TICKS AND TICK-BORNE DISEASES OF CATTLE AND SHEEP IN NORTH DARFUR STATE, SUDAN

By
Suad Abadllah Hammad Ibrahim
B.V.Sc., 1999
Nyala University

Supervisor
Prof. Mahmoud Musa Mahmoud
Department of Preventive Medicine and Veterinary Public Health
Faculty of Veterinary Medicine
University of Khartoum

Co-Supervisor
Dr. Shawgi M. Hassan
Department of Parasitology
Faculty of Veterinary Medicine
University of Khartoum

A dissertation submitted to the University of Khartoum
in partial fulfillment of the requirements for the Degree of
Master of Tropical Animal Health (M.T.A.H)

February 2009
DEDICATION

To my father and mother

To my brothers and sisters

To all those who helped me, with all my love
ACKNOWLEDGEMENTS

Thanks to Almighty Allah for His blessing on me that enabled me throughout my work.

I would like to express my gratitude and appreciation to my supervisor Prof. Mahmoud Musa Mahmoud, Department of Preventive Medicine; I also wish to express my deep sense of gratitude and sincere appreciation to my co-supervisor Dr. Shawgi M. Hassan for beneficial advice, much care and considerable assistance. I am greatly indebted to the Department of Preventive Medicine and Veterinary Public Health. My sincere thanks also to Prof. AbdelRahim Mohamed El Hussein, Director, Central Laboratory. I would especially like to acknowledge the assistance of Dr. Khalid Anan, Central Laboratory for his kind support during the laboratory work.

My thanks are also extended to Dr. Mekki Abdalla, Dr. Dia Salih, Dr. Khalid Taha, Dr. Bukhary and Dr. Esam Adam for their help in my work.

Special thanks to all the Technical staff of Department of Parasitology, Faculty of Veterinary Medicine, University of Khartoum.

I am very grateful to Elfasher Laboratory and the rest of the staff especially Dr. Mona Jido.

Special thanks are due to my colleagues at M.T.A.H. The 7th batch.

Last but not least, I would like to express my gratitude to the members of my family for their patience and encouragement.
LIST OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEDICATION</td>
<td>I</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>II</td>
</tr>
<tr>
<td>List of contents</td>
<td>III</td>
</tr>
<tr>
<td>List of figures</td>
<td>V</td>
</tr>
<tr>
<td>List of tables</td>
<td>VI</td>
</tr>
<tr>
<td>Abstract</td>
<td>VII</td>
</tr>
<tr>
<td>Arabic abstract</td>
<td>VIII</td>
</tr>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
</tbody>
</table>

CHAPTER ONE: LITERATURE REVIEW .................................... 4

1.1 The ticks .................................................................. 4
1.2 Taxonomy .................................................................. 4
1.3 Biology .................................................................. 5
  1.3.1 Tick life cycle ........................................... 5
    1.3.1.1 One-host tick ......................................... 5
    1.3.1.2 Two-host tick .......................................... 5
    1.3.1.3 Three-host tick ...................................... 6
1.4 Ecology .................................................................. 6
1.5 Tick distribution in the Sudan ................................ 7
1.6 Economic importance of ticks ................................ 8
  1.6.1 Direct effects ............................................. 8
  1.6.2 Toxicosis ................................................... 9
  1.6.3 Transmission of diseases ................................ 9
1.7 Tick-borne diseases of importance .......................... 10
  1.7.1 Anaplasmosis .............................................. 10
  1.7.2 Babesiosis ................................................ 11
  1.7.3 Theileriosis ............................................. 12
  1.7.4 Heartwater ................................................. 13
1.8 Control of ticks and tick-borne diseases .................... 14

CHAPTER TWO: MATERIALS AND METHODS ........................... 16

2.1 Study area ............................................................. 16
  2.1.1 Sites selected ............................................... 16
2.2 Collection of samples ............................................ 17
  2.2.1 Tick collection ............................................. 17
  2.2.2 Blood smear collection .................................... 19
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>FIG</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Types of cattle and sheep in the study area</td>
<td>18</td>
</tr>
<tr>
<td>2</td>
<td>Diagram showing location of test samples and control sera on the slide.</td>
<td>23</td>
</tr>
<tr>
<td>3</td>
<td>Photo of <em>Amblyomma lepidum</em> (male).</td>
<td>26</td>
</tr>
<tr>
<td>4</td>
<td>Photo of <em>Amblyomma varegatum</em> (male).</td>
<td>27</td>
</tr>
<tr>
<td>5</td>
<td>Photo of <em>Boophilus decoloratus</em> (female)(a,b)</td>
<td>28</td>
</tr>
<tr>
<td>6</td>
<td>Photo of <em>Hyalomma dromedarii</em> (male).</td>
<td>29</td>
</tr>
<tr>
<td>7</td>
<td>Photo of <em>Hyalomma impeltatum</em> (male).</td>
<td>30</td>
</tr>
<tr>
<td>8</td>
<td>Photo of <em>Hyalomma marginatum rufipes</em> (male).</td>
<td>31</td>
</tr>
<tr>
<td>9</td>
<td>Photo of <em>Hyalomma truncatum</em> (male).</td>
<td>32</td>
</tr>
<tr>
<td>10</td>
<td>Photo of <em>Rhipicephalus evertsi evertsi</em> (female)(a,b).</td>
<td>33</td>
</tr>
</tbody>
</table>
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Seasonal changes of <em>Hyalomma impeltatum</em> infesting cattle in May and September 2008 in Efasher area, North Darfur</td>
<td>36</td>
</tr>
<tr>
<td>2</td>
<td>Seasonal changes of <em>Hyalomma impeltatum</em> infesting sheep in May and September 2008 in Efasher area, North Darfur</td>
<td>37</td>
</tr>
<tr>
<td>3</td>
<td>Seasonal changes of <em>Hyalomma impeltatum</em> infesting cattle and sheep in May and September 2008 in Efasher area, North Darfur</td>
<td>38</td>
</tr>
<tr>
<td>4</td>
<td>Means (± SE) of <em>Hyalomma impeltatum</em> infesting cattle and sheep in May and September 2008 in Efasher area, North Darfur</td>
<td>39</td>
</tr>
<tr>
<td>5</td>
<td>Means (± SE) of <em>Hyalomma impeltatum</em> infesting cattle in May and September 2008 at different sites in Efasher area, North Darfur</td>
<td>40</td>
</tr>
<tr>
<td>6</td>
<td>Means (± SE) of <em>Hyalomma impeltatum</em> infesting sheep in May and September 2008 at different sites in Efasher area, North Darfur</td>
<td>41</td>
</tr>
<tr>
<td>7</td>
<td>Means (± SE) of <em>Hyalomma impeltatum</em> infesting cattle and sheep in May and September 2008 at different sites in Efasher area, North Darfur</td>
<td>42</td>
</tr>
<tr>
<td>8</td>
<td>Ticks collected in very low numbers from cattle in Elfasher area, Northern Darfur during May and September 2008</td>
<td>43</td>
</tr>
<tr>
<td>9</td>
<td>Ticks collected in very low numbers from sheep in Elfasher area, Northern Darfur during May and September 2008</td>
<td>44</td>
</tr>
<tr>
<td>10</td>
<td>Prevalence rates of <em>Theileria lestoquardi</em> antibodies in sheep in different sites in Elfasher area, North Darfur as determined by IFA test during May and June 2008</td>
<td>45</td>
</tr>
</tbody>
</table>
In this survey, ticks were collected from 54 cattle and 53 sheep in the North Darfur State to study their genera and species during May to September 2008. Cattle and sheep were from Darassalaam, Wadaa, Wadkuta, Alawona, Zamzam, and El Fasher.

