بسم الله الرحمن الرحيم

Sudan University of Science and Technology

College of Graduate Studies

Prevalence and Risk Factors Associated with Abomasal Nematodes Infection in Slaughtered Sheep in Khartoum State, Sudan

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

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September 2017

Acknowledgements

Thanks first and last to Almighty Allah, who gives me the health and strength to make this work possible.

I would like to express thanks to my supervisor, Dr.: Naglaa Abd El Hakeem Abass for her advice and constructive criticism in reviewing the dissertation.

Thanks to Sudan University of Science & Technology, College of Veterinary Medicine, for giving me the chance to join the master program of Preventive Veterinary Medicine (M.P.V.M) and to work in its laboratories.

Abstract

A cross sectional study was conducted from February to May 2017 to investigate the prevalence of abomasal nematodes infection and to assess the relationship between the occurrence of these parasites and factors of age, sex, locality, body condition and breed in slaughtered sheep in Khartoum State, Sudan.

A total of 350 abomasi were collected from three slaughterhouses namely: Karary, Nasr eldeen and Sabaloga in Karary, East Nile and Umbada localities respectively, and examined using postmortem examination (worm recovery).

The result showed that abomasal nematodes infection is common in sheep and the prevalence is estimated to be 15.1% (53/350). Worm recovery revealed the presence of *Haemonchus* spp. in all positive infested sheep with abomasal nematodes 100% (53/53).

The subsequent risk factors revealed association with sheep abomasal nematodes in the univariate analysis under significant level of P-value ≤ 0.5: sex (p-value = 0.000) and breed (P-value = 0.001). These factors may be contributing factors for the relatively high prevalence of abomasal nematodes among sheep.

ملخص

اجريت دراسه مقطعيه في الفتره من شهر فبراير الى مايو2017 وذلك لتقدير معدل الانتشار بديدان المنفحه والتقصي حول عوامل الخطر المرتبطه بها من العوامل الاتية: العمر , الجنس, المنطقه, حالة الجسم و السلاله و ذلك في ذبيح الضان بولاية الخرطوم – السودان .

تم جمع 350 منفحة من مسالخ كرري , السبلوقه ونصرالدين بمحليات كرري , امبده وشرق النيل على التوالي و تم شخيص الاصابه بواسطة فحص ما بعد الذبح للمنفحه.

اظهرت الدراسه ان نسبة انتشارالاصابه بديان المنفحه 15.1%(53\350) وكانت ديدان الهيمونكس(الهلاع) هي السائده في نتائج الدراسه 100%(53\53) .

في التحليل الفردي لمعرفة عوامل الخطر المرتبطه بالاصابه باستخدام مربع كاي وجدت علاقه معنويه تحت قيم معنويه اقل من او يساوي 0.05- بين حدوث المرض وكل من عوامل الخطر التاليه: جنس الحيوان (القيمه المعنويه =0.000) و سلالة الحيوان (القيمه المعنويه=0.001)

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INTRODUCTION

World sheep population exceeded 1 billion head in 2010, which plays a vital socioeconomic role in the countries throughout the world (FAO, 2010). About 205 million of these sheep are found in Africa, mainly in arid and semi- arid areas of sub-Saharan and provide up to 30% of agricultural gross domestic product in developing countries (FAO, 2010).

Parasites play an important role in every ecosystem, as one of the regulating mechanisms of population dynamics for species within that system (Sinclair *et al*., 2007). Parasitic diseases in the tropics are responsible for great losses in the meat industry than any other infectious or metabolic disease (Gonfa *et al.*, 2013).

A ruminant gastrointestinal tract is divided into four stomachs (rumen, reticulum, omasum and abomasum) in addition to the small intestine (duodenum, jejunum and ileum) and large intestine (caecum, colon) (Dyce *et al*. 1987).

Gastro-intestinal nematodes infections of ruminant livestock cause major problems in the developing world. These parasites are difficult to manage because in some cases they develop resistance to all available commercial dewormers and the resistance to de-wormers is now a common problem worldwide (Zajac, 2000; Kaplan, 2004).

Cost-effective damages incurred by these parasites include reduced animal performance and weight gain, condemnation of whole carcass or affected organs at slaughterhouses, cost of treatment and mortality in severe cases (Gatongi *et al*., 1997).

The main nematodes causing severe losses to the livestock industry are *Haemonchus spp., Oesophagostomum spp., Cooperia spp.* and *Trichostrongylus spp.*, (Waller, 2006).

The epidemiology of gastrointestinal tract parasites in livestock varied depending on the local climatic conditions, such as humidity, temperature and rainfall, in addition to other factor such as vegetation and management practices. These factors largely determine the incidence and severity of various parasitic diseases in a region (Takelye, 1991).

Diagnosis of gastrointestinal nematode infections plays a major role in investigating parasite epidemiology. The anti-mortem diagnosis of nematode infections in livestock has been based on the detection of nematode eggs or larvae in the feces by microscopic examination using flotation methods (Roeber *et al.*, 2013).

