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Prevalence and Risk Factors of Tick Infestation in Sheep for Different Localities in River Nile State –Sudan

معدل انتشار وعوامل خطر الاصابة بالقراد في الضان بالمحليات المختلفة بولاية نهر النيل - السودان

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master in Preventive Veterinary Medicine (M.P.V.M)

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DEDICATION

To my parents, sisters and brothers

To my aunts and my uncles

To my dear husband

To my dear kids

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Firstly, thanks to almighty Allah for giving me the strength and power to complete this work.

With a great touch of pleasure, I would like to express thanks to my supervisor **Dr. Sara Basher Taha**, for her advice, direction, and continuous interest and constructive criticism.

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Abstract

Across sectional study was conducted between June to August 2018 in River Nile State, Sudan to investigate the prevalence of tick infestation in sheep. In addition to that, the risk factors (localities, herd size, housing type, rearing system, feeding type, breed, sex, age, coat color, seasons, tick control, methods of tick control, and removal of manure) that might be associated with tick infestation were also investigated.

Totally, 340 ticks (male 185, female 155) were collected from 135 sheep between June to August 2018. Tick collection was carried out in five localities namely, Shendi, Al Matamah , Ad-Damer, Atbara , and Berber.

Around 66.7% of total examined animals were infested with ticks, while 33.3 % of them were not infested with ticks. Based on the locality, Atbara showed the highest prevalence of tick infestation (100 %), followed by Ad- Damer (81.8 %), Shendi (76.2 %) , Berber (55.6 %), and the lowest prevalence was observed in Al Matamah (28 %).

The results showed that the most abundant tick species collected in this survey were *Rhipicephalus eversti eversti* (38%), followed by *Hyalomma anatolicum* (23.8 %), *Rhipicephalus sanguineus* (20.6%), *Rhipicephalus praetextatus* (16.4%), and *Hyalomma dromedarii* (1.2%).

The chi – square analysis showed that there was a significant association between tick infestation and localities ($p = 0.000$) , housing type ($p = 0.000$), feeding type ($p = 0.000$), sex($p = 0.021$), control of tick ($p = 0.001$), methods of tick control ($p = 0.005$), and removal of manure ($p = 0.000$).

On the other hand there was no significant association was observed between tick infestation and herd size ($p = 0.481$), rearing system ($p =0.127$), age ($p = 0.754$), coat color ($p =0.846$),

These results showed that the prevalence of tick infestation in sheep in the River Nile State's localities was high. Therefore, more

studies are required in order to control ticks and minimize their distribution

This study is a part of a project aimed to investigate the prevalence and risk factors associated with ticks infestation in ruminants (cattle, sheep, and goats) in River Nile state in order to highlight the need for effective control measures and to reduce the prevalence of tick.

الخلاصة

أجريت دراسة مقطعية في الفترة بين يونيو الى أغسطس 2018 في ولاية نهر النيل بالسودان للتحقق من انتشار الإصابة بالقراد في الضان. بالإضافة إلى ذلك تم التحقق من عوامل الخطر (المحليات ، حجم القطيع ، نوع المسكن ، نظام التربية ، نوع التغذية ،السلالة ، الجنس ، العمر ، لون الجلد ، المواسم ، مكافحة القراد ، طرق مكافحة القراد ، وإزالة الروث) التي قد تكون مرتبطة بالإصابة بالقراد.

تم جمع 340 قرادة (ذكور 185 ، إناث 155) من 135 من الضان في الفترة بين يونيو الى أغسطس 2018 . تم جمع القراد من خمس محليات هي شندي والمتمة والدامر وعطبرة وبربر.

حوالي 66.7% من مجموع الحيوانات المفحوصة كانت مصابة بالقراد ، بينما% 33.3 منها لم تكن مصابة بالقراد. واستناداً إلى المحليات ، أظهرت عطبرة أعلى نسبة انتشار للإصابة بالقراد (% 100) ، تليها الدامر (% 81.8) ، شندي (% 76.2) ، بربر (% 55.6) ، وأقل انتشار كان في المتمة (% 28).

اظهرت النتائج ان اكثر انواع القراد وفرة التي تم جمعها في هذا المسح هى رايبيسيفلاس ايفرساي (38%)، تليها هيالوما اناتوليكم (% 23.8)، رايبيسفلاس سانقوينس(20.6%) ، ثم رايبيسفلاس بريتديتس(16.4%)، واخيرا هيالوما درومو داري (1.2%).

أظهر تحليل مربع كاي وجود علاقة معنوية بين الإصابة بالقراد والمحليات (p = 0.000)، نوع السكن (p = 0.000) ، نوع التغذية (p = 0.000) ، الجنس (p = 0.021) ، السيطرة على القراد (p = 0.001) ، وطرق التحكم في القراد (p = 0.005) ، وإزالة الروث (p = 0.000).

من ناحية أخرى لم يلاحظ وجود ارتباط معنوي بين الإصابة بالقراد وحجم القطيع (p = 0.481) ونظام التربية (p = 0.127) والعمر (p = 0.754) ولون الجلد (p = 0.846).

أظهرت هذه النتائج أن انتشار القراد في الضان بمحليات ولاية نهر النيل كان عالياً. لذلك ، هناك حاجة إلى مزيد من الدراسات من أجل السيطرة على القراد وتقليل انتشاره.

هذه الدراسة هي جزء من مشروع يهدف إلى التحقق في انتشار القراد وعوامل الخطر المرتبطة بالإصابة بالقراد في المجترات (الأبقار والضان والماعز) في ولاية نهر النيل من أجل تسليط الضوء على الحاجة إلى تدابير المكافحة الفعالة والحد من انتشار القراد.

Introduction

Sudan has one of the largest livestock populations in Africa. Cattle, sheep, goats, and camels provide milk and meat for local consumption and only meat for export (Epstein, 1971). In addition to that, ruminants provide ancillary functions for the country as they produce manure for the agriculture process (Wilson, 2018).

In spite of their importance to the national economy, generally, the livestock does not receive sufficient attention and financing in Sudan and almost all animals are owed by traditional pastoralists (Wilson, 2018). Moreover, livestock in Sudan, on one hand, are affected by different types of diseases and on the other hand, they receive little health care (Wilson, 2018). Adding to that the general output of this sector is very low in relation to the numbers of animals and to the sector's potential (Wilson, 2018).

Ticks are the most important group of vectors of pathogens that affecting domestic animals and humans including several species of protozoa, bacteria, helminthes, and viruses (Jongejan and Uilenberg, 2004). Ticks may cause direct and indirect effects on their hosts such as feeding on blood causes anemia, tick bites lead to secondary infections like mastitis and dermatitis, tick paralysis, tick anxiety, devaluation of hides and disease transmission (El Ghali, 1992). Additionally, ticks feeding can also reflect negatively on meat and milk production (Mohammed, 2003).