Three hundred adult ticks were collected. Four genera and eight species were identified. These included *Amblyomma lepidum*, *A. variegatum*, *Hyalomma dromedarii*, *H. impeltatum*, *H. marginatum rufipes*, *H. truncatum*, *Boophilus decoloratus*, *Rhipicephalus evertsi evertsi*. All of which are famous for harboring and transmitting arthropod-bone infection. The most predominating tick species was *H. impeltatum*.

To determine diseases which are possibly transmitted by ticks, 96 blood smears were examined but all the samples revealed no blood parasites. Also, 100 sheep serum samples from different areas were examined using IFA test to elucidate *Theileria lestoquardi* antibodies. Thirty Two per cent revealed antibodies against *T. lestoquardi*. The highest mean prevalence (12%) was in El Fasher town while the lowest mean (1%) was recorded in Wadaa.

In spite of the short period of the study some economically important ticks were reported. It is, therefore, recommended to conduct an intensive survey using advanced techniques in the North Darfur State that is rich in livestock. It is also recommended to apply tick control measures depending on an intensive survey outcome.
ملخص الطربوحة

تم جمع عينات قراد من 54 بقره و53 ضان من سلالات الأبقار والضان الموجودة بولاية شمال دارفور لمعرفة انواعها وانواع طفليات الدم التي تنقلها وذلك في مابين شهر مارس وسبتمبر 2008. هذه الأبقار والضان موزعة في ستة مناطق من المراعي الطبيعية في دار السلام - ودعة - ودكوة - عالونا - ززمزم - الخان. جمعت 300 عينة قراد من الطور البالغ متطفلا على الأبقار والضان وتم التعرف على ثمانية أنواع وهي: Amblyomma lepidum, A. variegatum, Hyalomma dromedarii, H. impeltatum, marginatum rufipes, H. truncatum, Boophilus decoloratus, Rhipicephalus evertsi evertsi وكلها مشهورة بنقل الأمراض. وتم تحديد انتشار طفليات الدم المنقوطة بواسطة القراد تم فحص 96 عينة شريحة م، بعد صيغة بعضها تاصيب جسم ولم يسجل أي طفل في هذه العينات. كما تم فحص 100 عينة اقترح على استخدام اختبار الأجسام المضادة الفلورسنتي المنتج غير المباشر وظهور الأجسام المضادة لطفيل Theileria lestoquardii في عينة 32 عينة (32%) و heavenly معدل انتشار كان (12%) في مدينة الفاخر بينما أقل معدل (1%) قد سجلت في ودعة.

رغم قصر فترة الدراسة إلا أن الدراسة دلت على وجود القراد الاهتمام اقتصاديا والناقل للمرض، وبما أن هذه الولاية من الولايات الغنية بالثراء الحيويية فإنها تحتاج إلى مزيد من المسح في هذا المجال. وذلك باستعمال التقنيات المتطورة لمعرفة الأمراض التي ينقلها القراد. وتوصي كذلك بمكافحة القراد حسب ما تتمخص عنه نتائج المسح الشامل مستقبلا.
INTRODUCTION

Ticks are important ectoparasites in tropical and subtropical areas. They harm animals by feeding on blood and as vectors for various agents of disease in both man and animals. The effective control of tick-borne diseases depends on understanding of the epidemiological factors that favour the establishment of ticks and the parasites carried by them. The geographic distribution of ticks can be determined by Geographical Information System (Korok, 2005) and by (Hoogstraal, 1956).

Ticks are blood feeding external parasites of mammals, birds and reptiles throughout the world. Approximately 850 species have been described worldwide (Furman and Loomis, 1984). There are two well established families of ticks, the Ixodidae (Hard ticks), and Argasidae (soft ticks). Both are important vectors of diseases caused by bacteria, rickettsiae, protozoa, and viruses.

Infestation with ticks causes direct and indirect damage to animals. The direct damage arises from tick bite, dermatitis and loss of blood on which the tick feeds, whereas indirect damage is caused by diseases transmitted through the tick bite (Bwangamoi, 1979, cited in Lazarus, 2002). Tick-borne protozoan diseases, most importantly theileriosis and babesiosis, rickettsial diseases such as anaplasmosis, cowdriosis and ehrlichiosis, as well as direct effects of tick infestation are the major health and management problems affecting productivity of livestock in many developing countries. Africa has an estimated 200 million cattle, 70% of which are under risk from simultaneous infestation by several species of ticks (Dipeolo et al., 1992). Wildlife
are also infested with the same or other species of ticks and in many instances may act as tick-borne disease reservoirs (Brocklesby and Barnett, 1966).

In the Sudan, ticks and tick–borne diseases are widespread. They represent a threat to domestic, exotic cattle and their crosses in the country causing substantial losses in both animals and their products (Latif, 1994). Ticks infesting livestock in the Sudan are mainly due to some species of the genera Amblyomma, Boophilus, Hyalomma and Rhipicephalus (Hoogstraal, 1956).

The Sudan is the largest African country with livestock estimated to be 137 million of which 40 million are cattle, 50 million sheep, 42.5 million goats, 4 million camels and 0.5 million horses, in addition to wildlife and an unknown number of donkeys, dogs and cats (Abdallah, 2007). Inspite of the large number of livestock, the outcome is reduction in production and productivity, due to tick infestation.

The major factors limiting livestock productivity in Northern Darfur is poor nutrition, lack of drinking of water, overgrazing, and diseases such as bacterial, viral and parasitic diseases, external parasites most important of which are ticks, lice, mites and flies in transmission of diseases. Studies on parasitic diseases are needed to show the impact of control of external parasites mainly ticks, and diseases transmitted by biting Flies. External parasites have not been studied extensively in Northern Darfur State before; therefore the objective of this study was:-
1- To study ticks on cattle and sheep in the Elfasher area with a view to determine tick species this may be responsible for parasitic diseases and ill health.
CHAPTER ONE
LITERATURE REVIEW

1.1. The ticks:

A tick is one of the members of group of arachnids which parasitize on mammals, birds, and reptiles. All ticks are blood sucking parasites. Ticks are found in most parts of the world but are generally limited to those habitats frequented by their hosts namely, and to woods, tall grasses, crevices and shrubby vegetation where they climb and wait to cling on a passing host (Oleg Kozhukhov, 2007). There are two families of ticks, the family Argasidae (soft ticks), which lacks scutum and the dorsum is covered by leathery integument and the family Ixodidae (hard ticks) whose scutum or dorsal shield covers the entire upper surface of male and relatively a small area just behind the head in the female (Soulsby, 1982).

1.2. Taxonomy:

Ticks are classified under the class Arachnida, Order Acarina, suborder Ixodoidea, families Ixodidae, Argasidae, and Nuttalliellidae which are distributed worldwide (de Lafuente and Kocan 2006). There are 899 tick species which parasitize vertebrates including Argasidae (185 species) Ixodidae (713 species) and Nuttalliellidae (one species) (Barker and Murrell, 2004). Family Ixodidae (hard ticks) contains (684) species under many genera. These include Amblyomma (102 species) Aponomma (24 species) Boophilus (5 species) Dermacentor (30 species) Haemaphysalis (155 species) Hyalomma (30 species), Ixodes (254 species), Cosmiomma (1 species), Nasomma (1 species),

4
Rhipicephalus (70 species), Anomalohimalaya (3 species), Rhipicentor (2 species), and Margaropus (3 species).

1.3. Biology:

Ticks are divided in two major families of which the Ixodidae (hard ticks) are of greater veterinary importance than the Argasidae (soft ticks). There are four stages in the life cycle of ticks which are egg, larva, nymph, and adult (Hoogstraal, 1956; Bowman, 1999).