Globally, parasitic diseases continue to be a major constraint for poor developing countries. They are rarely associated with high mortality and their effects are usually characterized by lower outputs of animal products (FAO, 2002).

There are many reports on the prevalence of gastrointestinal tract infections in small ruminants from different regions in the Sudan. These reports indicate that such infections could be a major problem to sheep industry in the country (Omer *et al*., 2003). Epidemiological studies play a crucial role in the development of comprehensive and sustainable programs for controlling gastrointestinal nematodes in livestock. Therefore the current study was designed to:

1. To determine the prevalence of abomasal nematodes infections in sheep of different age groups slaughtered in Khartoum state.

2. To investigate the potential risk factors possibly associated with these infections.

CHAPTER ONE

LITERATURE REVIEW

1. Gastrointestinal Nematodes:

Gastrointestinal nematodiasis remains as one of the most important infections limiting small ruminant production in tropical Africa. Several Superfamilies play an important role in the veterinary field including *Trichostrongyloidea*, *Strongyloidea*, *Metastrongyloidea*, *Ancylostomatoidea*, *Rhabditoidea*, *Trichuroidea*, *Filarioidea*, *Oxyuroidea*, *Ascaridoidea* and *Spiruroidea* (Zajac, 2006).

The most common species of nematodes associated with parasitic gastroenteritis in small ruminants in most sub-Saharan countries are *Haemonchus contortus*, *Oesophagostomum columbianum*, *Trichostrongylus colubriformis*, *Trichostrongylu*s *axe*i *Bunostomum trigonocephalum*, *Cooperia curticei*, *Trichuris ovis*, *Trichuris globulosus*, *Strongyloides papillosus*, *Gaigeria pachyscelis* and *Chabertia ovina*. Of these species, *Haemonchus contortus*, *Ostertagia circumcincta* and *Trichostrongylus* spp. (*T. axei*, *T. colubriformis and T. vitrinus*) are the most important. Lungworms such as *Dictyocaulus filaria*, *Muellerius capillaris* and *Protostrongylus rufescens* cause parasitic bronchitis particularly in young animals (Hansen and Perry, 1994; Lughano and Dominic, 1996).

2. Abomasal Nematodes in Sheep:

Soulsby (1982) recorded several genera of abomasal nematodes in sheep, these are: *Trichostrongylus* (T.*colubriformis and* T.*axei), Marshallagia* (M.*marshalli,* M.*orientalis and* M. *mongolica*), O*stertagia* (O.*ostertagi,* O. *trifurcate* ,O.*circumcincta,* O.*pinnata,* O. *grosspiculagia* other genera related to *ostertagia* (*pseudostertagia* and *speculopteragia*),*Teladorsagia davtiani* , *Haemonchus contortus* , *mecistocirrus digitatus* and *Cooperia spatulata.*

2.1. *Haemonchus contortus:*

Are large worms, up to about 25 mm long and possess a small buccal cavity with a tiny lancet which is used for slitting capillaries during blood feeding .There is a pair of prominent, wedge-shaped cervical papillae. Male parasites look red. In the female parasite, the white ovary and egg –filled uterus are spirally twisted around the red blood filled intestine giving the appearance of “barber's pole”. The vulval flap can often be seen (Hutchinson, 2009). The egg is typical strongylid and is passed by an infected animal in the 16- 32 morula stage.

2.1.1. *Ostertagia circumcincta*:

Are slender brown worms, about 12 mm and uniform in thickness throughout their length (Hutchinson, 2009).

2.1.2. *Trichostrongylus axei*:

Is very small, less than 7 mm and tapers markedly to the anterior end (Urquhart *et al.,* 1996).

Microscopically, classification of adult nematodes from Ostertagia genus is based mostly on tail morphology of males, genital cone and spicules, structure of bursa and esophageal valve dimensions (Hoberg *et al*., 2001).

2.2. Life Cycle:

Life cycles of abomasal nematodes are similar in which the adult female worm produces eggs that are passed with feces to the pastures, while on herbage, the eggs hatch to produce first stage larvae (L_1). These larvae then grow and shed their cuticle to become second stage larvae (L_2) which molt and develop into third stage larvae (L_3). Third stage larvae are the infective juvenile worms that migrate up the blade of grass and are ingested by the host. In the abomasum, L_3 penetrate the mucosa and molt to L_4 within forty eight- hour to mucosa. Most of the worms return to the surface of the abomasal mucosa as L_4 and then molt to (L_5) before they mature to adult parasites that are capable of reproduction and continuation of the life cycle. If conditions are unfavorable, L_4 larvae can enter in a state called hypobiosis. This hypobiosis is due to either hostile immunity or unfavorable environmental conditions such as dry or very cold weather. When environmental conditions improve, development resumes and the life cycle is completed.

Fourth stage larvae have a small buccal cavity with several teeth that are used to pierce the mucosal cavity and feed on blood. The final molt occurs within three days and the adult worms lay eggs and continue to feed on blood. Blood feeding causes severe anemia that result in decreased pigmentation of the mucus membrane (Soulsby, 1982).

