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Gastrointestinal helminth parasites of ruminants slaughtered in Shendi abattoir, River Nile State, Sudan

A thesis submitted for the degree of M.Sc. in

Zoology (Parasitology)

By

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Dedication

To my beloved mother.

To my all family members.

To my friends and colleagues.

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الملخص

أجريت هذه الدراسة لتوفير بعض المعلومات الأساسية عن الديدان الطفيلية المعوية التي تصيب المجترات المذبوحة بمسلخ مدينة شندي بولاية نهر النيل، السودان، فى الفترة من سبتمبر 2015 إلى أكتوبر 2016م. تم جمع عينات براز من عدد 687 حيوان ذات أعمار واجناس مختلفة، وفحصها باستخدام تقنيات الطفو والترسيب جنبا إلى جنب مع تقنية ماكماستر لتعداد البيض. تم ايجاد 411 عينة مصابة تحمل نوع أو أكثر من الديدان المتطفلة بنسبة انتشار كلى للاصابة بلغ 59.8٪ وكثافة بلغت 548.23 بيضة للجرام من البراز.

سجلت انواع الشريطية تينيا *Taenia* أعلى نسبة انتشار (25.3٪) بين مختلف أنواع الطفيليات التي تمت ايجادها أثناء الدراسة، تليها انواع الاسترونجيلويدس *Strongyloides* (14.8٪)، المونيزيا *Moniezia* (5.2٪)، الفاشيولا *Fasciola* (4.4٪) الأسكاريس *Ascaris* (3.3٪)، النيماتوديروس *Nematodirus* (2.5٪)، البارامفيستوموم *Paramphistomum* (1.7٪)، الهيمونكس *Haemonchus* (1.2٪)، الديبيليديوم *Dipylidium* (0.6٪)، الأوستيرتاجيا *Ostertagia* (0.4٪)، الترايكوسترونجيلس *Trichostrongylus* و الديكتيكالس *Dictyocaulus* (0.1٪).

وجد أن المجترات البالغة تكتسب نسبة انتشار أعلى للاصابة مقارنة بتلك الأصغر سنا ومع هذا لا يوجد فارق إحصائي معنوى ($P > 0.05$). على الجانب الاخر، وجد ان المجترات الذكور تكتسب نسبة انتشار أعلى للاصابة مقارنة بالإناث، وهذه ذات فارق إحصائي معنوى ($P < 0.05$).

وجد أن نسبة انتشار الديدان الطفيلية أعلى ($P < 0.05$) بين المجترات خلال موسم الأمطار مقارنة بموسم الجفاف. أشار التحليل الإقليمي إلى أن الماعز من نهر النيل والنيل

الأزرق وغرب السودان أكثر اصابة مقارنة بالمجترات الأخرى التي تم فحصها، بينما في النيل الأبيض وشرق السودان كانت الاصابة بين الماشية و هى المجموعة الوحيدة التي تم فحصها. أعلى متوسط لكثافة بيض الديدان المتطفلة تم تسجيلها بين صغار المجترات مقارنة مع البالغين ($P < 0.05$). كذلك وجد أن الماشية الإناث سجلت أعلى متوسط لكثافة بيض الديدان، وهناك فارق إحصائي معنوى ($P < 0.05$) عند مقارنة الذكور مع الإناث للمجترات.

بالمثل، كان هناك فارق إحصائي معنوى ($P < 0.05$) في متوسط كثافة بيوض الديدان المتطفلة بين المجترات التي تم فحصها وفقا لمناطق استيرادها. الماشية الواردة من النيل الأبيض ذات كثافة بيوض ديدان عالية في حين أن الماعز الوارد من النيل الأزرق ذات كثافة بيوض أدنى. وجد أن متوسط إنتاج البيض من الديدان الطفيلية بين المجترات التي تم فحصها أعلى نسبيا خلال موسم الجفاف مقارنة بموسم الأمطار، هذا الاختلاف ذات فارق إحصائي معنوى ($P < 0.05$).

ختاما، تدعو نتيجة هذه الدراسة إلى ضرورة اتخاذ التدابير الوقائية الفعالة والمكافحة تجاه طفيليات المجترات في جميع أنحاء البلاد.

الكلمات المفتاحية: المجترات، الديدان المعوية الطفيلية ، انتشار و شدة الاصابة، مسلخ شندي، السودان.