1.3.1. Tick life cycle:

The life cycle of tick involves according to feeding habitat a characteristic number of host individuals. The Argasid species are characterized by multi-host feeding pattern, whereas the life cycle of most Ixodid species typically involves a 3-host cycle, though some species have a 1 or 2 host cycle. According to the number of the hosts they require during their life cycle, ticks can be classified into three groups:

1.3.1.1. One-host tick:

One-host ticks parasitize large hosts mainly bovines and equines. Once the larva finds a suitable host, feeding and moulting proceed sequentially on the same host until the adult stage is reached. This type of life cycle is characteristic of Boophilus spp.

1.3.1.2. Two-host tick:

In these species, the larval and nymphal stages are spent on the same animal, but the nymph drops off to moult to the adult stage, which then seeks a final host. A few species in the genera Hyalomma and Rhipicephalus, (e.g. H. marginatum rufipes and R. evertsi evertsi).
Living typically in regions with long dry or cold seasons, and irregularly available hosts have a 2-host life-cycle.

1.3.1.3. Three-host tick:

In these species, the larvae, nymphs, and adult females feed on different host individuals. Larvae and nymphs detach and fall to the ground before moulting to the next stage and searching for a new host. In many instances larvae and nymphs of most species feed on small mammals (rodents) or birds, while adults prefer larger hosts.

1.4. Ecology:

Tick distribution and their population vary according to their adaptability to ecology, eco-climate, microhabitats ambient temperature, rainfall and relative humidity which are critical factors affecting life cycle of ticks (Tatchell and Easton, 1986). The relative humidity, on the other hand, remains an important factor for survival of ticks by regulating the water balance and prevents dehydrations as stated by Hassan (2003). He also stated that, the high humidity is particularly more required for survival of Ixodid ticks than the Argasid ticks. Ixodid ticks quickly die of desiccation when exposed to humidity below critical equilibrium values. Schulze et al. (2001) found that *Ixodes scapularis* tended to quest earlier and later in the day when temperatures were low and the relative humidity higher. Hence humidity plays an essential role in ticks activities and survival. Rainfall is another factor which has a significant role in ticks ecology and distribution throughout the world. The effect of the rainfall on ticks challenge to their hosts was investigated at Kyle Recreational Park in Zimbabwe (Mooring et al., 1994). They found that *R. appendiculatus* adult infestation on host were 2-3 times more during
the high rainfall. They concluded that ticks burden on hosts are high during the wet season due to high rainfall. Vegetation also provides the shade and optimum humidity in microclimate habitats of ticks enhancing their survival during adverse situation (Hassan, 2003). They are widely distributed throughout the world particularly in tropical and subtropical countries. Age grading of ticks requires theoretical adaptation because of fundamentally different relationship between feeding and transmission opportunities of insect and tick (Zahid et al., 2006). Estrada–Pena (2001) reported that seasonal dynamics exert a major influence on the dynamics of transmission of tick-borne pathogen. Chaka et al. (2001) studied determination of the physiological age of *R. appendiculatus*. The age structure of a population of vectors of disease pathogens is a most useful characteristic for epidemiological studies.

1.5. Tick distribution in the Sudan:

In the Sudan, tick fauna is composed 64 species and subspecies of both Argasid and Ixodid ticks (Hoogstraal, 1956). Most ticks of potential medical and veterinary importance in Ethiopian fauna region are found in the Sudan. Ticks occupy a wide range of ecological niches that form the climate of the country. Most Sudanese tick collections were made from Equatoria region (Hoogstraal, 1956). Osman and Hassan (2003) reported that distribution of *A. lepidum* in the Sudan is generally concentrated in the eastern parts of the country (from Torit and Kapoeta in the South and as far as Kassala in the north). The tick is absent from Northern and Khartoum provinces. It is present together with *A. variegatum* in Darfur, Kordofan, Baher Elgazal and Equatoria provinces (FAO, 1987; Osman, 1978; Abdalla,
The ecological distribution of ticks found on cattle, sheep, goat and camels in Darfur and Kordofan regions was studied by Osman (1978) and Osman et al. (1982). In Southern Darfur, ticks reported on cattle were *H. truncatum*, *H. rufipes*, *H. impeltatum*, *Boophilus annulatus*, *R. sanguineus*, *R. longus*, *R. e. evertsi* and *R. simus* (Osman, 1978). In Southern Sudan the prevalent ticks are *A. lepidum*, *A. variegatum*, *B. decoloratus*, *B. annulatus*, *H. rufipes*, *H. truncatum Haemaphysalis leachii leachii*, *R. e. evertsi*, *R. simus*, *R. pravus*, *R. appendiculatus*, and *R. sanguineus* (Morzaria et al., 1981; Julla, 1994; Korok, 2005; Salih, 2008).

### 1.6 Economic importance of ticks:

Ticks cause great economic losses to livestock and have adverse effects on livestock in several ways (Snelson, 1975) and parasitize a wide range of vertebrate hosts and transmit a wide variety of pathogenic agents than any other group of arthropods (Oliver, 1989). Ticks constitute the most important livestock pest in Africa and are found in the entire 30 million square kilometers of the African continent (Punyua, 1992). Ticks affect livestock health in three ways:

#### 1.6.1. Direct effects:

Attachment to the host causes irritation and direct injury of the skin, with subsequent ulceration and sometimes secondary bacterial infection. Feeding by large numbers of ticks causes reduction in live weight and anaemia among domestic animals, while tick bites also reduce the quality of hides and skins. Apart from irritation or anaemia in the case of heavy infestations, tick can cause severe dermatitis (FAO, 1998). These parasites generate direct effects in cattle in terms
of milk production and reduced weight gain (L¨Hostis and Seegers, 2002; Peter et al., 2005).

1.6.2. Toxicosis:

Some ticks are capable of releasing toxins in the host which causes progressive, ascending, and febrile paralysis. Although affected animals may die, the paralysis is relieved quickly if the ticks are removed. Most domestic animal species appear to grades from tick paralysis. Tick paralysis is characterized by an acute ascending flaccid motor paralysis caused by the injection of a toxin by certain ticks while feeding. Example is paralysis caused by feeding of Dermacentor andersoni. The most common tick toxicosis is probably "sweating sickness" caused by an epitheliotropic toxin produced by Hyalomma truncatum.

1.6.3. Transmission of diseases:

Ticks can be carriers of pathogens, which they transmit from host to host during blood sucking and cause a large variety of diseases (FAO, 1998). The major diseases include babesiosis, theileriosis, anaplasmosis, heartwater, East Coast fever and some viral diseases. In addition, other diseases of lesser importance cause severe economic losses to the livestock industry (Drummond, 1983; Bran, 1983). The presence, dynamics and amount of parasitized stock by ticks exert a major influence on the kinetics of transmission of tick-borne diseases (Morel, 1980). Generally, ticks become infected with the causative organisms of diseases while they are feeding on infected animals. Then, the organism may be transmitted from stage to stage in the tick (an example is Theileria parva transmitted by Rhipicephalus appendicuatus), or from the female tick through the egg to the larvae
an increase of several thousand times in vector potential (an example is *Babesia bovis* transmitted by *B. decoloralus*). When the next stage or generation subsequently feeds on another animal, the organism is transmitted to that animal if it is susceptible to the disease (Drummond, 1983). Tick-borne diseases generally affect the blood or lymphatic system (FAO, 1998). Tick fever organisms, like *Anaplasma marginale*, are significant causes of cattle morbidity in Australia, USA, China and other countries (CRC-VT, 2001)

1.7. Tick-borne diseases of importance:

The major tick-borne diseases of importance to the livestock industry can be classified according to Coetzer *et al.* (1994) and Kaufmann (1996) as follows:

1.7.1. Anaplasmosis:

This group of diseases is caused by Rickettsia-like organisms of the genus *Anaplasma*, which are usually transmitted by ticks, but may also be transmitted mechanically by biting diptera (e.g. Tabanidae and *Stomoxys*). Anaplasmosis affects domestic and wild ungulates and is widespread throughout the tropics. Anaplasmosis in cattle, caused by *Anaplasma* species is characterized by jaundice, anaemia, and debility. It is transmitted by the tick through transovarian and stage to stage transmission (Wanduragla and Ristic, 1993).