Decreased immunity causes the larvae to emerge from arrest and the resulting parasite load is known as the spring rise (Kahn, 2005). While the life cycles of *H. contortus*, *O. Ostertagi*, and *T. axei* are very similar, there are physiologically important differences in the life cycle which leads to differences in their pathogenicity and economic impact (Hutchinson, 2009).

2.3. Epidemiology:

2.3.1. Gastrointestinal helminthes in Africa:

Gastrointestinal nematodes are distributed worldwide and recognized as a major constraint to livestock production throughout tropics and elsewhere (Dagnachew *et al*., 2011).

In a study carried out to determine the prevalence of abomasal nematodes of small ruminants of Ogaden region, Ethiopia, a total of 196 abomasi of animals (114 sheep and 82 goats) were examined according to standard procedures. An overall prevalence rate of 91.2% and 82.9% *Haemonchus contortus*. was recorded in sheep and goats, respectively. Likewise, an overall prevalence of 37.7% and 40.2% *Trichostrongylus axei* was recorded in sheep and goats, respectively (Kumsa and Wossene, 2006).

A survey on the prevalence and intensity of infection with gastrointestinal helminths of Dorper sheep was carried out on a ranch in Kajiado district, a semi-arid area of Kenya. Examination of fecal samples in all age groups (lambs, yearlings and adults) for helminth eggs revealed mixed *strongyle* infections with *Trichostrongylus* (55%), *Haemonchus* (28 %), *Cooperia* (10.5 %) and *Oesophagostomum* (6.5%)(Ng'an'ga *et al.*, 2004).

An investigation was conducted by Atta Elmannan (1983) on gastrointestinal parasites in sheep in Sinnar Distict, Sudan. The prevalence was 83.9%. The highest worm burden was for *Trichostrongylus axei*.

In a study carried out at Omdurman abattoir, 1200 abomasal samples from sheep were examined for estimation of the prevalence of *Haemonchus contortus*. The results of this study indicated that haemonchosis was widely spread among sheep and the prevalence was 32% (Omer *et al*., 2003).

In additional study conducted by Ghada (2000) during November 1997 to October 1998 to determine the species and prevalence of gastrointestinal helminths from White Nile State, a total of 507 faecal samples and 30 gastrointestinal tracts were collected random and processed, using microscopic examination, faecal culture and postmortem technique. Nematode infections were the commonest, reaching 90.0% of the examined animals. *Trichostrongylus colubriformis* was the major nematode species with an infection rate of 86.7% followed by *Haemonchus contortus* with a prevalence of 76.6%. The study showed that nematodes might be involved in causing significant losses in sheep production in the Sudan.

An epidemiological study conducted on sheep from Central Kordofan involving Coprological examination of 498 fecal samples and 45 gastrointestinal tracts showed mixed helminth infections in 91.1% of gastrointestinal tracts examined. Nematode infections were the commonest, reaching 82.2% of the animals examined. The prevalence of *Haemonchus contortus* and *Trichostrongylus colubriformis* was 68.9% and 60%, respectively (Abdelnabi *et al*., 2011).

Ahmed and Elmalik (1997) investigated the prevalence of Nematodes in sheep brought to Khartoum from different localities of Sudan. Four genera were identified from faecal culture. These were *H. contortus*, *Strongyloide papillosus*, *Oesophagostomum spp*. and *Trichostrongylus spp*. with a prevalence rate of 56.3, 36.6, 3.7 and 3.4%, respectively. The highest rate of infection was observed during the rainy season (85%) compared with a rate of (35.6%) during the winter.

In another study, gastrointestinal tracts of 79 sheep and 161 goats were obtained from abattoir of Tulus locality in South Darfur State in western Sudan from March 2006 to February 2007 and examined for the presence of gastrointestinal parasites. The prevalence of different nematodes in sheep were, *Haemonchus contortus* (53.4%), *Strongyloides papillosus* (26.2%) *Trichostrongylus colubriformis* (14.7%), *Cooperia pectinata* (3.1%), *Oesophagostmum columbianum* (2.2%), *Skrjabinema ovis* (0.3%) and *Trichuris globulosa* (0.1%) (Almalik *et al*., 2008).

Edrees (2006) reported a high infection rate of internal parasites in sheep of *Haemonchus* spp. and *Strongylus* spp., 8% and 2.6%, respectively in Khartoum State.

Boukhari *et al.*, (2016) examined a total of 240 fecal samples of sheep in a cross Sectional study carried out in Khartoum State to estimate the prevalence of *Haemonchus spp.* eggs in sheep feces and to investigate potential risk factors associated with them. The overall prevalence of *Haemonchus* eggs was 12.1%.

The most common nematodes reported in ruminants in the Sudan are H. *contortus,* T. *axei,* T.*colubriformis,* S.*papillosus,* O.*columbianum and* T.*ovis* (Eisa and Ibrahim, 1970; El Bbadawi *et al*., 1978; Atta Elmannan, 1983).

