only natural predator. Chi square test revealed association between tick infestation prevalence and different applied control methods (x^2 = 50.059; *P* = 0.000) (Table 3.2).

The cattle kept in herds where manure was not remove periodically had the highest prevalence of tick infestation (83.1%), while 63.3% was reported for cattle kept in herds practiced monthly manure removing and the least percentage (50.5%) reported among cattle kept with weekly manure removing. The Chi-square test indicated association between tick infestation prevalence and removing of manure (x^2 = 32.926; *P* = 0.000) (Table 3.2).

Table 3.2: Summary of Univariate analysis for risk factors associated with tick infestation in River Nile State, Sudan (n=355 cattle) using the Chi-square test

Risk factor	No.examined	No. infested (%)	Df	x^2	*P*-value
Age			2	25.941	0.000
Young< 2 years	135	63 (46.7%)			
Adult 2-5years	61	42 (68.9%)			
Old>5 years	159	119 (74.8%)			
Sex			1	24.185	0.000
Female	271	190 (70.1%)			
Male	84	34 (40.5%)			
Breed			2	2.052	0.358
Local	36	26 (72.2%)			
Cross	318	197 (61.9%)			
Pure	1	1 (100%)			
Coat color			3	7.368	0.061
White	93	49 (52.7%)			
Black	155	99 (63.9%)			
Brown	95	68 (71.6%)			
Mixed	12	8 (66.7%)			
Herd size			2	2.487	0.288
Small	78	55 (70.5%)			
Medium	236	145 (61.4%)			
Large	41	24 (58.5%)			
Housing type			2	17.131	0.000
closed	5	2 (40.0%)			
open	255	160 (62.7%)			
Semi closed	125	62 (49.6%)			
Raising system			1	1.585	0.453
Mixed	50	35 (70%)			
One species	305	189 (62.0%)			
Feeding type			1	3.591	0.058
Roughages	106	59 (55.7%)			
Mix	249	165 (66.3%)			
Tick control			1	46.910	0.000
Yes	277	149 (53.8%)			
No	78	75 (96.2%)			

Continue:

Control methods			3	50.059	0.000
Acaricides	255	141 (55.3%)			
Natural predator	6	2 (33.3%)			
Both	16	6 (37.5%)			
None	78	75 (96.2%)			
Removing of manure			2	32.926	0.000
Weekly	188	95 (50.5%)			
Monthly	49	31 (63.3%)			
Not periodically removed	118	98 (83.1%)			

3.3 Multivariate analysis

Multivariate analysis for potential risk factors using logistic regression was conducted including eight variables; location, housing, sex, age, coat color, control of tick, type of tick control and removing of manure. None of these factors remained significant for tick infestation prevalence. The final logistic regression model was shown in Table 3.3.

3.4Tick survey

Two tick genera and six species were identified during the survey period; *Rhipicephalus evertsi evertsi*, *Rhipicephalus praetextatus*, *Rhipicephalus sanguineus*, *Hyalomma anatolicum*, *Hyalomma rufipes*and *H. truncatum*. Overall, a total of 2,018 ticks were collected from 224 cattle including 1148 males (56.9%) and 870 females (43.1%). From the total count, *Hyalomma anatolicum* was the dominant tick species 1565 (77.6%), followed by *Rhipicephalus evertsi evertsi* 275 (13.6%), *Rhipicephalus sanguineous* 139 (6.9%), *Rhipicephalus praetextatus* 35 (1.7%), *Hyalomma rufipes 2* (0.1%) and *Hyalomma truncatum* 2 (0.1%) were the least (Table 3.4).

Referring to the collected ticks, our results indicated that there were more males than females. The male to female ratio and the predilection site for each identified species was illustrated in Table 3.4. The male to female ratio of *Hyalomma rufipes* and *Hyalomma truncatum* was not figure out because there was no any female tick identified throughout the counting.

The highest infested site was the tail 115 cattle (51.3%), 51 cattle (22.7%) were infested in different sites at the same time followed by udder 30 (13.4%), ear 14 (6.25%), brisket 7 (3.12%), knee 4 (1.8%), testes 2 (0.9%) and finally eye 1 (0.4%) (Table 3.5).