Abstract

This study was conducted to provide some basic information regarding gastrointestinal (GI) helminth parasites of ruminants (cattle, sheep and goats) slaughtered in the abattoir of Shendi city, River Nile State, Sudan, from September 2015 to October 2016. Fecal samples were collected from 687 animals of different ages and sexes and analyzed using the flotation and sedimentation techniques along with a McMaster technique for egg counts per gram of feces. 411samples were found positive with one or more helminth parasites, giving an overall prevalence of 59.8% and intensity of 548.23 eggs per gram feces. The cestode *Taenia* spp recorded the highest prevalence (25.3%) among the various species of parasites encountered during the study, followed by *Strongyloides* spp (14.8%), *Moniezia* sp (5.2%), *Fasciola* sp (4.4%), *Ascaris* sp (3.3%), *Nematodirus* sp (2.5%), *Paramphistomum* sp (1.7%), *Haemonchus* sp (1.2%), *Dipylidium* sp (0.6%), *Ostertagia* sp (0.4%), *Trichostrongylus* sp and *Dictyocaulus* sp (0.1%). Adult ruminants were found to acquire the highest prevalence of infection compared with younger ones. However, this was statistically not significant ($P > 0.05$). On the other hand, male ruminants found to acquire higher prevalence of infections than females, and this was found statistically significant ($P < 0.05$). The prevalence of helminth was significantly ($P < 0.05$) higher among ruminants during the rainy season compared with the dry season. Regional analysis indicated that goats

from the River Nile, Blue Nile and West Sudan acquired more infection than other ruminants examined. While in the White Nile and East Sudan, infection was found among the only group examined, cattle.

The highest mean egg output was recorded among young ruminants, with a significant difference ($P < 0.05$) when compared to the adult ones. Female cattle were found to acquire higher egg output, and there was a significant difference ($P < 0.05$) when comparing males with females of the examined ruminants. Likewise, there was a significant difference ($P < 0.05$) in fecal egg counts among the examined ruminants according to the region of import. Cattle from the White Nile were found to acquire the highest egg output, while goats from the Blue Nile had the lowest. The mean egg output of helminth among the ruminant examined were relatively higher during the dry season compared with the rainy season, and this difference was statistically significant ($P < 0.05$).

In conclusion, the result of this study calls for the need for an effective preventive measures and control towards parasites of ruminants throughout the country.

Key words: Ruminants, gastrointestinal helminth parasites, prevalence, intensity, Shendi abattoir, Sudan.

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Chapter one

Introduction

1.1 General introduction

Gastrointestinal (GI) tract parasites are known to be widespread in many countries and that is cause to limit production of ruminants (Fabiyi, 1987; Gross *et al*., 1999; Keyyu *et al*., 2005), with estimated annual losses of US $ 2 billion due to mortality in animals caused by these parasites (Hann and Bekure, 1991).

The helminth infections of ruminants are mostly caused by nematodes such as *Ostertagia* spp, *Capillaria* spp,*Trichuris* spp, *Strongyliodes* spp, *Trichostrongylus* spp and *Cooperia* spp; cestodes such as *Moniezia* spp, *Taenia* spp and Trematodes such as *Dicrocoelium* spp, *Fasciola* spp, and *Amphistomes.* The direct losses caused by these parasites are attributed to acute illness and death, and indirect losses include the diminution of productive potential such as decreased growth rate, weight loss in young growing animals and late maturity of slaughter stock (Hansen and Perry 1994; Zahid *et.al.*, 2005; Kanyari *et al*., 2009, Raza *et al*., 2014).

The prevalence of parasitical disease infection varies greatly between areas depending on many factors such as level of agriculture, pasture management, micro and macro-climate of the environment, immunological and nutritional status of the host, present of intermediate hosts, vectors and the numbers of

infected larvae and eggs in the environments (Tum *et al*., 2004; Nwosu *et al*. 2007; Dagnachew *et al*., 2011).