2.3.2. Risk factors associated with Gastrointestinal Nematodes:

The epidemiology of gastrointestinal parasite depends on several factors:

2.3.2.1. Environmental Factors:

The micro-climatic factors include; sunlight, temperature, soil moisture, rainfall, humidity, and soil texture. These factors affected development, survival and transmission of free living stage of gastrointestinal nematodes parasites (Lughano and Dominic, 1996).

The development process takes 7 to 10 days in optimal circumstances like high humidity and warm temperature (Hansen and Perry, 1994). So, in most African countries, the circumstances are favourable for larval development in the environment. For example, the optimal development of Trichostrongylid occurs at temperature ranging from 10 to 36 °C. (Lughano and Dominic, 1996).

Strongylus and Trichostrongylus larvae such as *Trichostrongylus colubriformis* and *Oesophagostomum columbianum* are known to be resistant to desiccation so they are able to live in exceedingly low or high temperatures (Lughano and Dominic, 1996).

Some gastrointestinal nematodes have ability to survive tough conditions via arrested development of larvae (usually $_{L3}$ or early $_{L4}$) within the host. This phenomenon called hypobiosis .Under optimal conditions (absence of hypobiosis), nematodes survive in the host throughout desiccated and worm period as adult (Donald, 1968; Hansen and Perry, 1994).

The collective effect of micro-climatic factors is responsible for the periodic variations in the convenience of L_3 on pasture, and consequently the incidence of worm loads in the hosts. This periodic variation of parasite population dynamics has been described in a number of studies in many African countries (Debela, 2002).

The contamination with nematode eggs is increased by high stocking density and thus makes the infective stages to be more nearby to susceptible animals ,so, management practice play a vital role in the epidemiology of gastrointestinal nematodes. Sometimes pasture poverty and soil erosion obligate animals to graze nearer to faecal material, thereby results in the uptake of higher numbers of infective larvae (Lughano and Dominic, 1996).

2.3.2.2. Parasite factors:

The intrinsic multiplication rate of the nematode species regulates the rate of finding and accordingly the nematode burden in the host. The multiplication rate is determined by the fecundity of the adult worms. For instance a female *Haemonchus contortus* could produce thousands of eggs each day, and larval amounts on pasture can fast increase during the rainy seasons (Soulsby, 1982; Hansen and Perry, 1994). *Trichostrongylus spp.* has a minor biotic potential and hence its founding is slower (Lughano and Dominic, 1996).

2.3.2.3. Host factors:

Host influences such as age, sex, nutrition and occurrence or absence of intercurrent infections can affected both the incidence rate and severity of infection with gastrointestinal nematodes (Lughano and Dominic, 1996).

Several studies considered the association between sex and parasite incidence. Female sheep is more likely to get the infection of gastrointestinal nematodes than male due to the gestation stress and pre- parturient parasitic rise (Valcarcel & Romero, 1999; Gauly *et al.*, 2006; Tehrani *et al*., 2012). In contrast, Mushtaq and Tasawar (2011) observed the prevalence of gastrointestinal nematode parasites was higher in male sheep as compared to female due to stimulatory effects of estrogens and inhibitory effect of androgens on immune responses, while Qamar (2009) stated that both sexes were equally affected by the helminths.

Age was investigated by (Urquhart *et al*., 1996; Valcarcel & Romero 1999; Raza *et al.*, 2007; Mohammed *et al.*, 2015) the results of these studies showed significant association between the adult sheep and parasitic infection due to repeated exposure. On the other hand, Lateef (2005) in Pakistan and Dagnachew *et al*., (2011) in Ethiopia reported that suckling lambs are more susceptible due to less immune response.

Many studies revealed that the infestation of gastrointestinal nematodes parasite in definite breeds more than others (Chaudary *et al*., 2007: Radostits *et al*., 2007). In the Sudan, Boukhari *et al*., (2016), reported that the Kabashi breed was recorded the highest prevalence of haemonchosis (26.7%) compared to Hamari (8%) and Ashgar (9.5%).

2.4. Transmission:

Gastrointestinal nematodes are transmitted directly by ingestion of free L_3 (infective stage) from contaminated pasture (Soulsby, 1982).

2.5. Diagnosis of Abomasal Nematodes in Sheep:

Several techniques have been described for identification and diagnosis of gastrointestinal nematodes based on demonstrating the rate of eggs and larvae in faecal samples presence of parasites recovered from the digestive tracts and serological tests (Hutchinson, 2009).

2.5.1. Flotation Technique:

The simple flotation method is a qualitative test for the detection of nematode and cestode eggs and coccidia oocysts in the faeces. It is based on the separating of eggs from faecal material and concentrating them by means of a flotation fluid with an appropriate specific gravity (Hansen and Perry, 1994).

Using highly dense saturated solutions (salt, sugar, magnesium sulphate etc.) with or without centrifugation are well documented. The flotation method is simple and effective for even the most basic laboratories (Hutchinson, 2009).

2.5.2. Faecal Egg Counts and Larval Culture:

The tests most commonly employed for the diagnosis of gastrointestinal and pulmonary nematode infections in ruminants with speciation by way of larval culture and differentiation. Fecal egg counts do not always correlate well with the number of adult worms present in the animal (Hutchinson, 2009).