In Sudan, ticks and tick-borne diseases are widespread, cause substantial economic losses, and constitute major obstacles to the development of animal wealth. Among these diseases, Tropical Theileriosis, Malignant Ovine Theileriosis, Cowdriosis, Babesiosis, and Anaplasmosis are considered as the most important diseases (Dolan, 1989).

Around 70 species of ticks were identified in Sudan. They mainly belong to the genera *Amblyomma*, *Hyalomma* and *Rhipicephalus* (Hoogstraal, 1956). Although, the prevalence and the distribution of ticks were studied in the River Nile State, the distribution of ticks changed dramatically due to climate changes (Hassan and Salih, 2013). Therefore, an annual investigation is necessary in order to update our data and to expect which kind of new diseases could be occurred.

The objectives of this study were:

1- To identify the tick species in the River Nile State.

2- To estimate the prevalence of ticks in the River Nile State.

3- To determine the potential risk factors associated with tick infestation in sheep in River Nile State.

Chapter one

Literature review

1.1 Etiology:

Ticks are blood sucking ectoparasites of mammals, birds and reptiles with 850 species have been described worldwide (Bishop *et al.*, 2008). They act as vectors for diseases that transmitted to domestic and wild animals and human (walker *et al.*, 2003). Ticks are classified into subclass Acari, which include three families, Aragasidae (soft ticks) and Ixodidae (hard ticks) (Barker and Murrell, 2004) and Nuttalliellidae (monotypic) (Nava *et al*., 2009).

1.2 Taxonomy of ixodid ticks:

Phylum: Arthopoda (walker *et al*., 2003).

Class: Arachnida, (Scorpion, Spiders, Harvestmen, Ticks and Mites) (Jonathan and Robert, 2001).

Subclass: Acari (Dhooria, 2016).

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

Families: (1) Argasidae (soft ticks) (walker *et al*., 2003).

Genera: *Argas, Otobius, a*nd *Ornithodoros*

Families: (2) Nuttaliellidae (Nava *et al.,* 2009)

Genera: Nuttalliella

Families: (3) Ixodidae (hard ticks) (walker *et al*., 2003).

Genera: *Amblyomma*, *Hyalomma*, *Dermacentor*, *Haemaphysalis*, *Ixodes***,** *Rhipicephalus*, *Margaropus* and *Rhipicentor* (Horak *et al*., 2003).

1.3 Morphology of Ixodidae tick (Hard tick)

Tick morphology consists of two primary regions; capitulum (the mouthparts) and idiosoma (the body). Capitulum has three specialized structures called palps, chelicerae, and a hypostome that function together and allow ticks to penetrate the host skin and extract a blood meal from the tissues. Idiosoma contains legs, and internal organs such as respiratory, digestive, and reproductive structures. The numbers of legs are different between the stages. Whereas nymphs and adults have four pairs of legs, the larva has three pairs only (Walker *et al*., 2003).

Hard ticks have a dorsal scutum of the hardened cuticle. The scutum extends over the entire dorsum of the idiosome in males but it covers the anterior third of the dorsal side of female (Sonenshine and Roe, 2014).

1.4 The life cycle of ticks

There are three active stages in the life cycle of hard ticks, larvae, nymphs, and adults. Each stage takes a blood meal only once and then periods are spent on vegetation between meals (Walker *et al*., 2003).

Ticks' feeding on their hosts and the period of feeding varies from several days to weeks, according to some factors such as host type, stage of tick, and ticks species. A 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 compared with unfed adult female ticks (Sonenshine and Roe, 1991).

In the hard ticks, mating takes place on the host, except in species of the genus *Ixodes* where it may also occur when the ticks are still on the vegetation (Walker *et al*., 2003).

The females secrete one or more types of pheromones, which attract males (FAO, 1984). Male ticks remain on the host for long period and may mate with other females. Females mate only once and when they engorged, they detach from the host and have enough sperm to fertilize all their eggs (Walker *et al*., 2003).

A female hard tick lays eggs between 2,000 to 20,000 according to the species of tick in the physical environment (Walker *et al*., 2003). The temperature and humidity affect largely the hatching of the eggs and the activity of the larvae. Hot conditions are favorable for hatching (Hoogstraal, 1956).Number of eggs laid and eggs hatched were positively associated with females engorgement weights; there are high mortality rates of females in the sun and most of the eggs desiccated(El Ghali and Hassan, 2010)

The life cycle of hard ticks are classified according to the number of hosts into three groups (Latif and Walker, 2004);

1.4.1 One host ticks

Ticks belong to this group remain on the same host for the larval, nymph, and adult stages and only leaving the host prior to laying eggs, an example is *Rhipicephalus (Boophilus) decoloratus* (Walker *et al*., 2003)

1.4.2 Two host ticks

In these species both larvae and nymphs feed and develop on the same host while adults feed on another host. *Rhipicephalus evertsi evertsi* and *Hyalomma rufipes* are examples of two host ticks (Kettle, 1995).

1.4.3 Three host ticks

Each stage of the three host ticks feeds on a different host species such as *Amblylomma spp*, *Rhipicephalus apendiculatus* (Soulsby, 1982).

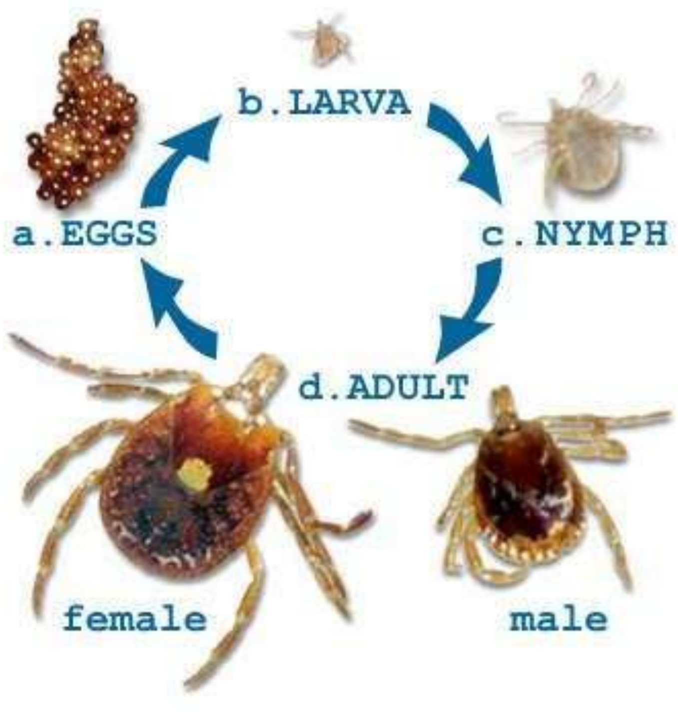

Figure1.1: Life Cycle of Tick (Geevarghese and Mishra, 2011)

1.5 Ecology and Epidemiology of tick

Ticks spread in most parts of the world. Generally, they found in the areas where their hosts exist. Tick’s habitat is composed of a variety of living and non-living things in the area in which they live (Latif and Walker, 2004).