GI parasites are known to be widespread in Sudan, causing limiting in domestic animal production as many studies have concluded (Eisa *et al*., 1962; El Badawi *et al*., 1978; Atta El Mannan, 1983). The internal helminth species reported in cattle in Southern Sudan were *Fasciola gigantica*, *F. bovis*, Hydatid cyst, cysticercus bovis, *Haemonchus contortus, Neoascaris* and *Moniezia* (Eisa *et al*., 1962; Eisa, 1963; El Badawi *et al*., 1976). In western Sudan, *Fasciola gigantica*, *Paramphistomum* spp, *Schistosoma bovis*, cysticercus bovis, *Nematodirus* spp, *Oesophagestomum radiatum, Haemonchus, Trichostrongylus, Cooperia*, *Strongyloides* and *Chabertia* were reported (EL Badawi, 1978; Abdalla,1989; Mohammed and Elmalik, 2000). Moreover, infection with nematodes belonging to the genera, *Oxyuris*, *Parascaris*, *Strongylus*, *Strongyloides* and *Trichuris* were detected in equines in southern Darfur (Kheir and Kheir, 1981). Six genera of nematodes, 2 genera of trematodes were found in cattle in Damazin District (Mohammed and Atta El Manan, 2003). In Gedarif State, the common helminth parasites that infect cattle were *Oesphagestomum radiatum, Chabertia ovina*, *Ascaris* spp and *Trichostraongylus* spp (Mohamed *et al*., 2013). In the River Nile state, *F. gigantica*, *Trichuris ovis* and *Strongyloides papillosus* were reported on cattle (El-Doush, 1995)

In general, numerous parasitic worm infections were detected in cattle, sheep and equines in Sudan, while goats and camels were found to harbor few parasite infections rate (Atta El Manan, 1983).

1. 2 Overall Objective of the study

This study was designed to provide some basic information on the GI helminth parasites that infect ruminants (cattle, sheep and goats) slaughtered at abattoir of Shendi city, River Nile State, Sudan, from September 2015 to October 2016.

1. 2. 1 Specific Objectives

- To identify the GI helminth parasites that infect ruminants slaughtered at abattoir of Shendi city.
- To determine the prevalence of GI helminth parasites among ruminants slaughtered at abattoir of Shendi city.
- To determine the intensity of GI helminth parasites among ruminants slaughtered at abattoir of Shendi city.
- To evaluate the parameters of GI helminth infections, according to age, sex, season and place of import of the ruminants slaughtered at abattoir of Shendi city.

Chapter two

Literature review

2. 1 Epidemiology of ruminant parasites

Epidemiology of parasites involves the distribution of the parasites and diseases from one animal to the other, or simply the spread of parasites among animals (Waller, 2003). The epidemiology of parasitical disease of ruminants varies greatly between areas, depending on many factors such as level of agriculture, pasture management, farm management, grazing habits, micro and macro-climate of the environment, immunological and nutritional status of the host, present of intermediate hosts and the numbers of infected larvae and eggs in the environments (Nwosu *et al*. 2007).

Gastrointestinal (GI) parasites are the most common infections of human and animal and particularly in tropical and sub tropical developing countries (Adeyeba and Akinlabi, 2002; Odu *et al*., 2011). Moreover, the most common GI helminth parasites infect ruminants worldwide; belong to the phyla Platyhelminthes (flatworms) and Nemathelminthes (roundworms). The former phylum has two classes, Cestoda (tapeworms) and Trematoda (flukes) (Urquhart *et al*., 1996; Keyyu *et al*., 2005). These parasites include *Ascaris* spp, hook worms *Trichuris trichura*, *strongyloides stercoralis*, *Entamoeba histolytica* and *Giardia lamblia* (WHO, 1987; Nikolic *et al*, 1998). Other common helminth parasitic diseases of humans and animals are liver trematodes

named *Fasciola hepatica* and *Dicrocoelium dendriticum*. They live in the bile duct of humans and ruminants and infection in human led to health issues in society and in cattle causes enormous economic losses. Prevalence studies reveal that *Fasciola* species are by far the most economically important trematode of ruminants in the tropics (Maingi *et al*., 1997; Abunna *et al*., 2010). Additionally, one of the important parasitic diseases in ruminants is hydatid cyst, the larval form of taeniid cestode of the genus *Echinococcus* in intermediate hosts (Moro and Schantz, 2009). Hydatidosis of livestock animals causes decreasing in production of meat, wool, and milk and hereby high economical loses. Furthermore, the infected organs of the slaughtered animals are being condemned.

On the other hand, blood or haemoparasites also have a global distribution and its incidence of infections in ruminants has been reported (Bell-sakyi *et al*., 2004; Guerrant *et al*., 2006; Okorafor and Nzeako, 2014). The most economically important genera of these parasites are the trypanosomes: *Trypanosoma vivax, T. congolense* and *T. brucei*; Babesia: *Babesia bigemina* and *B.bovis;* Anaplasma and Ehrlichia (Cowdria), and to a less extent Theileria: *Theileria parva* and *T.veilifera* (Mtshali *et al*., 2004; Kamani *et al*., 2010). African animal trypanosomosis, Babesiosis and Cowdriosis are considered as the most important constraints to the health and improved productivity of cattle and other ruminants in sub-Saharan Africa (FAO, 1984; Bell-sakyi *et al*., 2004). Haemoparasites have generally shown to cause destruction of red blood cells

resulting in anaemia, jaundice, anorexia, weight loss and infertility (Jonsson, 2006; Akande *et al.*, 2010).