2.5.3. Postmortem Examination (Worm Recovery):

Necropsy is the furthermost direct method to identify and diagnose gastrointestinal parasitism. Adults can be simply seen. Important infections with *Ostertagia*, *Trichostrongylus* and other smaller nematodes can be well seen in Gastrointestinal tract by washings and staining for 5 minutes with strong iodine solution, (Hutchinson, 2009).

2.6. Prevention and Control:

The problem of controlling gastrointestinal parasites is of particular economic significance in production systems worldwide (Rinaldi *et al.*, 2007).

To be effective, parasite control programs need detailed information of the parasite's biology and epidemiology, grazing management, herd structure, parasite periodic survival and the climate conditions in specific zones (Hansen and Perry, 1994).

According to type of macro-climate which reveals on the seasonality of development and survival of L_3 on the pasture, comprehensive strategic control programs are made.

Humid weather is always favourable for the development and growth of infective larvae. In this type of climate, it’s important to determine levels of parasitism and the epidemiology of the existent species in order to regulate programing of strategic anthelminthic dosing.

In dry areas, the contamination of pastures with GINs parasites is commonly restricted to zones with surface water or irrigation. Haemonchosis is the main hazard in such areas. Under this climatic condition, schedule and regulation of anthelminthic will depend on outcomes of previous epidemiological studies described formerly (Hansen and Perry, 1994).

Mixing of regulating stocking amount, ideal usage of safe pastures (safe pasture is that earlier browsed by other species) and planed use of antihelmentics are suggestive preventive methods in Savannah type climates. If safe pastures are available, new stock could be treated by an anthelminthic at the beginning of the rainy season and later residence them on the safe pasture. If safe pasture is not obtainable, successive treatments at three week intervals at the start of the rains could prevent livestock from excessive parasite burdens (Hansen and Perry, 1994; Lughano and Dominic, 1996).

Chapter Two

Materials and Methods

1. Sheep:

The Sudan has a large population of small ruminants estimated at 40 million (FAO, 2013). This is considered as one of the highest animal populations in Africa. There are several breeds of sheep in the country such as Kabashi, Hamari, Shukri and Zagawi in Northern and Western Sudan and Watish in Central Sudan. They are raised for their meat, milk and hides in different parts of the country (FAO, 2008).

2.1. Study design and sample size:

A cross-sectional study was conducted from February-May 2017 to determine the prevalence of sheep abomasal nematodes infections and to investigate potential risk factors associated with their occurrence.

The sample size was calculated according to the formula described by Thursfiled (2007) based on previous prevalence (27.3%) of internal nematodes of sheep in the Sudan reported by Edrees (2006) with 95% confidence interval and 5% desired absolute precision. To carry out this survey multistage random sampling was used (Figure. 2.1)

2.2. Study area:

The study was carried out in Khartoum State which lies between latitude 15º 32.799′ N and longitude 32º 32.0166′ E and has a semi-desert climate. The state has an average of rainfall less than 300 mm per year and average annual temperature ranging between 22.7º and 37.1º C. The State characterized by three distinct seasons; cold-dry from November to February, hot-dry from March to June, and hot-wet season from July to October.

There is 442.672 sheep in the State (Sudan Ministry of Animal Resources and Fisheries, 2011).

For sample collection three slaughterhouses in three different localities: Karary (Karary), East Nile (Naser Eldeen) and Umbada (Sabaloga) were visited.

2.3. Sample collection and Questionnaire survey:

A total of 350 abomasi were included in the study and systemic sampling was used to select individual animals. Following slaughter and evisceration, abomasi were ligated and separated from omasum and duodenum to avoid leakage and contents mixing. Each abomasum was collected into labeled plastic bag and transported to the parasitology laboratory, College of Veterinary Medicine, Sudan University of Science and Technology.

A questionnaire was designed to provide information about potential risk factors hypothesized to be associated with abomasal nematodes infections in sheep. Prior to sample collection, the questionnaire was completed for every slaughtered sheep in an interview with the owner (Appendix 1). Data about age, sex, locality, Body condition score and breed were recorded. Sheep were categorized as suckling (<1 year), (Young 1-3 years) and (old >3 years), body condition score was categorized as poor and good according to Kistner (1980).