Since ticks spend part of their life cycle in the environment. Their development and survival depend on many factors including vegetation cover, moisture and temperature conditions, and photoperiod (Dantas-Torres, 2010; Randolph, 2009). In addition to that, changes in climate and in vegetation covers such as deforestation, the establishment of large-scale agriculture schemes, and desertification affect the macro and micro-environment of ticks and hence their distribution (Helikson and Jones, **1991**).

Relative humidity and rainfall are critical factors determining the longevity of ticks (Tatchell and Easton, 1986). The relative humidity considers as an important factor for the survival of ticks by adjusting water balance and preventing dehydration. On another hand, high humidity is particularly more required for the survival of Ixodid ticks than the Argasid ticks. Ixodid ticks die quickly when exposing to a degree of humidity below critical values (Hassan, 2003) .

Rainfall is another factor that has an influential role in the distribution of ticks throughout the world, that ticks' burden on hosts is high during the wet season compared with the dry season (Mooring *et al*, 1994).

The effect of climate change, particularly the temperatures, in tropical zones may be lethal to some species of ticks and affecting habitat suitability and forcing certain tick species to colonize in new areas. For example, in South Africa it has been predicted that increasing the temperature by 2^{o} C decreases habitat suitability for four tick species including *Rhipicephalus decoloratus*, *Amblyomma hebraeum*, *Rhipicephalus appendiculatus* and *Hyalomma truncatum* (Estrada-Pena, 2003).

Each species of tick has a critical temperature that greatly affects the survival of ticks. For example, 32 ^{o}C is the critical temperature for *Ixodid spp* whereas 45 ^{o}C is the critical temperature for *Hyalomma spp* (Hoogstraal, 1956). Temperature can influence in the distribution of ticks (Gubler *et al*., 2001, Deni *et al*., 2008). For instance, the high temperature reduces the fertility of ticks and inhibits host-seeking activity, which could indirectly increase tick mortality rates by reduced host-finding success (Eisen *et al*., 2016).The effect of low temperature in ticks depends on a range of factors, including tick species, developmental stage, and the number of days of tick exposure to a given temperature.

For example, *Ixodes. ricinus* can survive 24 hours when they exposed to temperatures rang beween14.4º C to 18.9ºC. But exposure to 10º C for 30 days can be lethal for them (Dautel and Knülle**,** 1997).

Long and thick vegetation cover provides shade and optimum humidity in microhabitats of ticks thereby enhances their survival; the survival of ticks under direct sunlight was significantly shorter than their survival in the shade (Hassan, 1997).

1.6 Tick – borne diseases

1.6.1 Theileriosis

Theileriosis is a tick-borne disease that causes a wide range of damage. It is the most economically important infection of domestic ruminants in sub-Saharan Africa. Theileriosis is caused by *Theileria* spp (Gao *et al*., 2002).

In Sudan, Malignant ovine theileriosis is an endemic disease caused by *Theileria lestoquardi* and causes great loss among sheep. The disease mainly transmitted by *Hyalomma anatolicum* (Smith and Sherman. 2011). High morbidity and mortality rates have been reported in Sudan (Salih *et al*., 2003; El Imam *et al.,* 2015).

In Northern Sudan, it was reported as causing serious losses among sheep. The disease flares up in summer in a pattern of seasonal outbreaks (El Hussein *et al.,* 1993; ElGhali and EI Hussein, 1995; Ahmed 1999).

Recent surveys have demonstrated the spread of *Theileria lestoquardi* into Western Sudan, in areas where malignant ovine theileriosis has not been reported previously, with a high infection rate among both goats (41%) and sheep (69%) (Osman *et al*., 2017).

1.6.2 Babesiosis

Babesiosis is a tick-borne disease caused by a parasite of the genus *Babesia* (Homer *et al*., 2000). The disease affects mammals and birds and significantly impacts the health of farms and pets animals. Therefore, *babesia* infection is associated with huge economic losses worldwide (Schnittger *et al*., 2012). *Rhipicephalus spp* are predominant tick vectors, the parasite is transmitted by tick through transovarial and by trans-stadial in the two-host tick (*Rhipicephalus eversti eversti*) (Hall, 1985).

Babesia ovis is pathogenic especially in sheep and its case-fatality in susceptible hosts range from 30% to 50% in field infection, (Hashemi-fesharki ,1977). The disease is characterized by fever, anaemia, icterus and hemoglobinuria. Economic losses result from the deaths among affected sheep and goats, and the cost of control programs..(Phillip and Peter, 2015).

1.6.3 Anaplasmosis

Anaplasmosis is caused by Rickettsia-like organisms of the genus *Anaplasma*, which transmit mainly by *Boophilus spp* (Blood and Radostits , 1990). The disease can be also transmitted by other species of ticks (Bram *et al*., 1983). The disease affects both domestic and wild ungulates animal and it is widespread throughout the tropics region (Wanduragala and Ristic, 1993).

In Sudan *Anaplasma marginale* and *A. centrale* were diagnosed in cattle. *A. marginale* was reported all over the country (Elhussein *et al*., 2004). 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 state

Anaplasma ovis mainly exists in small ruminants such as sheep and goats, and it has been confirmed present in most regions of the world both in farm and wild animals (Kuttler, 1984).

1.6.4 Heartwater disease (cowdriosis)

Heartwater or cowdriosis is a disease of domestic and some wild ruminants. It caused by an intracellular *Rickettsia,, Ehrlichia ruminantium* and is transmitted by *Amblyomma spp* (Semu, *et al*., 2001). Heartwater is most severe in small ruminants and causes considerable economic losses of domestic livestock (Uilenberg, 1983).

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

1.6.5 Nairobi sheep disease

The causative agent is the Nairobi sheep disease virus, a member of the genus *Nairobivirus*. It is highly pathogenic for sheep and goats. It is transmitted by *Rhipicephalus appendiculatus* (Maclachlan and Dubovi, 2010). The disease is characterized by gastroenteritis and paralysis, which in many cases lead to death (Davies, 1997; Kettle, 1995).