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, the incidence of the disease in traditionally managed cattle was very low (1.5%) in northern Sudan (Abdallah, 1984). *A. marginale* was regularly observed in the blood smear of healthy cattle in areas of the Blue and
White Nile ecosystems (Jongejan et al., 1987). Suleiman and Elmalik (2003) reported prevalence of *Anaplasma* spp. infection in Khartoum State using IFA test. In 147 samples, they found 11.6% positive for the disease.

Treatment with long-acting tetracyclines and imidocarbs is effective. An attenuated vaccine of *A. centrale* was used to control the disease in Australia, Bolivia, Colombia and Argentina (Montenegro-James, 1991).

**1.7.2. Babesiosis:**

Babesiosis is widespread throughout the tropics causing heavy losses in non-resistant livestock. Babesiosis is caused by protozoan parasites transmitted by ticks of the genus *Boophilus*. Without treatment, mortality rates are very high. Infection with *Babesia* spp. are characterized by haemolytic syndrome which includes continuous fever, high parasitaemia, anaemia, icterus and often haemoglobinuria which colours the urine dark brown and which gives the disease the common name of "red water". Infections associated with *B. bovis* are acute or sub acute, rapidly leading to death. Acute disease can cause nervous symptoms such as "pedaling" movements and aggressive behaviour. In cows abortion and agalactia (reduction or loss of milk) are early signs of infection. In Zebu cattle young animals, less than nine months old, are more resistant to the disease (Soulsby, 1982). Within the European cattle, all age groups are highly susceptible (De Vos and Potgieter, 1994). Within the host animal *Babesia* species multiply asexually forming erythrocytic forms which lead to formation of gametocytes which are picked by feeding ticks. Development of the organism to infective stage within ticks depends
on temperature. It is more rapid in ticks held at 28°C than those held at 25°C (De Vos and Potgieter, 1994). The parasite reaches the salivary glands, enters the acini and undergoes more multiplication forming sporozoites. Piroplasms appear in the blood of the host 7-35 days post tick bite (Seifert, 1996). This is followed by appearance of the symptoms manifested by rise in temperature, lachrymation, salivation and oedema of subcutaneous tissues. The disease is differentiated from anaplasmosis by the absence of hemoglobinurea in anaplasmosis and leptospirosis infection of young animals in the case leptospirosis (Hall, 1985).

1.7.3. Theileriosis:

Theileriosis is caused by species of the protozoa *Theileria*, transmitted by ticks of the genera *Rhipicephalus, Hyalomma* and *Amblyomma*. *Theileria* spp is responsible for the most pathogenic tick-borne disease of cattle. *T. parva*, causes East Coast fever (ECF), which affects millions of cattle in eastern and southern Africa (Norval *et al.*, 1992), while *T. annulata*, which causes tropical theileriosis, is widespread throughout the Mediterranean basin, the Middle East and Asia. On feeding of infected ticks on a susceptible animal, sporozoites are injected with the saliva to invade lymphocytes. The sporozoites then initiate transformation of the lymphocyte into lymphoblastoids within which the macroschizonts develop into microschizonts. Rupturing of lymphocytes then occur resulting in the release of free merozoites which invade red blood cells to develop into piroplasms which are picked up by the feeding tick to develop sexually into sporozoites in the tick salivary gland (Irvin, 1985). In the Sudan, occurrence of the disease has been realized since the beginning of last
century (Abdallah, 2007). Since then it has been shown to be endemic allover the northern parts of the country (FAO, 1983, Osman, 1992). The efficient field vector of *T. annulata* has been found to be *H. a. anatolicum* (FAO, 1983). High losses particularly in calves, exotic breds and their crosses have been reported. Latif and Shawgi (1982) found that cross-breed calves in Nisheishiba usually die of the disease at the age of 14-29 days with a death rate decreasing after the age of 50 days. In southern Sudan, antibodies to *T. annulata* were detected during serological surveys. However, as the parasite vectors were not reported to occur in the area, it was suggested that these antibodies, shown by IFA test might have been due to cross reactivity with *T. parva* antibodies (FAO, 1983).

1.7.4. Heartwater:

Heartwater or cowdriosis is specific to cattle, sheep, goats and some wild ruminants, and is prevalent in much of Africa and the Caribbeans. It is caused by the rickettsia organism *Ehrlichia ruminantium* transmitted by ticks of the genus *Amblyomma* through stage to stage transmission (Uilenberg and Camus, 1993). Heartwater is most severe in small ruminants. The disease is one of the most devastating livestock in sub-saharan Africa (Collin *et al.*, 2003; Deem, 1998) and causes considerable economic losses of domestic livestock. However, indigenous cattle can also be affected if poor conditions weaken their immune system, or if animals are moved from an area free of Heartwater to an endemic area. Heartwater is characterized by nervous signs (continuous movement of head and limbs, ear, tongue and jaw). Muscular tremors and circling with rigidity of the neck (Uilenberg *et al.*, 1983; Petney *et al.*, 1987). Endothelial cells of
jugular vein, brain and blood vessels stained with Giemsa’s stain will reveal colonies of dark blue or reddish purple coloured organisms.

**1.8. Control of Ticks and tick-borne diseases:**

Tick control strategy depends mainly on the fact that ticks are found during their life cycle in many habitats which are represented by animals as hosts, cracks, crevices, soil and pasture, and so combating them should be directed to these habitats. Control strategies should be established upon full information on the magnitude of the economic losses and the benefit of the control. Therefore, veterinary epidemiology and economic hold a unique role in the national policies and strategies for improved animal health worldwide (Brain et al., 2001). The role of epidemiology, and economics was referred to by Perry and Young (1995).

Indigenous cattle have been exposed to ticks and tick-borne diseases for a prolonged period of evolutionary time, and have survival without major losses where the ecological relationships between them have not been disturbed. It is widely recognized that indigenous breeds are highly resistant to ticks and acquire immunity to tick-borne diseases if exposed to them at an early age. If the losses in cattle production, from ticks and the diseases they transmit, are to be prevented or eliminated, it is necessary to control ticks. The widest treatment of animals is by dipping or spraying with natural or synthetic chemicals (FAO, 1982a). Strict tick control is only feasible on farms or ranches which are fenced off and where no stray animals or birds can come in from outside. Other domestic and wild animals are often a complicating factor in proper tick control. *Amblyomma* spp. and *Hyalomma* spp. are especially difficult to control, as the
immature stage of these ticks commonly feed on small animals, and are brought into farms by birds (FAO, 1982b).