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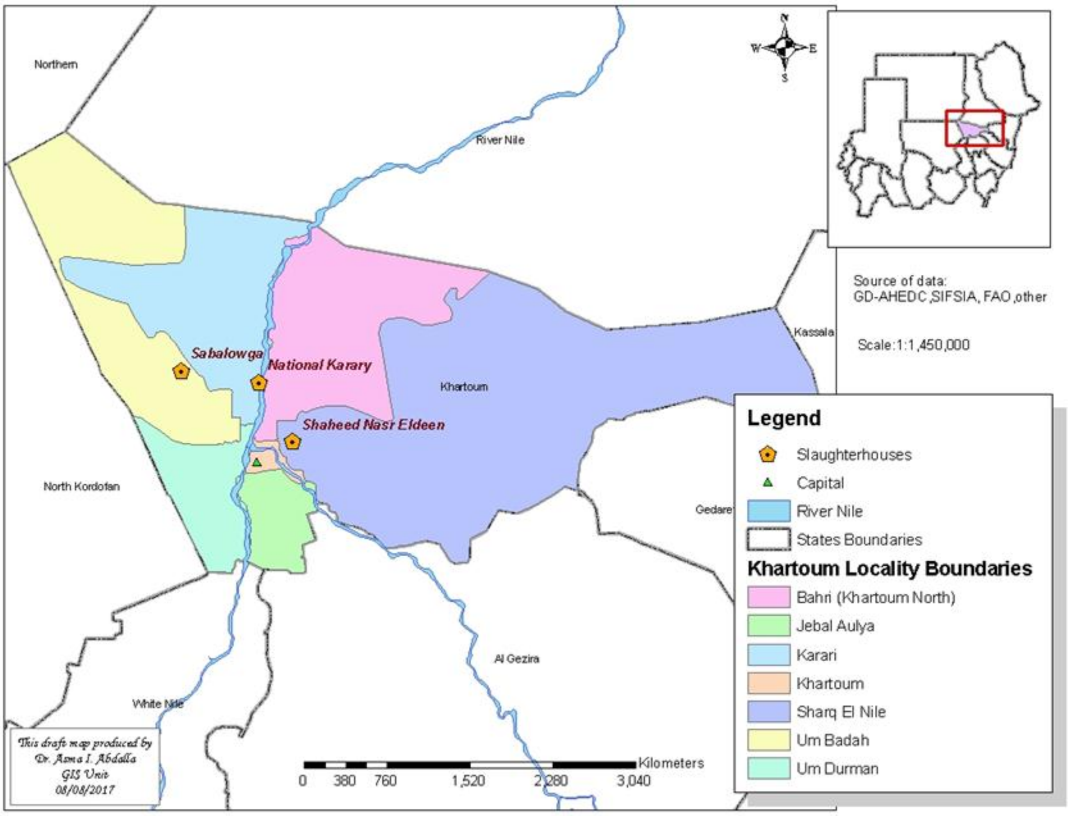

Figure. 2.1: Study area with selected slaughterhouses

2.4. Worm recovery:

Each abomasum was opened with pairs of scissors along its greater curvature and the abomasal contents was spilled into a sieve (180 μm) (Figure.2.2). The attached worms were scraped from the mucosa and removed from the abomasal folds (Figure.2.3) with the gloved hand and a stream of water. The sieve contents were washed out as possible (Hutchinson, 2009) (Figure.2. 4). When the material has been sufficiently washed the sieve is inverted over a large beaker, and the contents, which contain the coarser fibre and any worms which present are removed by water from the opposite direction. Aliquots are examined in large petri dishes under dissecting microscope (Robertson and Elliott, 2012).

Nematodes were collected, preserved and identified using the keys described by Soulsby (1982).

Figure. 2.2: Sieve

Figure. 2. 3: A bomasal folds (Attached worms)

Figure. 2.4: Washing and Sieving Technique

2.1.4. Data analysis:

The collected data were coded and entered into an Excel spreadsheet (Microsoft Excel, 2007). Statistical analysis was performed using statistical package for the social sciences (SPSS), version 16 software. Percentage was used to calculate prevalence. Data were statistically analyzed using Chi-squared test to calculate degree of association between risk factors and prevalence of abomasal nematodes. 95% confidence interval (CI) and $p \leq 0.05$ was considered for statistically significant difference.

Chapter Three

Results

3.1. The prevalence of abomasal nematodes in slaughtered sheep in Khartoum State:

A total of 350 abomasi of sheep were examined by postmortem examination (worm recovery) for the presence of abomasal nematodes in three localities in Khartoum State between February-May 2017. An overall 15.1% (53/350) of sheep abomasal nematodes in the current study (Table 3.1).

3.2. Worm recovery:

With respect to the species prevalence of abomasal parasites, 53 (100%) sheep were found to harbor only *Haemonchus contortu*s. (Figure. 3.5).

3.3. Risk factors analysis:

In this study, as far as different age groups of sheep were concerned, 30 out of 159 (18.9%) suckling (<1 year old), 10 out of 56 (17.9%) young (1-3 years old) and 13 out of 135 (9.6%) (Older than 3 years) were infested with parasites (Figure. 3.6).

In the Chi-squared test, the result showed that there was no association between abomasal nematodes infection and the age of animal (x^2= 5.231; *P* = 0.073) (Table.3. 2).

Considering sex of sheep examined, female animals had higher prevalence proportion (22.3%) than males (6.4%). There was significant variation in abomasal nematodes infection between male and female (x^2= 17.055; *P* = 0.000) (Table.3. 2).

Concerning locality of examined animals, the rate of infection was in Karary, East Nile and Umbada (15%), (14.7%) and (18.2%), respectively. No association was found between the infection with nematodes in abomasi and locality of the examined sheep (x^2= 0.170; *P* = 0.918) (Table.3. 2).