1.7 Economic importance of ticks

Ticks are the most important ectoparasites of livestock in tropical and sub- tropical area, and are responsible for severe economic losses in livestock. Economically the most important *Ixodid* tick of tropical regions belongs to *Hyalomma*, *Rhipicephalus* , and *Amblyomma* (Frans, 2000).

1.7.1The effects of ticks

Ticks cause a direct and indirect adverse effect on their hosts. They feed on blood that leads to anemia; the injuries caused by their attachment with the skin results in damage of hides and predispose animals to a secondary infection. Some ticks are able to release toxins into the host, causing ascending paralysis, and fever. Although affected animals may die, paralysis is relieved quickly if the ticks are removed (Latif and Walker, 2004). The most common tick cause paralysis is *Rhipicephalus. evertsi*, *Haemaphysalis punctata and Ixodes ricinus* (Blood and Radostis, 1990).

Hassan (1997) estimated that feeding of *Amblyomma* species on the udder caused mastitis and teat damage resulting in a highly significant loss in milk yield. In addition to that, Pegram *et al*. (1996) estimated the annual cost of chemical acaricides per head in Zimbabwe at 963 US$.

1.7.2 Importance of tick-borne diseases

Ticks act as vectors transmitting a wide spectrum of pathogens causing important diseases to humans and animals such as *Theileriosis*, *Babesiosis* , *Anaplasmosis* , *Rickettosiosis* (also known as spotted fever), and Lyma disease (Hajdusek *et al*., 2013). The main effects of tick-borne diseases are reflected in the reduction of production, loss of weight and death of a substantial proportion of the affected animals (Hoogstraal, 1956; Karrar *at el*., 1963).

Ticks become infected with the pathogenic organisms while they feed on infected animals, then the organism may be transmitted either from stage to stage (transstadial transmission) such as *Theileria parva* transmitted by *Rhipicephalus appendicuatus*, or via egg (transovarial transmission) such as *Babesia bovis* transmitted by *Boophilus* *decoloratus*. When the next stage or generation of ticks feeds on another animal, the organism is transmitted to that animal (Drummond, 1976).

Tick-borne diseases are responsible for hundreds of millions of US dollar losses per year in tropical and temperate areas. In Sudan, no accurate economic evaluations have been made. However, economic losses in Khartoum State alone due to tropical *Theileriosis* have been estimated to be between 4 and 6 million US (Latif, 1994). In addition, Siddig *et al* (2003) reported that the total loss due to an outbreak of *Theileriosis* in a dairy farm in Khartoum State to be about 62000 US.

1.8 Ticks in Sudan

1.8. 1 Distribution of the tick in Sudan

Sudan is mostly an arid country, with five ecological zones can be identified, the desert climate zone, the semi-desert zone, the dry zone, the semi dry zone and the semi wet zone (OIE, 2013)

The most salient geographical features of the country are the Nile Valley, Nubian, and Bayuda Deserts in the north (Anon, 2011). This exceptional climate and environmental diversity along with a variety of domestic and wildlife hosts serve to align with the biological requirement of a variety of tick species (ElGhali and Hassan, 2012). In Sudan, before separation, livestock estimated to be 137 million of which 40 million cattle, 50 million sheep, 42.5 million goats, 4 million camels, and 0.5 million horses (Anon, 2005).

Ticks fauna in Sudan include over 70 species prevalent in different ecological zones, most of these ticks have economically important in Africa namely *Rhipicephalus appendiculatus* , *Hyalomma anatolicum* , *Amblyomma lepidum* , *Rhipicephalus decoloratus* , and *Rhipicephalus annulatus* (Hassan and Salih , 2013). *Rhipicephalus appendiculatus and Hyalomma anatolicum* are the most important species in Sudan since they are the main vector of East Coast fevers, tropical theileriosis and malignant ovine theileriosis which are considered as the major obstacles to animal production improvement in Sudan (Latif and Shawgi,1982; Imam, 1995; FAO, 1983).

In northern Sudan, Hoogstraal (1956) identified *Amblyomma exornatum*, *Hyalomma dromedarii*, *Hyalomma impeltatum*, *Hyalomma impressum*, *Hyalomma marginatum*, *Hyalomma detritum*, *Hyalomma* *rufipes*, *Hyalomma excavatum*, *Hyalomma truncatum*, *Rhipicephalus evertsi evertsi*, *Rhipicephalus praetextatus* and *Rhipicephalus sanguineus*

Later, Ahmed *et al*., (2005) reported that in River Nile State *Hyalomma anatolicum anatolicum* was the predominant species (73.6 %), follow by *Rhipicephalus sanguineus* group (14.7 %), *Rhipicephalus evertsi evertsi* (9.1 %), *Rhipicephalus simus* (2 %) and *Hyalomma dromedarii* (0.5 %).

Several factors affect tick distribution in Sudan including the movement of animals either for trade or nomadism, deforesting, desertification, and global climatic changes. These factors may oblige ticks to extend their distribution ranges reverse than their known geographic regions. For example, in Sudan Amblyomma *variegatum* has extended its range north of 12^{o} N, while *Hyalomma anatolicum* has moved south of 14^{o} N, *and Rhipicephalus annulatus* was found in the semi-arid zone (Hassan and Salih, 2013).

1.8.2The economic impact of tick in Sudan

Livestock plays a great role as a food system and store of wealth. It has provided more than 60% of the estimated value added to the agricultural sector in Sudan in the years 2007-2010 (Anon, 2011).

Ticks and tick–borne diseases are widespread in Sudan and constitute large obstacles to the development of production (El Hussein *et al*., 2004).

In addition, these diseases lead to economic losses due to high morbidity and mortality, harming the internal and international livestock trade. Light or no healthcare practices can lead to the endemicity of these diseases. Diseased animals become reservoirs (Chand *et al.*, 2015; Kumar *et al*., 2015).

1. 9 Tick Control

It aims to reduce tick numbers, animal infection levels, and prevent disease transmission. Control of ticks and tick-borne disease has begun since the early twentieth century. Some countries succeeded in control programs such as the USA. However, other countries failed due to poor financial resources and the presence of various ecological and climatic factors (FAO, 1984). Furthermore, with the changing environmental conditions due to global warming, the epidemiology of the tick infestation and vectorial potential of the ticks are likely to change and thus fail to control (Kabir *et al*., 2011).

1.9.1 Conventional tick control

The application of chemical acaricides used to control of ticks. This method can apply either by dipping, spraying or pour on. Acaricides such as organophosphate, organo-chlorine and synthetic pyrethroid have been recently used in a wide range (Awumbil, 1996; George, 2000).