Immunization using anti tick vaccine, exploitation of natural resistance phenomenon of tick infestation, an observed phenomenon during the tick-host relationship is the development of resistance against ticks. This resistance appears to be maintained on subsequent infestation with the same tick species and sometimes show the ability to cross react with other tick species. This consists either of innate or acquired components and featured by reduced attachments, engorgement and development of the ticks (Latif, 1984). Manipulation of the environment to make it hostile to survival conditions of non-parasitic stages of ticks by modification of habitats (Suleiman, 2005; Fourier et al., 1996) are among the package. Burning (Davidson et al., 1994) and heavy grazing are likely to reduce tick population. A simulation model has been developed by Hernandez et al. (2000) to evaluate cattle tick population dynamics, in systematic pasture rotation systems, and integrated pest management (IMP) approaches for managing ticks in the tropical dry forest ecological zones in Venezuela.
CHAPTER TWO
MATERIALS AND METHODS

2.1. Study Area:

The study area is located in South and South east of Elfasher town. Annual rainfall in northern Darfur is generally low and very variable ranging from 20 to more than 50 mm (low in the north to high in the south of the state). Soil types and soil fertility are of two types sandy and clay soils. The first type covers 90% of the area. Various types of livestock including cattle, sheep, goats, camels in addition to equines and poultry are raised under traditional husbandry system characterized by poor husbandry practices with low productivity. Animal population in North Darfur is estimated as 4,997,000 cattle, 6916330 sheep, 3100761 goats, 1582390 camels and considerable numbers of donkeys and horses (report form Ministry of Animal Resources North Darfur State, 2001). The majority of these livestock are indigenous breeds owned by agro-pastoralists and sedentary cultivators. In Elfasher, natural grazing takes place except in limited areas where crop residues and cut forages are fed depending on seasonal fluctuation. Livestock are major source of livelihood in Elfasher as in many parts of Darfur. They are owned by a large segment of the community and attempts to increase their productivity are on important means to improving the standard living of the people.

2.1.1. Sites selected:

Six areas in Elfasher were selected to carry out the study. The selection was based on facts that these areas are highly populated with
livestock and during these months the animals move out of areas that are otherwise inaccessible.

2.2. Collection of samples:

Six sites and some farms in Elfasher town were selected. These sites were Wadaa, Darasalam, Elfasher town, Zamzam, Wadaluta and Alawona. Ticks were collected from the animal (cattle and sheep) kept under open grazing system. The samples included tick collection, blood smears and serum from blood collected from jugular vein. This was conducted during May and November 2008. Selection of cattle and sheep for samples collection was at random targeting adults of different breeds from pastoralists cattle and sheep of different sex groups.

2.2.1. Tick collection:

The animals were restrained and all visible ticks were collected using a pair of blunt forceps. 10 -20% animals were sampled in each area. The total samples collected were 154 animals from the six locations (74 heads of cattle and 80 heads of sheep). The ticks were put in glass bottles half-filled with 70% ethanol, tightly plugged with a rubber plug. Each bottle was labeled indicating site, animal number and date of collection.
2.2.2. Blood smear collection:

Blood smears were made from ear veins of animals on clean slides from which tick were collected. The blood smears were prepared according to McCosker (1975) by a drop of blood put on a microscope slide and using another slide to spread the blood at an acute angle that makes a thin film. They were air dried and fixed in absolute methanol for 2-3 minutes. The slides were labeled indicating site, type of animal, and date of collection.

In the laboratory, the smears were stained using 10% solution of Giemsa's stain for 30 minutes. The slides were washed with distilled water, air dried and scanned under X100 magnification using oil immersion lens for presence of piroplasms.

2.2.3. Serum collection:

80 serum samples were collected from each animal from the same sheep from which ticks were collected and 20 samples from other sheep in the same areas. Whole blood was taken from jugular veins using vacutainer tubes. Blood was allowed to clot at room temperature. Serum was separated and kept in vials that were labeled indicating site, type of animal and date of collection prior to storing at -20°C until used. In the laboratory, for IFA test the serum was used at dilution in PBS 1/80

2.3. Serological tests:

The most widely used diagnostic test for *Theileria* spp. is the indirect fluorescent antibody (IFA) test. For the IFA test, both schizont and piroplasm antigens may be prepared on slides or in suspension and preserved by freezing at less than or equal to -20°C,
except in the case of the piroplasm suspension, which is stored at 4°C.  

2.3.1. The indirect fluorescent antibody (IFA) test:  

The indirect fluorescent antibody (IFA) test is the most widely used diagnostic test for *Theileria* spp. The IFA test protocol was described by Burridge *et al.* (1974), FAO (1984) and Darghouth *et al.* (1996).

2.3.2. Phosphate buffered saline:  

One tablet of phosphate buffered saline (PBS) Dulbecco A (oxoid, England) pH 7.2 was dissolved in 1000 ml distilled deionised water and autoclaved at 15 lbs/sq in pressure for 15 minutes.

2.3.3. Conjugate:  

Rabbit anti-sheep immune gammaglobulin (IgG) conjugated to fluorescein isothiocyanate (FITC) was used. The conjugate was used at dilution in PBS that gives no loss of titre of positive control serum in the IFA test. Evans blue at a concentration of 0.01% was added to the conjugate as a counter stain.

2.3.4. Control sera:  

Positive control (C +ve) sera were obtained from Razzi institute, Iran. Negative control (C –ve) sera were obtained from BDSL, UK. Control sera (C –ve and C +ve) were diluted directly to 1/80.

2.3.5. Antigen preparation:  

The schizont antigen was prepared from a local *T. lestoquardi* and *T. annulata* cell line at low passage (<20 passage) Schizont
antigen slides were prepared from in vitro cultures of *T. lestoquardi* (Atbara)-infected cells. These cells were centrifuged, washed and resuspended in BPS, 3.5% bovine serum albumin. Cell suspensions were transferred into 12 wells of clean PTFE (polytetrafluoroethylene) coated multispot slides by pipetting 100µl of the suspension (1×10^7 cells/ml) into a well and immediately aspirated the excess. The slides were allowed to air-dry for one hour, fixed in acetone for min and allowed to dry at room temperature. According to the method described by FAO (1984). Antigen-coated slides were individually wrapped in tissue paper and packed in aluminium foil with five slides in each packet. The slide packets were labeled and stored in airtight, waterproof plastic containers at −20°C until used.

2.3.5.1. Mountant:

A volume of 50 mM tris buffer pH 9.2 was made up 50 ml and the pH was adjusted with NHCL (121 mb/l=6.05 mg in 50 ml). A volume of 10 ml was mixed with 20 ml glycerol to make a 66% solution of glycerol in PBS and stored at 4°C.

2.3.5.2. Schizont antigen slide:

The schizont antigen slides were allowed to thaw at 4°C for 30 minutes then placed at room temperature for another 30 minutes before they were unwrapped and labeled with sites and animal numbers.