Regarding Body Condition Score (BCS), 163 and 187 animals were found in good and poor body condition, respectively (Figure. 3.7). No statistical significant association was observed between categories of body condition and infestation of abomasal nematodes (x^2= 1.212; *P*= 0.271). However, sheep had poor body condition (17.1%) are more likely to be infected compared with good ones (12.9%) (Table.3. 2).

Out of 350 sheep examined, 289 animals were Hamari breed and 61 animals Kabashi breed. The prevalence proportion was observed only in Hamari breed (18.3%). There was statistically significant association between breed and abomasal nematodes infection (x^2 = 13.183; P = 0.001) (Table.3. 2).

Figure.3.5. *H. contortus* worm

Figure. 3.6. *H.contortus*, male bursa with dorsal aspect

Figure. 3.7. *H.contortus*, Female with the large vulvar flap

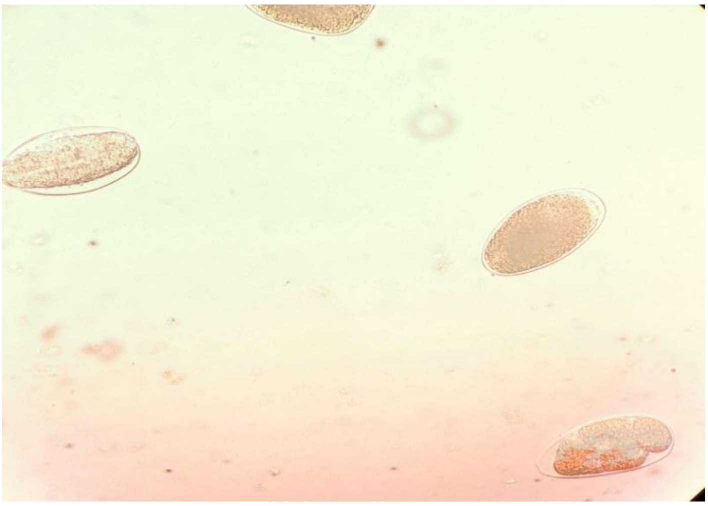

Figure. 3.8. ***H. contortus*, female egg**

Table 3.1: An overall prevalence of abomasal nematodes in slaughtered sheep in Khartoum State:

Sheep examined	Positive	Negative	Prevalence (%)	95% Confidence interval
350	53	297	15.1	11.77-19.28

Table 3.2: Summary of univariate analysis for risk factors associated with abomasal nematodes in Khartoum State, Sudan (n=350) using the Chi-squared test.

Risk factor	No. tested	No. positive (%)	df	x^2	p- value
Age					
Suckling <1	159	30 (18.9)	2	5.231	0.073
Young 1-3	56	10 (17.9)			
Old > 3	135	13 (9.6)			
Sex					
Female	193	43 (22.3)	1	17.055	0.000*
Male	157	10 (6.4)			
Locality					
Karary	294	44 (15)	2	0.170	0.918
East Nile	34	5 (14.7)			
Umbada	22	4 (18.2)			
BCS					
Poor	187	32 (17.1)	1	1.212	0.271
Good	163	21 (12.9)			
Breed					
Hamari	289	53(18.3)	1	13.183	0.001*
Kabashi	61	0 (0)			

* = highly significant

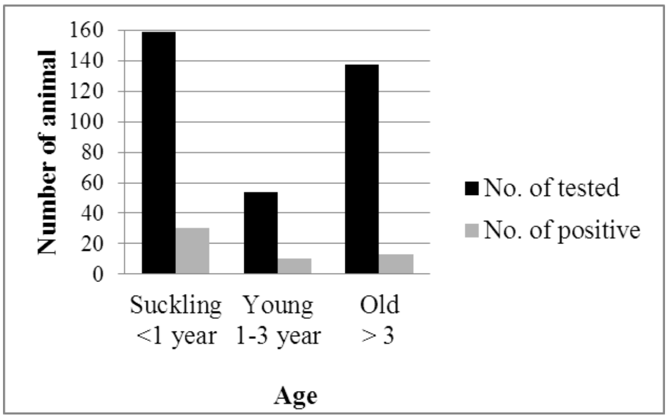

Figure. 3.9: Prevalence of abomasal nematodes in different age groups of slaughtered sheep in Khartoum State, Sudan

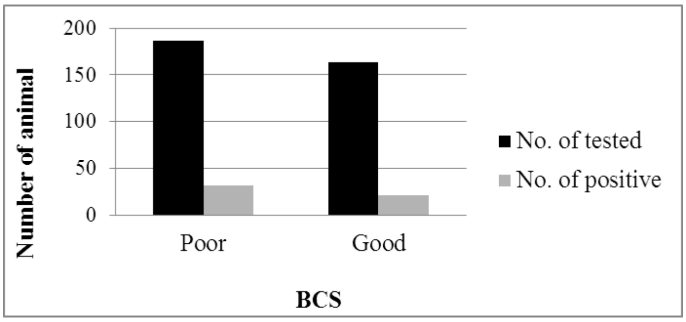

Figure. 3.10: Prevalence of abomasal nematodes in different categories of body condition in slaughtered sheep in Khartoum State, Sudan

Chapter four

Discussion

The prevalence of abomasal nematodes in certain region is influenced by a multi-factorial system. This system consists of hosts, parasite and environmental factors. Abomasal nematodes are common blood feeders that cause losses like anemia, reduced productivity and death in heavily infected animals (Hansen and Perry, 1994).