Table 3.3: Multivariate analysis of potential risk factors associated with tick infestation prevalence using logistic regression

Risk factor	Odds Ratio	P-*value	95% Confidence interval	
			Lower	Upper
Location				
Shendi (ref)				
Al Matama	0.730	0.528	0.275	1.940
Eldammar	1.069	0.886	0.429	2.664
Atbara	0.581	0.382	0.173	1.959
Barber	0.485	0.195	0.162	1.450
Housing				
Closed (ref)				
Open	0.176	0.231	0.010	3.026
Semi closed	0.335	0.418	0.024	4.715
Sex				
Female	0.673	0.318	0.309	1.465
Age				
Young (ref)				
Adult	0.385	0.021	0.171	0.867
Old	0.240	0.000	0.115	0.502
Coat color				
White (ref)				
Black	0.978	0.946	0.520	1.842
Brown	0.521	0.087	0.248	1.098
Other	0.731	0.682	0.163	3.272
Control				
Yes(ref)	0.044	0.000	0.012	0.159
Type of control				
Acaricides (ref)				
Natural predators	0.969	0.961	0.273	3.435
Remove of manure				
Weekly (ref)				
Monthly	0.729	0.515	0.281	1.890
Not periodically	0.570	0.294	0.199	1.631

Table 3.4: Overall prevalence of different tick species and their distribution in different predilection sites in examined cattle

Tick species	No. of ticks	Male	Female	Male to female ratio	Predilection sites
Hyalomma anatolicum	1565 (77.6%)	876 (56.0%)	689 (44.0%)	1.3:1	Tail- udder- ear-wither-brisket-knee-eye- testes
Rhipicephalus evertsi evertsi	275 (13.6%)	168 (61.1%)	107 (38.9%)	1.6:1	Tail- udder- ear
Rhipicephalus sanguineous	139 (6.9%)	81 (58.3%)	58 (41.7%)	1.4:1	Tail- udder-ear-wither-brisket-knee-eye
Rhipicephalus praetextatus	35 (1.7%)	19 (54.3%)	16 (45.7%)	1.2:1	Tail- udder-ear-eye
Hyalomma rufipes	2 (0.1%)	2 (100%)	0 (0%)	-	Tail
Hyalomma truncatum	2 (0.1%)	2 (100%)	0 (0%)	-	Tail- udder
Total	2,018	1148 (56.9%)	870 (43.1%)		

Table 3.5: Distribution rate (%) of tick infestation in different predilection sites of examined cattle

Predilection site	No .of Cattle	Percentage (%)
Ear	14	6.25
Brisket	7	3.12
Knee	4	1.8
Udder	30	13.4
Testes	2	0.9
Tail	115	51.3
Eye	1	0.4
Mix	51	22.7
Wither	-	-

CHAPTER IV

DISCUSSION

The important of ticks refer to their substantial economic impact in product and productivity which result from transmission of tick-borne diseases, blood loss which result in severe anemia, loss of production, weakness and immune suppression (Arthur 1962) (Ghosh *et al*., 2007)

Three hundred and fifty-five cattle were examined in 5 localities of River Nile State, where 224 (63.1%) of which were infested by one or more tick species. As far as we know, few previous studies were conducted in the country to determine the tick prevalence among livestock and to identify potential risk factors associated with high tick infestation and earlier reports were only focused on identifying tick species from different areas. Ali (2019) reported that the prevalence of tick fauna in cattle in Omdurman Locality-Khartoum State was 71.2%, while Elrayah (2019) reported 73.7% among the same species in Khartoum locality. In addition, Ibrahim (2020) informed that the prevalence of tick infestation in cattle in Khartoum North was (93.3%).

In our study we observed lower prevalence compared with previous studies from Khartoum State.