2.3.6. Staining of antigen:

The antigen slides, once thawed and labeled were placed in Petri dishes on a moist filter paper. To each labeled slides, 25µl of
C+ve and C-ve were added in the wells 4 and 5, respectively (Fig. 1). The test sera were added to the rest of the wells by adding 25µl diluted sera using a single micropipette. A clean separate tip was used for each test serum. The slides were put in a plastic box with moist filter paper and incubated at 37°C for 30 minutes to allow antigen/antibody reaction takes place. They were then dipped with PBS in staining jar for 30 minutes to remove excess sera, with the buffer being renewed after the first 15 minutes. The slides were then held inverted onto a filter paper for excess PBS to drain. The slides were re-placed in a petri-dish with a moist filter paper, and 10 µl of the diluted conjugate was applied to each well of the slides. Then, they were incubated at 37°C for 30 minutes in the dark and washed with PBS as described above.
Fig. 2 A diagram showing location of test samples and control sera in the PTFE-coated multispot slide. (1-3 and 6-8, test sera)
2.4. Statistical analysis:

Ticks collected were subjected to appropriate general liner model (GLM) procedure of statistical analysis using SAS package. The SAS was used to perform analysis of variance (ANOVA) and mean separations were performed using Ryan- Einot- Gabriel-Welsch multiple range test (REGWQ) according to Day and Quinn (1989).
CHAPTER THREE

RESULTS

3.1. Tick survey

Several tick species were identified. Out of the 300 ticks collected, 4 genera and 8 different species were identified. These were the genera *Hyalomma*, *Amblyomma*, *Boophilus*, and *Rhipicephalus*. The individual tick species included *H. impeltatum*, *H. m. rufipes* *H. truncatum*, *H. dromedarii*, *A. variegatum*, *A. lepidum*, *R. e. evertsi*, and *B. decoloratus*. Most of the ticks collected were from the upper perineum. With the exception of *B. decoloratus*, *R. e. evertsi*, males outnumbered the females for all species encountered (Table 9). No *Amblyomma* spp. female were collected during the study period.
Fig. (3) *Amblyomma lepidum*, male.

Animal species: Cattle  
Place: Zamzam  
Date of collection: 7/9/2008
Fig (4) *Amblyomma variegatum, male*

Animal species: Cattle        Place: Zamzam
Date of collection 7/9/2008
Fig (5) *Boophilus decoloratus*, female(a,b)
Animal species: Cattle       Place: ELfasher
Date of collection 5/9/2008
Fig (6) *Hyalomma dromedarii*, male

Animal species: Sheep          Place: wadaa
Date of collection  25/5/2008
Fig (7) *Hyalomma impeltatum*, male

Animal species: Sheep  Place: Alawana
Date of collection 26/5/2008
Fig (8) *Hyalomma marginatum rufipes, male*

Animal species: Cattle  
Place: Darassalaam  
Date of collection: 11/5/2008
Fig (9) *Hyalomma truncatum*, male

Animal species: Cattle  Place: Wadkuta
Date of collection  18/5/2008
Fig (10) *Rhipicephalus evertsi evertsi*, female(a,b)

Animal species: Cattle  
Place: Elfasher  
Date of collection 7/9/2008
3.2. Ticks infesting cattle and sheep:

All cattle examined were found to be infested with the four tick genera and eight different species that included *A. lepidum, A. variegatum, B. decoloratus H. impeltatum H.m. rufipes, H. truncatum*, *R. e. evertsi, H. dromedarii* while sheep were infested with one genus (four species). (Table 9)

3.2.1. *H. impeltatum:*

This tick species was more predominant throughout the period of study in all areas. On cattle, the highest means were recorded in May (7.31±0.60) while the lowest means were recorded on September (5.40±0.53) (Table 1). Among the sites, the highest means were recorded in Wadaa (11.75±0.95) while the lowest means were recorded in Wadkuta (3.33±0.49) (Table 5). There was no significant difference in the means between the months and area. The highest mean tick infestation of sheep was during May (7.32±0.43) while the lowest means was in September (5.26±0.55). (Table 2). Among the sites the highest means were at Wadaa (13.83±1.74) while the lowest means were at Wadkuta (1.60±0.40) (Table 6). There was also no significant difference in the means between the months and area. The highest mean total body ticks was at Wadaa (12.64 ± 0.93) while the lowest mean was at Wadkuta (2.54 ± 0.41) (Table 7). Among the months, *H. impeltatum* recorded the highest means in May (7.32±0.43) and in September was (5.26 ±0.55) (Table 3). There was no significant difference in the means between the months and area in cattle and sheep. Mean cattle infestation with *H. impeltatum* (6.85±0.48) and sheep infestation was (6.72±0.48) with no significant difference (Table 4).
3.2.2. Ticks recorded in low numbers:

Ticks recorded in very low numbers in cattle included *H. m. rufipes*, *H. truncatam*, *H. dromedarii*, *B. decoloratus*, *A. variegatum*, *R. e. evertsi*, *A. lepidum* (Table 8). While ticks in sheep included *H. m. rufipes*, *H. truncatam*, *H. dromedarii* (Table 9). Variations in tick population on Cattle among the areas showed that *H. impeltatum* was the most predominant tick in almost every area. In sheep, only one genus. In Alawana area we have found *H. impeltatum*, and *H. m. rufipes* (Table 9).

3.3. Blood parasites and macroschizonts:

From the total 96 blood smear samples (sheep 52, cattle 44) laboratory examination showed neither piroplasms nor macroschizonts.

3.4. Serological findings:

Indirect fluorescent antibody test was performed using *T. lestoquardi* schizont antigens for detection of antibodies against *T. lestoquardi*. Out of 100 serum samples, 32% were found positive for *T. lestoquardi* antibodies. Prevalence was 60% in Elfasher, 40% in Zamzam, 33.3% in Alwona and 23.3% in Wadkuta. The lowest prevalence was in Wadaa 6.7% (Table 10).
Table 1: Seasonal changes of *Hyalomma impeltatum* infesting cattle in 2008 in Elfasher area, North Darfur.

<table>
<thead>
<tr>
<th>Month</th>
<th>Number of animals</th>
<th><em>H. impeltatum</em> males</th>
<th><em>H. impeltatum</em> females</th>
<th><em>H. impeltatum</em> males + females</th>
</tr>
</thead>
<tbody>
<tr>
<td>May</td>
<td>47</td>
<td>3.61 ± 0.44&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.70 ± 0.53&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.31 ± 0.60&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>September</td>
<td>15</td>
<td>4.05 ± 0.50&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.33 ± 0.34&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.40 ± 0.53&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Means (± SE) followed by same letter in each column are not significantly different at 5% level based on Ryan Q test (REGWQ).
Table 2  Seasonal changes of *Hyalomma impeltatum* infesting sheep in 2008 in Efasher area, North Darfur.

<table>
<thead>
<tr>
<th>Month</th>
<th>Number of animals</th>
<th><em>H. impeltatum</em> males</th>
<th><em>H. impeltatum</em> females</th>
<th><em>H. impeltatum</em> males + females</th>
</tr>
</thead>
<tbody>
<tr>
<td>May</td>
<td>49</td>
<td>3.46 ± 0.36&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.85 ± 0.34&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.32 ± 0.62&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>September</td>
<td>19</td>
<td>3.78 ± 0.46&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.36 ± 0.33&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.15 ± 0.47&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Means (± SE) followed by same letter in each column are not significantly different at 5% level based on Ryan Q test (REGWQ).
Table 3: Seasonal changes of *Hyalomma impeltatum* infesting cattle and sheep in 2008 in Efasher area, North Darfur.

<table>
<thead>
<tr>
<th>Month</th>
<th>Number of animals</th>
<th><em>H. impeltatum</em> males</th>
<th><em>H. impeltatum</em> females</th>
<th><em>H. impeltatum</em> males + females</th>
</tr>
</thead>
<tbody>
<tr>
<td>May</td>
<td>96</td>
<td>3.54 ± 0.29a</td>
<td>3.78 ± 0.31a</td>
<td>7.32 ± 0.43a</td>
</tr>
<tr>
<td>September</td>
<td>34</td>
<td>3.91 ± 0.33a</td>
<td>1.35 ± 0.24b</td>
<td>5.26 ± 0.55b</td>
</tr>
</tbody>
</table>

Means (± SE) followed by same letter in each column are not significantly different at 5% level based on Ryan Q test (REGWQ).
Table 4: Means (± SE) of *Hyalomma impeltatum* infesting cattle and sheep in May and September 2008 in Efasher area, North Darfur.