The disadvantages of chemical acaricides are the development of resistance of ticks to various acaricides besides the environmental pollution and toxicity to man and animals (Aziz, 2003). Moreover, intensive and thus expensive dipping or spraying programs have been mainly unsuccessful in eradicating ticks and tick-borne diseases (Jongejan and Uilenberg, 1994).

1.9.2 Ecological control

Ecology plays an important role in tick control (Estrada-Pena, 2003). In general, burning of pasture, bushes, and grasses, cultivation of grazing areas, use of mixed farming, removal of manure, and sealing off cracks in animal sheds reduce tick contact with hosts, and contribute to control of ticks (ElGhali, 1992; Hassan, 2003).

1.9.3 Biological control

Ticks have numerous natural enemies, but only a few species have been evaluated as tick bio-control agents (Samish, *et al.*, 2004). Domestic chickens play an important role as a natural predator for ticks in the free management system (Hassan *et al*., 1991, 1992).

Other predators such as toads, snakes, rodents and lizards play also a role in tick control (Hassan, 2003).

1.9.4 Tick and tick-borne diseases vaccination

There was a vaccine developed against tick infestations in early 1990s.This vaccine contained the recombinant *Rhipicephalus microplus* Bm86 gut antigen (de la Fuente and Kocan, 2003; Willadsen, 2006).

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

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

Chapter two

Materials and Methods

2.1 Study area

The study was conducted in River Nile state, which is located in the north part of Sudan. The state is bordered by Khartoum state to the south, Arab Republic of Egypt to the north, Kassala state and Red Sea state to the east and Kordofan state to the west. River Nile State lies between latitude 16 -22 ◦N and longitude 30 – 32 ◦E with an area of 124 thousand square kilometers.

The climate in River Nile state is semi desert and the maximum temperatures are between 47^{0}C in summer to 8^{0}C in winter. The mean rainfall is between 150 mm in the south part to 25 mm in the north part of the state.

Figure 2.1: shows the study area (River Nile state) in dark area

2. 2 Study design and sample size

Across sectional study was conducted to investigate the prevalence of ticks affecting sheep, the sample size calculated by using the formula of Thrusfield, (2007):

$$n = (1.96)^2 . P_{exp} (1-P_{exp})/d^2$$

n= Sample size

P_{exp} = expected prevalence

d = desired absolute precision (d =0.05)

Ticks samples were taken from 135 sheep selected randomly from five localities; Shendi, Al Matamah, Ad-Damer, Atbara and Berber (Table 2.1).

Table 2.1: The number of the sample collected from different localities (five localities).

Locality	**Shendi**	**Al Matamah**	**Ad-Damer**	**Atbara**	**Berber**	**Total**
Number of animals	63	25	22	7	18	**135**

2.3 Collection of ticks

The ticks were collected manually from their predilection sites of the sheep's body (preferred regions for ticks), which included ears, tails, udders and testicles.

The ticks were transferred into tubes that contained 70 % ethanol. Each tube was labeled with animal number and the locality.

A companion questionnaire was designed for each animal and has a number of potential risk factors such as localities, herd size, housing type, rearing system, feeding type, breed, sex, age, coat color, seasons, tick control, methods of tick control, and removal of manure in the sheep.

Herd size was classified into three groups; small herd (less than 70 animal), medium herd (70 - 140) animal and big herd (more than 140) animal.

Sheep examined in this study was classified into two groups according to housing type; open type and semi-closed.

The rearing system was classified into two groups; one rearing system (one animal species) and mixed rearing system (more than one species).

Sheep examined were classified according to feeding type into two groups, feed on roughages only and feed on both roughages and concentrates (mixed type).

Sheep breed classified into two groups; local breed and cross breed.

Sheep examined (70) female and (65) male.

Sheep were classified according to age into three groups, young (less than 6 months), adults (6 months to 3 years) and olds (more than 3 years).

The coat color of examined sheep was classified into four groups, white color, black color, brown color, and mixed color (more than one color).

In this study there about 47 of the sheep owners were practiced tick control, while 88 of them did not practice any type of tick control.

Regarding the methods of tick control, 44 of the sheep owners used only acaricides to tick control, while 4 of them used mixed methods (acaricides and natural predators) to tick control. Eighty-eight of the sheep owners did not apply any method in order to control ticks .

The farms classified into three groups based on the regulation of removal manure; farms removed manure weekly, monthly, and irregularly.

2. 4 Identification of ticks

Morphologically, tick samples were identified under a stereoscopic dissecting microscope in Entomology and Tick Department (CVRL).

According to the keys provided by (Hoogstraal 1956) ,and (walker *et al* 2003).

2. 5 Statistical analyses

The analysis was carried out using the (SPSS-16). The overall prevalence of tick infestation was calculated by divided infected animals by the overall number of examined animals. The associations of the potential risk factors with tick infestation were analyzed using Chi-square test. The confidence interval (CI) was held at 95% and $P<0.05$ was set for statistical significance.

Chapter Three

Results

3.1 Prevalence of tick infestation in relation to localities

A total of 135 sheep were selected randomly from five localities namely Shendi , Al Matamah , Ad-Damer , Atbara , and Berber in River Nile state and examined for tick infestation between June to August 2018 . Among 135 sheep examined 90 were infested with ticks (66.7%) and 45 were non-infested (33.3 %). The results showed that the highest prevalence of tick infestation was in Atbara (100 %) , followed by Ad-Damer (81.8%), Shendi (76.2 %), Berber (55.6 %), and the lowest prevalence of tick infestation was in Al Matamah (28 %). The Chi analysis results showed that there was a significant association between tick infestation and localities (p =0.000) (Table 3.1).

Table 3.1: The number of sheep examined for tick infestation in different localities in River Nile state.

Locality	No of animals	Infested animals	Non infested	Df	X^2	P value
Shendi	63	48 (76.2 %)	15 (23.8 %)	4	26.164	0.000
Al Matamah	25	7 (28 %)	18 (72%)			
Ad- Damer	22	18 (81.8 %)	4 (18.2 %)			
Atbara	7	7 (100 %)	0 (0%)			
Berber	18	10 (55.6 %)	8 (44.4 %)			
Total	135	90(66.7%)	45(33.4%)			

3.2 Tick species

A total of 340 ixodid ticks 185 male and 155 female were collected from 135 sheep. Five tick species from two genera were identified during the study, these included *Hyalomma anatolicum* , *Hyalomma dromedarii* , *Rhipicephalus eversti eversti* , *Rhipicephalus sanguineus and, Rhipicephalus praetextatus.*

The most abundant tick species collected in this survey was *Rhipicephalus eversti eversti* (38%), followed by *Hyalomma anatolicum* (23.8 %), *Rhipicephalus sanguineus* (20.6%), *Rhipicephalus praetextatus* (16.4%), and *Hyalomma dromedarii* (1.2 %) (Table 3.2).