Jelalu *et al*., (2016) and Ramadan *et al*., (2016)reported that the prevalence of hard ticks infesting cattle were 75.5%and 6.17% in Arbegona district in south Ethiopia , and Qalyobia governorate in Egypt, respectively. This variation in tick prevalence from different areas could be attributed to differences in environment related factors that affect tick survival like temperature, humidity, rainfall and vegetation, and differences in husbandry practices including tick control plans (Estrada-Pena., 2009)

The present study revealed that tick infestation prevalence is increased by age as74.8%, 68.9% and 46.7% were recorded for cattle >5 years old, adult cattle with 2-5 years old and cattle with ages < 2 years old, respectively. This is in agreement with Rehman *et al*., (2017), who described a significantly lower tick burden in calves as compared to older animals. This result disagrees with Latif *et al*., (1991) who found that no difference between numbers of ticks carried by yearling calves (12-18 months old) and older cattle, this finding is probably associated with low immunity and resistance of older animals.

Tick infestation prevalence was also affected by sex; as higher infestation rate was detected in females (70.1%) than males (40.5%) with high significant association (P = 0.000). This result is in agreement with the reports of Sarker (2007); Rony *et al*., (2010) and Asmaa *et al*., (2014), who reported a significantly higher prevalence of ectoparasitic infestations in female than male in cattle. This result may be elucidated that examined female cattle were not kept properly in the farm with good management system for dairy purpose, or may be due to stress from pregnancy and lactation (Sutherst *et al*., 1983).

In case of breed, tick infestation rate was higher in pure Frisian 100%,then local breed (Butana) 72.2%and at the last cross Frisian , and there was not significant association among different breeds (x2 = 2.052; P =0.358) (Table 3.2). This result is disagree with (Tessema and Gashaw (2010) and (Guma *et al.,* 2015) who observed the higher prevalence of tick infestation in cross breed than local breeds, and agree with Belew and Mekonnen (2011) recorded that local breeds were more infested by tick (44.96%) than cross breeds (15.83%).This variation might be due to a high infestation rate which was observed in the local breed of cattle in the current study.

Regarding coat color, the current survey showed that high tick infestation prevalence was in cattle with brown (71.6%), mixed (66.7%), black (63.7%) and white color (52.7%) at the last. Our finding is agree with Gasparin *et al*., (2007), who recorded that lighter colored animals are more resistant than dark colored ones, and disagrees 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.

Higher infestation rate was detected in cattle raised in open system (62.7%), followed by those kept in semi closed system (49.6%) and finally cattle kept in the closed system (40.0%), and there is high significant association between housing type and tick infestation prevalence. This result is in line with Rehman *et al*., (2017), who observed the higher tick prevalence in farms that adopted grazing practice than farms adopted stall feeding system. Similarly, Alrayah (2019) reported that the prevalence of ticks was higher in semi-close system (75.7%) compare with the prevalence in close system (69.7%). This could be due to the fact that mixed grazing at the same pasture provides maximum opportunity for tick to infest large population at a time (Abdalla , *and Hassan,* 2010).

According to the current study, there is significant difference in tick prevalence between cattle kept without tick control (96.2%) compared with those kept with application of different control methods (53.8%). This agrees with Bedada (2014) from Ethiopia who reported higher prevalence of tick infestation in the uncontrolled area than in the controlled area .This result explained that application of control method leading to reducing tick numbers.

In terms of methodology of tick control, using chicken as natural predator was obviously effective in reducing infested tick prevalence among investigated cattle (33.3%), followed by using both natural predator and acaricides (37.5%), while using acaricides only showed low effectivity (55.3%). This in line with (Hassan, *et al*., 1991) and Hassan, *et al*., (1992) who noted that the introduction of hens as a means of biological control resulted in reduced tick numbers.

We found that removing of manure was considered as a risk factor associated with tick infestation. 83.1% was recorded in cattle kept in herds where manure was not periodically removed as compared with 63.3% for cattle kept in herds practiced monthly manure removing, while only 50.5% among cattle kept with weekly manure removing. These results are in line with Fadlalla, (2019) and Hassan,(2020)who found that the frequency of removal of manure had asignificant influence on the prevalence of tick infestation (P=0.005), (P=0.000) respectively . It is evident that good management practices like application of hygiene measures reduced the free-living stages of ticks on the ground. (Walker *et al.*, 2003) .