<table>
<thead>
<tr>
<th>Host</th>
<th>Number of animals</th>
<th><em>H. impeltatum</em> males</th>
<th><em>H. impeltatum</em> females</th>
<th><em>H. impeltatum</em> males + females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle</td>
<td>62</td>
<td>3.73 ± 0.36a</td>
<td>3.12 ± 0.42a</td>
<td>6.85 ± 0.48a</td>
</tr>
<tr>
<td>Sheep</td>
<td>68</td>
<td>3.33 ± 0.29a</td>
<td>3.16 ± 0.29a</td>
<td>6.72 ± 0.48a</td>
</tr>
</tbody>
</table>

Means (± SE) followed by same letter in each column are not significantly different at 5% level based on Ryan Q test (REGWQ).
Table 5: Means (± SE) of *Hyalomma impeltatum* infesting cattle in May and September 2008 at different sites in Efasher area, North Darfur.

<table>
<thead>
<tr>
<th>Site</th>
<th>Number of animals</th>
<th><em>H. impeltatum</em> males</th>
<th><em>H. impeltatum</em> females</th>
<th><em>H. impeltatum</em> males + females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wadaa</td>
<td>8</td>
<td>5.75 ± 0.52a</td>
<td>5.00 ± 1.08a</td>
<td>11.75 ± 0.95a</td>
</tr>
<tr>
<td>Darasalam</td>
<td>12</td>
<td>4.50 ± 1.28b</td>
<td>3.75 ± 1.39a</td>
<td>8.25 ± 1.15ab</td>
</tr>
<tr>
<td>Elfasher</td>
<td>12</td>
<td>3.58 ± 0.43ab</td>
<td>3.41 ± 1.18a</td>
<td>7.00 ± 0.90bc</td>
</tr>
<tr>
<td>Zamzam</td>
<td>20</td>
<td>3.55 ± 0.60ab</td>
<td>1.75 ± 1.27a</td>
<td>5.30 ± 0.66bc</td>
</tr>
<tr>
<td>Wadkuta</td>
<td>6</td>
<td>1.83 ± 0.40b</td>
<td>1.50 ± 0.80a</td>
<td>3.33 ± 0.49c</td>
</tr>
<tr>
<td>Alawona</td>
<td>4</td>
<td>1.50 ± 0.64b</td>
<td>4.00 ± 1.08a</td>
<td>5.50 ± 1.65bc</td>
</tr>
</tbody>
</table>

Means (± SE) followed by same letter in each column are not significantly different at 5% level based on Ryan Q test (REGWQ).
Table 6: Means (± SE) of *Hyalomma impeltatum* infesting sheep in May and September 2008 at different sites in Efasher area, North Darfur.

<table>
<thead>
<tr>
<th>Site</th>
<th>Number of animals</th>
<th><em>H. impeltatum</em> males</th>
<th><em>H. impeltatum</em> females</th>
<th><em>H. impeltatum</em> males + females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wadaa</td>
<td>6</td>
<td>6.50 ± 1.60a</td>
<td>7.33 ± 0.66a</td>
<td>13.83 ± 1.74a</td>
</tr>
<tr>
<td>Darasalam</td>
<td>14</td>
<td>4.21 ± 0.50ab</td>
<td>3.92 ± 0.55b</td>
<td>8.14 ± 0.85b</td>
</tr>
<tr>
<td>Elfasher</td>
<td>13</td>
<td>4.53 ±0.67ab</td>
<td>2.92 ±0.78bc</td>
<td>7.46 ± 0.99b</td>
</tr>
<tr>
<td>Zamzam</td>
<td>25</td>
<td>3.00 ±0.27b</td>
<td>1.16 ± 0.30bc</td>
<td>5.16 ± 0.39bc</td>
</tr>
<tr>
<td>Widakuta</td>
<td>5</td>
<td>0.20 ± 0.20c</td>
<td>1.40 ± 0.40c</td>
<td>1.60 ± 0.40c</td>
</tr>
<tr>
<td>Alawona</td>
<td>5</td>
<td>1.80 ± 0.37bc</td>
<td>3.40 ± 0.81bc</td>
<td>5.20 ± 0.91bc</td>
</tr>
</tbody>
</table>

Means (± SE) followed by same letter in each column are not significantly different at 5% level based on Ryan Q test (REGWQ).
Table 7: Means (± SE) of *Hyalomma impeltatum* infesting cattle and sheep in May and September 2008 at different sites in Efasher area, North Darfur.

<table>
<thead>
<tr>
<th>Site</th>
<th>Number of animals</th>
<th><em>H. impeltatum</em> males</th>
<th><em>H. impeltatum</em> females</th>
<th><em>H. impeltatum</em> males + females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wadaa</td>
<td>14</td>
<td>6.07 ± 0.72a</td>
<td>6.57 ± 0.69a</td>
<td>12.64 ± 0.93a</td>
</tr>
<tr>
<td>Darasalam</td>
<td>26</td>
<td>4.34 ± 0.62ab</td>
<td>3.84 ± 0.69b</td>
<td>8.25 ± 0.69b</td>
</tr>
<tr>
<td>Elfasher</td>
<td>25</td>
<td>4.08 ± 0.41ab</td>
<td>3.16 ± 0.68b</td>
<td>7.24 ± 0.55bc</td>
</tr>
<tr>
<td>Zamzam</td>
<td>45</td>
<td>3.24 ± 0.30bc</td>
<td>1.97 ± 0.20b</td>
<td>5.22 ± 0.36c</td>
</tr>
<tr>
<td>Wadkuta</td>
<td>11</td>
<td>1.09 ± 0.34c</td>
<td>1.45 ± 0.45b</td>
<td>2.54 ± 0.41d</td>
</tr>
<tr>
<td>Alawona</td>
<td>9</td>
<td>1.66 ± 0.33c</td>
<td>3.66 ± 0.62b</td>
<td>5.33 ± 0.83c</td>
</tr>
</tbody>
</table>

Means (± SE) followed by same letter in each column are not significantly different at 5% level based on Ryan Q test (REGWQ).
Table 8. Ticks collected in very low numbers from cattle in Elfasher area, Northern Darfur during May to September 2008.

<table>
<thead>
<tr>
<th>Tick species</th>
<th>Males</th>
<th>Females</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Amblyomma lepidum</em></td>
<td>12</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td><em>Amblyomma varegatum</em></td>
<td>7</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td><em>Boophilus decoloratus</em></td>
<td>0</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td><em>Hyalomma dromedarii</em></td>
<td>8</td>
<td>7</td>
<td>15</td>
</tr>
<tr>
<td><em>Hyalomma marginatum rufipes</em></td>
<td>23</td>
<td>3</td>
<td>26</td>
</tr>
<tr>
<td><em>Hyalomma truncatum</em></td>
<td>12</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td><em>Rhipicephalus evertsi evertsi</em></td>
<td>0</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>62</td>
<td>39</td>
<td>101</td>
</tr>
</tbody>
</table>
Table 9. Ticks collected in very low numbers from sheep in Elfasher area, Northern Darfur during May and September 2008.