Table 3.2: Prevalence of tick species.

Tick species	Male	Female	Male to female ratio	Total
Hyalomma anatolicum	46 (13.5%)	35 (10.3%)	1.3: 1	81(23.8 %)
Hyalomma dromedarii	1(0.3 %)	3 (0.9 %)	0.3: 1	4 (1.2 %)
Rhipicephalus eversti eversti	76 (22. 4 %)	53 (15. 6%)	1.4: 1	129 (38 %)
Rhipicephalus sanguineus	34 (10 %)	36 (10.6 %)	0.9: 1	70 (20.6 %)
Rhipicephalus praetextatus	28(8.2 %)	28(8.2 %)	1: 1a	56 (16.4%)
Total	185 (54.4%)	155 (45.6 %)	-	340

3.3 Predilection sites of tick infestation

with regards to tick predilection sites the results showed that ear was the highest infested site (43.2%), followed by mixed sites (ear, eye and tail) (29.4%), tail (27.1%), and finally udder (0.3%) (Table 3.3).

Table 3.3: Distribution rate of tick based on the predilection sites

Predilection site	Ear	Tail	Mixed	Udder
%	43.2	27.1	29.4	0.3

The predilection sites of *Hyalomma anatolicm* were ear, tail and eye, while *Rhipicephalus eversti eversti* were tail , ear , and udder. Ear and tail were the predilection sites of *Rhipicephalus sanguineus, Rhipicephalus praetextatus* and *Hyalomma dromedarii.*

3.4. Ticks burden of infested sheep

Regarding the ticks burden the results showed that 71 out of 90 sheep (78.9%) were infested by the low level of ticks burden (1 – 5 tick per animal), whereas 16 out of 90 sheep (17.8 %) were infested by a middle level of ticks burden (5- 10 tick per animal). Only one sheep out of 90 (1.1%) was infested by high level of tick burden (10 – 15 tick per animal), whereas 2 out of 90 sheep (2.2%) were infested by the highest level of tick burden (15 – 20 tick per animal).

Table 3.4: Ticks burden of infested sheep.

Number of ticks*	Number of infested sheep
1 – 5	71 (78.9 %)
5 – 10	16 (17.8 %)
10 - 15	1 (1.1 %)
15 - 20	2 (2.2 %)

***** The rang of tick number was classified based on Fadlalla, (2019**)**

3.5 Prevalence of tick infestation in relation to (herd size, housing type, rearing system, feeding type, breed, sex, age, coat color, tick control, methods of tick control and removal of manure).

3.5.1 Herd size

Herd size was classified into three groups; small herd (less than 70 animal), medium herd (70 - 140) animal and big herd (more than 140) animal. The prevalence of tick infestation in small, medium, and big herd sizes was 70.8 %, 60 % and 66.7 %, respectively. Chi-squared analysis results showed that there was no significant association between tick infestation and herd size (p = 0.481) **(Table 3.5)**.

3.5.2 Housing type

Sheep examined in this study was classified into two groups according to housing type; open type and semi-closed type. The prevalence of tick infestation in the two groups was 77.8 %, and 44.4 % respectively. Chi – square analysis showed that there was a significant association between the housing type and tick infestation (p = 0.000) **(Table 3.5)**.

3.5.3 Rearing system

The rearing system of examined sheep was classified into two groups; one rearing system (one animal species) and mixed rearing system (more than one animal species). The higher prevalence of tick infestation was reported in one rearing system (77.1%), while in the mixed rearing system the prevalence was (63 %). Chi – square analysis revealed that there was no significant association between the rearing system and tick infestation (p =0.127) **(Table 3.5).**

3.5.4 Feeding type

Sheep examined were classified according to feeding type into two groups, feed on roughages only and feed on both roughages and concentrates (mixed type).

Chi – square analysis showed that there was a significant association between the feeding type and tick infestation (p = 0.000). The prevalence of tick infestation was higher in animals that feed on roughages (78.3%) compared with animals that feed on mixed type (48.1%) (Table 3.5).

3.5.5 Breed

All of the examined sheep were of local breeds and the prevalence of tick infestation was 66.7%. Chi-square analysis showed that there was no statistics were computed (Table 3.5).

3.5.6 Sex

Females sheep had a higher prevalence rate of tick infestation (75.7%) compared with males sheep (56.9%). Chi – square analysis showed that there was a significant association between sex and tick infestation (p = 0.021) **(Table 3.5).**

3.5.7 Age

Sheep were classified according to age into three groups, young (less than 6 months), adults (6 months to 3 years) and olds (more than 3 years).Regarding to the age; old sheep had the highest prevalence of tick infestation (75%), followed by adults (67.6%), and finally young (60%).The analysis showed that there was no significant association between age and tick infestation (p = 0.754) **(Table 3.5).**

3.5.8 Coat color

The coat color of examined sheep was classified into four groups, white color, black color, brown color, and mixed color (more than one color). The obtained result showed that the mixed color coat group had the highest prevalence of tick infestation (71.4%), followed by the black coat group (69.2%), the brown coat group (69.1%) and the lowest prevalence of tick infestation was in the white coat group (61.7%).

Chi –square analysis showed that there was no significant association between coat color and tick infestation (p =0.846) (**Table 3.5**).

3.5. 9 Tick control

Our study revealed that about 47 of the sheep owners were practiced tick control, while 88 of them did not practice any type of tick control. The analysis showed that there was a significant association between tick control measure and tick infestation (p = 0.001). The prevalence of tick infestation was higher in farms where the owners didn't practice any type of tick control (76.1%) compared with farms that practiced tick control measures (48.9%) (Table 3.5).

3.5.10 Methods of tick control

Regarding the methods of tick control, 44 of the sheep owners used only acaricides to control ticks, while 4 of them used mixed methods (acaricides and natural predators). Eighty-eight of the sheep owners did not apply any method.

Chi-square showed that there was a significant association between methods of control and tick infestation ($p = 0.005$). The prevalence of tick infestation was higher in farms that did not apply any methods (76.1%), followed by the farms that used mixed methods (66.7%), and then the farms that used acaricides only (47.7%) (Table 3.5).

3.5.11 Removal of manure

The farms classified into three groups based on the regulation of removal manure; farms removed manure weekly, monthly, and irregularly.

The analysis showed that there was a highly significant association between manure removal and tick infestation ($p = 0.000$). The prevalence of tick infestation was higher in farms that removed the manure irregularly (80%), compared with monthly (45.2%) and weekly (28.6%) **(Table 3.5)**.