Concerning tick survey, the study revealed that *Rhipicephalus evertsi evertsi*, *Rhipicephalus praetextatus*, *Rhipicephalus sanguineous*, *Hyalomma anatolicum*, *Hyalomma rufipes* and *H. truncatum* were identified among examined cattle in River Nile State. These identified species were consistent with those reported by Hoogstraal (1956); Karar *et al*., (1963) and FAO (1983).Salih *et al*., (2004) confirmed the presence of *Hyalomma anatolicum* among cattle in Atbara and Eldammar.

According to this study, *H. anatolicum* was found to be the most prevalent tick species (77.6%), it is a xerophilic species thriving in semi-desert conditions in Northern Sudan (Jongejan *et al*., 1987). This finding is consistent with previous report of Salih *et al*., (2004), who reported that

H. anatolicum was the most abundant species in Atbara, Eldammar and Khartoum.

The study revealed that the number of males was higher than females in all tick species identified. According to Solomon *et al*., (2001), this may be due to the fact that fully engorged female tick drops off the host to lay eggs while males tend to remain on the host up to several months to continue feeding and mating with other females on the host before dropping.

Each tick species tended to prefer a site of attachment on the animal body, this study revealed that the most favorable predilection site for *Hyalomma anatolicum* was udder, tail, testes, brisket, ear, wither, knee and around eyes. In Pakistan, Kakar *et al*., (2017) observed that *Hyalomma* spp. attached more to external genitalia, udder and perineum while *Rhipicephalus sanguineous* was detected in ear, shoulder and neck.

Our survey found that the highest infested site was the tail (51.3%), followed by mixed infections (22.7%), udder (13.4%), ear (6.25%), brisket (3.12%), Knee (1.8%), testes (0.9%) and around eyes (0.4%). In Punjab Province, Pakistan, Atif *et al*., (2012)reported that the perineum, udder and external genitalia were the most tick infested sites in cattle followed by dewlap, inner thighs, neck and back, tail, ears, around eyes, flanks and legs. Furthermore, Asmaa *et al*., (2014) reported that udder and external genitalia were the most tick infested sites, (70.7% each) followed by neck and chest (63% each), inner thighs (61.1%), perineum (41.7%), ears (14.6%) and around eyes (11.7%). Sajid, (2007) explained that external genitals, perineum and inguinal/groin region of the body are highly supplied with blood and ticks usually prefer thinner and short hair skin for infestation as this helps in easy penetration of mouthparts of ticks into richly vascular area for feeding.

Conclusions

The current study showed that ticks are prevalent in cattle in River Nile State where tick-borne diseases are common. Some potential risk factors including age, sex, housing type, control of tick, tick control methods and removing of manure were found to be related to tick infestation prevalence.

Hyalomma anatolicum was the most abundant tick species among examined cattle. *Rhipicephalus evertsi evertsi*, *Rhipicephalus sanguineous*, *Rhipicephalus praetextatus*, *Hyalomma rufipes* and *Hyalomma truncatum* were also identified within the study area.

Recommendations

Based on the results of the current study, an appropriate control program of ticks and TBDs in River Nile State should be designed and implemented.

Cattle keepers should be aware about the importance of tick control and how to reduce the tick population by applying good management practices.

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Appendix1

QUESTIONNAIRE

Date:………………………………………….

Information of farm :

1- Owner name: **Telephone:** **……………**

2-Location: (1)Shendi … (2) Al Matama (3)Eddammar

(4) Atbara (5) Barbar

3- District: ……………………………………………………..

4- Coordinates: …………………………………………………

5- Farm number: …….......... **Herd size: ……………..**

6- Housing type: (1) closed (2) open (3) semi closed

7-Rearing system:(1) One species (2) Mixed species

8-Feeding type:(1) roughages (2) concentrate (3) mix

Data of Animal :

1- breed :(1)Local (2) Cross (3)Foreign

2- sex : (1)Male (2) Female

3- age:(1) young (<2 years) (2) adult (2-5) years (3) old (>5)years

4 - Coat color :(1)white (2)black (3) Brown (4) other

5- Predilection site:(1) Ear (2)brisket (3) knee (4) Udder (5) Testes (6)Tail 7) eye (8) mix (9) Not infested

6- Tick control practices : (1) Natural predators

(2) Acaricides Interval …………………..

(3)Booth Interval …………………..

(4) None

7- Hygiene (removing of manure):(l) Weekly (2) Monthly

(3) Other