In the present study, an overall of 15.1% prevalence of abomasal nematodes was obtained. The observed prevalence in sheep in the current study is lower than works of Demissie *et al.*, (2013) in Ethiopia and Gana *et al.*, (2015) in Nigeria who reported 80.6% and 85% of haemonchosis infection in sheep, respectively. This variation in prevalence proportions among these studies is probably due to variation in climatic condition.

According to the current study, detection of high prevalence of *Haemonchus contortus*, (53\53) (100%) in slaughtered sheep in Khartoum State agrees with the findings of Ghada, (2000*)* and Almalik *et al.*, (2008), who reported 76.6% and 53.4% in White Nile State and Tulus area in south Darfur State, respectively. This is might be due to the high biotic potential and shorter generation interval of *Haemonchus spp*., which lays up to 10, 000 eggs per day for several months. This phenomenon allows its greater contamination of grazing areas or its ability to survive adverse climatic conditions through hypobiosis (Soulsby, 1982).

Age was considered an important risk factor in gastrointestinal tract (GIT) infections (Raza *et al*., 2007). Our data showed that the adult worm load of *Haemonchus* spp. is higher in suckling (18.9%) and young sheep (17.9%) as compared to old ones (9.6%), This is in line with Lateef *et al*. , 2005 in Pakistan and Dagnachew *et al*., (2011) in Ethiopia, who attributed that to the immunological maturity in older ages due to the development of acquired immunity because of repeated exposures. Our finding is contradicted with Almalik *et al*., (2008) who reported that age has no effect in the prevalence of the parasite in sheep.

In our study, sex of the examined sheep was investigated. The higher prevalence of infection was in females (22.3%) as compared to males (6.4%). There was a highly significant association between abomasal nematodes and sex (P = 0.000). Our result is consistent with (Gana *et al.,* 2015) This finding supports the general understanding of helminth infections that difference in abomasal nematodes infection between sexes probably accounts for differences in sex hormones especially during the peri-parturient period because of the decreased immune status (Urquhart *et al*., 1996; Valcarcel and Romero, 1999 and Raza *et al.* , 2014). As well as the prolactin secretion during lactating period, this suppresses the immunity of the ewe and brings an apparent increase of the numbers of worms burden (Bowman, 1999). Our findings are disagreed with Gorski *et al.,* (2004) and Irfan-ur-Rauf *et al.,* (2013) in Kashmir and Poland, respectively, who reported that males were more infected with nematode species than females.

In our survey, different localities of Khartoum State have been investigated for the prevalence of abomasal nematodes infection. The highest prevalence of infection was recorded in Umbada (18.2%) followed by Karary (15%) and the lowest one recorded in East Nile (14.7%). No association between abomasal nematodes infection and different investigated areas of Khartoum State was reported (*P* =.918) and this could be due to similarity in management system adopted in these areas.

According to our results, the prevalence of abomasal nematodes in different body condition score of sheep was 12.9% in good body condition and 17.1 % in poor body condition. Although there was no association between the body condition score and abomasal nematodes infection (*P* =0.271), the rate of infection is higher in sheep with poor body condition. This is consistent with previous studies suggesting that animals with poor body condition have a little tolerance and lack of immunity and therefore more susceptible to infection (Gonfa *et al.*, 2013). Furthermore, helminths also led to a loss of appetite and poor utilization of food, which results in a loss of body weight (Knox *et al*., 2006).

According to our observations, there was a significant association between breed and prevalence of abomasal nematodes (*P*=0.001). Hamari breed was more likely to have abomasal nematodes (18.3%) than Kabashi breed (0%). This is could be due to genetic variation between breeds and the differences in sample size. Our result disagrees with a previous study conducted in Khartoum State by Boukhari *et al.,* (2014) who reported that the Kabashi breed was recorded the highest prevalence of haemonchosis (26.7%) compared to Hamari (8%) and Ashgar (9.5%). He concluded that some indigenous breeds are known with their resistance to endoparasites infestation.

Conclusion

1. The prevalence of abomasal nematodes in sheep in Khartoum State is (15.1%).
2. Haemonchosis is found to be the most important problem in sheep in the study area.
3. Sex and breed of sheep were found positively associated with abomasal infestation in Khartoum State.

Recommendation

1. Additional surveys should be conducted to cover Khartoum State and further investigation for the epidemiology and control of abomasal nematodes infection.
2. Effective control measures must be applied to reduce parasite burden and consequently sheep heath and production.

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