Table 3.5: **Analysis of risk factors associated with tick infestation using Chi-square analysis.**

Risk factor	No.of examined	No. of infested	df	X^2	p-value
Herd size					
Less than 70	72	51(70.8%)	2		
(70 – 140)	45	27(60%)		1.463	0.481
More than 140	18	12(66.7%)			
Housing type					
Open	90	70(77.8%)	1	15.000	0.000
Semi closed	45	20(44.4%)			
Rearing system					
One	35	27(77.1%)			
Mixed	100	63(63%)	1	2.334	0.127
Feeding type					
Roughages	83	65 (78.3%)		13.153	
Mixed	52	25(48.1%)	1		0.000
Animal breed					

Local	135	90(66.7%)	-	-	-
Sex					
Male	65	37(56.9%)	1	5.355	0.021
Female	70	53(75.7%)			
Age					
Young	20	12(60%)	2	0.566	0.754
Adult	111	75(67.6%)			
Old	4	3(75%)			
Color coat					
White	47	29(61.7%)	3	0.815	0.846
Black	13	9(69.2%)			
Brown	68	47(69.1%)			
Mixed	7	5(71.4%)			
Tick control					
Yes	47	23(48.9%)	1	10.200	0.001
No	88	67(76.1%)			
Tick control method					

Acaricides Both None	44 3 88	21(47.7%) 2(66.7%) 67(76.1%)	2	10.658	0.005
Removal manure Weekly Monthly Irregularly	 14 31 90	 4(28.6%) 14(45.2%) 72(80%)	 2	 22.794	 0.000

3.6 Multivariate analysis

Multivariate analysis results showed that there was a significant association between tick infestation with housing type and control of tick. Other factors such as localities, feeding type, sex, methods of control, and removal of manure were not associated significantly with tick infestation. **(Table 3.6)**.

Table 3.6: Multivariate analysis of risk factors using logistic regression with tick infestation in River Nile state.

Risk factor	Exp B	p-value	95% Confidence interval for Exp (B)	
			Lower	Upper
Locality				
Shendi	0.370	0.160	0.093	01.481
Almatama	2.748	0.997	0.000	-
h	1.637	0.997	0.000	-
Ad- Damer	143536971.1	0.998	0.000	-
Atbara	Ref	-	-	-
Berber				
Housing type				
Open	11.247	0.011	1.761	71.814
Semi closed	ref	-	-	-
Feeding type				
Roughages	0.465	0.32	0.102	2.123

Mixed	Ref	3 -	-	-
Sex Male Female	2.578 ref	0.06 9 -	0.928 -	7.163
Tick control Yes No	161.375 ref	0.00 1 -	9.039 -	2881.1 02 -
Tick control methods Acaricides	1.140	0.92	0.076	17.013

Both	ref	4	-	-
None	ref	-	-	-
Removal manure				
Weekly	0.354	0.280	0.054	2.332
Monthly	1.877	0.548	0.252	13.370
Irregularly	ref	-	-	-

*The level of significant was $p<0.05$

*EXP (B) =exponential (B) =Odds ratio.

CHAPTER FOUR

Discussion

In the present study, the overall prevalence of tick infestation in sheep in different localities in the Nile River State was (66.7%). This result is lower than the result reported by Ali, 2019 who found that the prevalence of tick infestation was (77. 4%) in Khartoum State. This variation might be a result of the different geographical and climatic regions (ElGhali and Hassan, 2012).

The results showed that the highest prevalence of tick infestation was in Atbara (100 %), followed by Ad- Damer (81.8 %), Shendi (76.2 %), Berber (55.6 %), and the lowest prevalence of tick infestation was in Al Matamah (28 %). The difference in the prevalence of tick infestation among the municipalities was also reported by Abdallah, (2007) who found that Tulus in South Darfur has the highest mean of ticks (25.08) per animal, followed by Nyala (22.19) per animal, and the lowest mean of ticks was collected in Umdafug (15.74) per animal (Abdallah, 2007). This difference between areas attributes to the difference in environmental factors such as climate (Estrada-Pena., 2009).

In the current study, a total of 340 ixodid ticks, 185 male (54.4%), and 155 female (45.6 %) were collected from sheep. This result is in agreement with Suad (2009) who found that the number of tick males generally is more than tick females. These results also confirm the results of Jongejan *et al*., (1987) who reported that male ticks usually outnumbered females of all species except *Boophilus* spp in central and southern Sudan. The males remain on the host for more period of time alternately feeding and mating. While the females feed, mate, become engorged and then drop off the animal to lay their eggs (Walker *et al*., 2003)

In the present study, five species were collected from sheep, *Hyalomma anatolicum* , *Hyalomma dromedarii* , *Rhipicephalus eversti eversti* , *Rhipicephalus sanguineus and, Rhipicephalus praetextatus.* This result was similar to Ahmed *et al*., (2005) who found five species of ticks that infested sheep in River Nile state, this included *Hyalomma anatolicum anatolicum*, *Rhipicephalus sanguineus* group, *Rhipicephalus* *evertsi evertsi*, *Rhipicephalus simus* and *Hyalomma dromedarii*. It is also similar to a previous study done by Hassan *et al*., (2018) who identified six species of ticks in Khartoum state, which included *Hyalomma anatolicum*, *Rhipicephalus eversti eversti*, *Rhipicephalus sanguineus*, *Hyalomma impeltatum*, *Rhipicephalus camicasi,* and *Rhipicephalus guithoni* (Hassan *et al*., 2018). It is clear that the tiny difference in the tick species among the states and also within the state can be linked with the variety in environmental conditions in River Nile state that do not allow the survival and reproduction of many other species that infect sheep such as *Amblyomma lepidum* and *Amblyomma variegatum* (Karrar *et al*., 1963, Osman *et al*., 1982).

The most abundant tick species collected in this survey was Rhipicephalus eversti eversti (38%), followed by Hyalomma anatolicum (23.8 %), Rhipicephalus sanguineus (20.6%), Rhipicephalus praetextatus (16.4%), and Hyalomma dromedarii (1.2 %). This finding disagreed with results reported by Ahmed et al.,(2005) who found in River Nile state the most abundant ticks in sheep were Hyalomma anatolicum (74%), followed by Rhipicephalus praetextatus(15%), Rhipicephalus sanguineus(9%), Rhipicephalus eversti eversti (2%), and Hyalomma *dromedarii* (0.5%).