<table>
<thead>
<tr>
<th>Tick species</th>
<th>Males</th>
<th>Females</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Hyalomma dromedarii</em></td>
<td>14</td>
<td>2</td>
<td>16</td>
</tr>
<tr>
<td><em>Hyalomma marginatum rufipes</em></td>
<td>18</td>
<td>10</td>
<td>28</td>
</tr>
<tr>
<td><em>Hyalomma truncatum</em></td>
<td>14</td>
<td>10</td>
<td>24</td>
</tr>
<tr>
<td>Total</td>
<td>46</td>
<td>22</td>
<td>68</td>
</tr>
</tbody>
</table>
Table 10. Prevalence rates of *Theileria lestoquardi* antibodies in sheep at different sites in Elfasher area, North Darfur as determined by IFA test during May to September 2008.

<table>
<thead>
<tr>
<th>Site</th>
<th>Number of animals</th>
<th>Number positive (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wadaa</td>
<td>15</td>
<td>1 (6.7)</td>
</tr>
<tr>
<td>Darassalam</td>
<td>25</td>
<td>5 (20)</td>
</tr>
<tr>
<td>Elfasher</td>
<td>20</td>
<td>12 (60)</td>
</tr>
<tr>
<td>Zamzam</td>
<td>20</td>
<td>8 (40)</td>
</tr>
<tr>
<td>Wadkuta</td>
<td>12</td>
<td>3 (25)</td>
</tr>
<tr>
<td>Alawona</td>
<td>8</td>
<td>3 (37.5)</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>32 (32)</td>
</tr>
</tbody>
</table>
CHAPTER FOUR
DISCUSSION

North Darfur State is rich in livestock; therefore the major epizootic diseases such as rinderpest, contagious bovine pleuropneumonia and foot and mouth disease should receive a great attention. (vaccination, improvement of diagnostic methods and raised awareness of livestock owners and pastoralists). Ticks are generally regarded as ectoparasites that cause the greatest economic losses to livestock production in the world (FAO, 1983). They are the most dominant pest distributed throughout the world with various intensities. Their economic impact varies with degree of damage they cause and diseases they transmit to livestock. On the other hand, there is little information available regarding ticks and tick-borne diseases in Northern Darfur particularly Elfasher area. Besides’ there was no systematic research done under natural conditions on tick abundance or the seasonal variations in tick population (Solomen et al., 1998). The present investigation revealed the presence of eight tick species infesting livestock in six selected locations in Elfasher area. Various tick species have been identified in different parts of the Sudan (Hoogstraal, 1956; Karrar, 1963). Moreover, the ecological distribution of the tick species has been reported in Darfur (Osman, 1978), Kordofan (Osman, 1982), Blue and White Nile (Jongejan et al., 1987), Kosti (El Imam, 1999) and south Kordofan (Sower, 2002). In the last century, there were many environmental changes that occurred and affected distribution of ticks and TBDs due to deforestation, desertification and misuse of land that established large mechanized schemes and farms and extensive animal movement due to drought.
and civil conflicts. The study revealed 4 genera, with 8 species of ticks in North Darfur, Elfasher area. These included *H. impeltatum*, *H. m. rufipes* *H. truncatum*, *H. dromedarii*, *A. variegatum*, *A. lepidum*, *R. e. evertsi*, *B. decoloratus*. This result is more or less similar to previously reported in South Darfur. Osman (1978) had reported twenty tick species in that region on domestic animals under nomadic systems. In the current study, *Hyalomma* spp. was the predominant species in the study area followed by *Boophilus, Amblyomma*, and the least was *Rhipicephalus*. However, disappearance of other tick species from pasture or animal in certain periods of the season does not mean their absence, but it can quickly come out or reappear under favorable climatic conditions.

With the exception of *B. decoloratus* and *R. e. evertsi*, males were in the majority in all collections. Males remain for a long time more on the host than females. The absence of females of *A. lepidum* and *A. variegatum* may suggest that the females had dropped off host for laying. It may also suggest that these two tick species had been accidentally introduced in the study area and are unlikely to have established themselves. The observed variation in tick populations among the areas could not be explained.

*Rhipicephalus* species were found in low numbers. This may be due to the unfavourable climatic conditions as the prevalence of this species is usually regulated or governed by the humidity, vegetation types and the length of rainy season (Hoogastraal, 1956). The dominant tick species in all areas was *H. impeltatum* followed by *H. m. rufipes*. This tick species is rare in the arid zone particularly where intensive system of husbandry is practiced (Abdallah, 2007). The low
level of *H. dromedarii* recorded in this study may be a reflection of the fact that cattle and sheep do not frequently come in contact with camels in this area since *H. dromedarii* is well known as a camel tick (Hoogastraal, 1956). Only few numbers of *B. decoloratus* were recorded during the study period in Elfasher area (Table 8).

No piroplasms and macroschizonts were seen in the blood smears. This indicates that the conventional parasitological methods may not be the suitable methods for field survey studies in apparently healthy animals. Moreover, most of the important tick-borne diseases are easily diagnosed by conventional parasitological techniques during the acute phase of infections. The infections are not usually detected by the conventional microscopy except though serology (FAO, 1984). If routine serological and parasitological surveys of sheep for tick-borne diseases are combined with tick survey and tick infection rates, then prediction of the transmission of *Theileria* spp could be made and used in control programmes (Young, 1981). The use of IFA test as a reference and gold standard test supported this assumption. On the other hand, sera from sheep unexposed to *T. lestoquardi* are guaranteed to be disease free, and thus represent the Target negative populations.

For serological tests in the study IFA test was used to detect antibodies against *Theileria. lestoquardi* in sheep. The reference test used by Hawa *et al.*, 1976 is a more recent test. Leemans *et al.* (1997) used schizont-based IFA test to detect antibodies against *T. lestoquardi* in sheep sera collected from the field. The finding of 32% positive of antibodies against *T. lestoquardi* is in agreement with Salih *et al.* (2003) who conducted a survey of *T. lestoquardi* antibodies
among Sudanese sheep. Prevalence of the antibodies against *T. lestoquardi* in this area with the absence of the field vector *Hyalomma anatolicum anatolicum* is difficult to explain. It is either the vector becomes prevalent in months other than May to September or the disease is transmitted by ticks other than *H. a. anatolicum*; these assumptions need further investigation. Similarly, if it is assumed that *H. a. anatalicum* is prevalent in North Darfur, *Theileria annulata* infections are expected to occur among cattle, a fact that is left open for future studies. On the other hand, the fact that *A. lepidum* and *A. variegatum* are recorded in the area is also alarming since heartwater disease is expected among ruminants.
CONCLUSIONS AND RECOMMENDATIONS

The objective of this survey was to study spatial distribution and population dynamics of ixodid ticks on cattle and sheep in North Darfur State. The study revealed that ticks of different species are distributed among the surveyed area which may be incriminated in transmission of diseases to animals and human. Therefore, it is recommended to study tick distribution and population dynamics in other parts of the State on domestic and wild animals. On the other hand, prevalence of four genera *Hyalomma, Boophilus, Amblyomma, Rhipicephalus* in the State may be alarming due to the fact that movement of domestic animals from tick-borne diseases endemic areas into the state may introduce these diseases. It is recommended to determine infection rate of *Theileria lestoquardi* and other tick-borne diseases in blood of domestic animals and in tick species using molecular biological techniques. It is also recommended to conduct intensive survey on prevalence of tick-borne disease pathogens particularly *T. annulata, T. lestoquardi, E. ruminantium* using advanced techniques. For longer periods and in different seasons to be able to draw a clearer picture of the diseases transmitted by such and other ticks. Ticks are not expected to be in abundance in the months chosen for the study.
REFERENCES


Perry, B.D. and Young, A.S. (1995). The past and Future role of epidemiology and economics in the control of tick-borne
diseases of livestock in Africa. The case of Theileriosis Preventive Veterinary Medicine. 25(2): 107-120.