This variation might be due to the difference in the times which the studies were conducted, Ahmed *et al*., (2005) conducted his study between October 1996 to March 1998. In addition, they found that *Hyalomma anatolicum anatolicum* approximately disappeared during the hot period between April and August, whereas the highest numbers were present in winter between November and February. Therefore, they concluded that there was only one generation of *Hyalomma anatolicum anatolicum* per year (Ahmed *et al*., 2005)

In this study, we observed that the highest infested site in examined sheep was the ear (43.2%), followed by mixed sites (ear or eye, tail) (29.4%), tail (27.1%), and finally udder (0.3%). These results were similar to the work of Ali, (2019) who found the highest infested site in sheep was the ear (9.85%) and the lowest infested site was the eye (0.26%). This might be due to the fact that the attachments of ticks depend on several factors, including temperature, skin thickness, density and season (Seyoum, 2005).

In present study, the results showed that 71 out of 90 sheep (78.9%) were infested by low level of ticks burden (1 – 5 tick per animal), whereas 16 out of 90 sheep (17.8 %) were infested by middle level of ticks burden (5- 10 tick per animal). On the other hand, 1 out of 90 sheep (1.1%) was infested by high level of ticks burden (10 – 15 tick per animal), while 2 out of 90 sheep (2.2%) were infested by the highest level of ticks burden (15 – 20 tick per animal). This result also was in disagreement with Ahmed *et al*., (2005) and Mohammed (1999) who found the mean numbers of ticks per sheep were (11.2) and (6.7), respectively. This may due to fact that ticks development and survival depend on many factors, including host availability, vegetation coverage, and climate. As the climate condition change has a big influence in tick distribution and density (Randolph, 2009; Dantas-Torres, 2010; Léger *et al.,* 2013).

The statistical analysis was revealed that there is no significant association between tick infestation and herd size (p = 0.481). This finding in line with Ali, (2019) who found no significant association between tick infestation and herd size (p=0.151). On the contrary, our results disagree with Hassan, (2020) who found a significant association between herd size and tick infestation. This result could be due to the fact that the high flock density increases the chance of tick to infest a large number of animals (Lihou, 2020).

The statistical analysis showed that a significant association between tick infestation and housing type (p-value = 0.000), where the prevalence of tick infestation in open type (77.8%) was higher than semi- closed type (44.4%). A similar finding was observed by Rehman *et al*., (2017), who reported the higher tick prevalence in farms that utilizes grazing practice than these farms that used a closed system. This might be due to animal movement from an ecological zone to another, which is considered as a means of the introduction of animals into new ecosystems that rich with ticks (Cumming, 1999).

Based on the rearing system, the higher prevalence of tick infestation was reported in one rearing system (77.1%), while in the mixed rearing system the prevalence was (63%). Chi-square analysis revealed that there was no significant association between the rearing system and tick infestation (p =0.127). This result was in disagreement with Alrayah

(2019) who found the rearing type had a significant influence in the prevalence of tick infestation (P=0.000). This difference could be due to several factors associated with tick survival such as climate, location, husbandry system and availability of the host (Tatchell and Easton, 1986).

Chi-square analysis showed that there was a significant association between tick infestation and feeding type (p-value = 0.000), whereas the prevalence of tick infestation was higher in animals that feed on roughages. (78.3%) compared with animals that feed on the mixed type (48.1%). On the contrary, Ali, (2019) found no association observed between the type of feed and ticks infestation (p-value = 0.181). This finding is most probably attributable to several important factors including malnutrition, poor husbandry systems, and management problems (Sileshi *et al.*, 2007).

Our study showed that in relation to sheep sex, female sheep had a higher prevalence rate of ticks infestation (51.9 %) than male sheep (48.1 %) (P-value= 0.021). This result is agreed with Rehman *et al.*, (2017) who found female animals had significantly higher ticks burden than males. In fact, a higher level of prolactin and progesterone hormones could make females more susceptible to any infection (Lloyd, 1983).

Although Chi-square results showed that there was no significant association between age and tick infestation (p = 0.754). Old sheep had the highest prevalence of tick infestation (75%), followed by adults (67.6%), and finally young (60%). This result resembled the findings of studies carried out by Manan *et al.* (2007), Vatsya *et al.* (2007) and Kabir *et al.* (2011). This might be due to the fact that young animals seem to be more capable of protecting themselves from ticks by innate and cell-mediated immunity (Okello-Onen *et al.*, 1999).

In the current study, there was no significant association between the prevalence of tick infestation and coat color was observed (p =0.846). This finding was opposite to that reported by Mohammed and Hassan (2007) who found that the coat color had a significant influence in the prevalence of tick infestation.

The prevalence of tick infestation on the farm that did not practice tick control was higher (76.1%) in comparison with farms that practiced tick control (48.1%). The analysis showed that there was a significant association between tick control and tick infestation (p- value=0.001). This result was agreed with Bedada (2014) who found that the prevalence of tick in uncontrolled areas was significantly higher than in controlled areas in Ethiopia.

There was a significant relationship between the tick infestation and the methods used to control ticks (p- value = 0.005), whereas the prevalence of tick infestation was higher in farms that didn't use any methods of tick control (76.1%) compared with the farms that used mixed methods (66.7%) or used acaricides for tick control (47.7%). This result opposes the results of Fadlalla (2019) who found there was no significant association between tick prevalence and the methods used to control ticks in Khartoum state. Although the use of acaricides was closely related to the prevalence of ticks since farms that used acaricides had low tick prevalence. However, they found that the ticks existed in all livestock, due to acaricides resistance might occur (Rehman *et al*., 2017).

On other hand, the analysis showed that there was a highly significant association between the removal of manure and tick infestation (p =0.000). These results are in line with Fadlalla, (2019), and Hassan, (2020)who found there the frequency of manure removal had a significant influence on the prevalence of tick infestation (P=0.005), (P= 0.000) respectively. 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 measures, which in turn reduce the population of the tick (Walker et al., 2003).

CONCLUSION

It can be concluded that the tick infestation in sheep in River Nile state, generally, was high (66.7%) of the examined sheep were infested with ticks. Five tick species belong into two genera were found during this study, these included *Rhipicephalus eversti eversti* which was the most common species in the state (38%), followed by *Hyalomma anatolicum* (23.8 %), *Rhipicephalus sanguineus* (20.6%), *Rhipicephalus praetextatus* (16.4%), and *Hyalomma dromedarii* (1.2%).

The analysis showed that there was a significant association between tick infestation and localities, housing type, feeding type, sex, tick control, methods of control, and removal of manure.While the other factors did not show any significant association with tick infestation.

RECOMMENDATIONS

1. Information about ticks and tick-borne diseases in River Nile state is few. Therefore, more studies are needed to assess the current tick's distribution and prevalence rate and to develop a scientific basis for their control.
2. We Need to laboring proper disease control measures in Sudan in order to increase animal production especially sheep and goats.
3. More investigations are needed to find out the relationship between tick infestation and the presence of tick-borne disease in farms and associated risk factors.

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Appendix

QUESTIONNAIRE

Date:……………………………………………

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