2. 2 Life cycle of GI parasites

The common modes of transmission of animal diseases to man include direct contact with animals, handling of polluted fomites or ingestion of infected meat or milk. Many diseases such as echinococcosis, amphistomiasis, trichinellosis, are zoonotic and can therefore be transmitted from animals to human beings. Indiscriminate slaughter of animals, sale of meat without ante-mortem and post-mortem examinations by a qualified veterinarian does not only jeopardize human health but also cause wide spread environmental pollution.

2. 2. 1 Nematodes

The most important and widely prevalent nematodes are the Trichostrongyle group: *Haemonchus, Ostertagia, Trichostrongylus, Mecistocirrus*, *Cooperia* and *Nematodirus*,beside *Oesophagostomum* and *Bunostomum.* The life cycles of most Trichostrongyles, *Oesophagostomum* and *Bunostomum* are similar: the cycles are direct, that is these nematodes do not require other animals to complete their life cycles (Besier *et al*., 2007; Radostits *et al*., 2007).

According to Hansen and Perry (1994), adult nematodes inhabit the gastro-intestinal tract. Eggs produced by the female are passed out in the faeces, then embryonate and hatch into first-stage larvae (L_1) which in turn moult into second-stage larvae (L_2) shedding their protective cuticle in the process. The L_2 larvae moult into third-stage larvae (L_3), but retain the cuticle from the

previous moult. This double-cuticled L_3 is the infective stage. The time required for the eggs to develop into infective larvae depends on temperature. Under optimal conditions (high humidity and warm temperature), the developmental process requires about 7 to 10 days. In cooler temperatures the process may be prolonged. Ruminants are infected by ingesting the L_3. Most larvae are picked up during grazing and pass to the abomasum, or intestine, ex-sheathing the extra cuticle in the process. The L_3 of the Trichostrongyle group penetrate the mucous membrane in the case of *Hemonchus* and *Trichosrongylus* or enter the gastric glands as in the case of *Ostertagia*. During the next few days the L_3 moult to the fourth stage (L_4) and remain in the mucous membrane (or in the gastric glands) for about 10 to 14 days. They then emerge and moult into a young adult stage (L_5). Most Trichostrongyles mature and start egg production about 3 weeks after infection.

The parasitic part of the life cycle of *Oesophagostomum* requires about 6 weeks to complete. The infective L_3 penetrate the lamina propria of the intestinal wall and the host response to the infection which surrounds the L_3 results in the formation of fibrous nodules. The larvae emerge into the lumen of the intestine after about 2 weeks and mature in the following 4 weeks. In animals previously infected, the larvae may spend a prolonged period of time (3-5 months) in the nodules. Eventually many of the larvae will die and the nodules may become calcified.

The L_3 larvae of *Bunostomum* infect ruminants when they are ingested or penetrate the hosts skin. Following skin penetration, the larvae are carried in the venous blood through the heart to the lungs, where they penetrate the alveoli, are coughed up and then swallowed, and so pass to the small intestine. Here they moult and mature 8-9 weeks after infection.

The infective larval stage of *Trichuris* is contained within the egg. The larva is released after the egg is ingested by the host. Adult female nematodes produce eggs. The period between the infection of an animal by ingestion of infective L_3 larvae and the first egg production by the adult female parasite is called the prepatent period. This period is different for different species of parasites and for the most the period is about 3-4 weeks.

Although *Toxocara vitulorum* is an intestinal nematode, the life cycle and the epidemiology of this parasite is markedly different from that of the Trichostrongyle group. *Toxocara vitulorum* is a large ascarid-type parasite (20-30 cm) which has a world-wide distribution. The prevalence is, however, much higher in the tropics and it causes severe problems in young calves (cattle, buffalo) in Southeast Asia and parts of Africa.

The life cycle of this helminth is direct with possible prenatal infection and with neonatal infection through colostrum being the major route of infection for calves in Southeast Asia. The adult parasites which live in the small intestines are prolific egg producers and a very large number of eggs are produced every day. The thick-walled eggs are very resistant to adverse climatic and

environmental conditions and may remain infective for a long period of time (several years). Only if the infective eggs are ingested by young calves will the life cycle be completed. The *Toxocara* larvae penetrate the intestinal wall and migrate via the circulatory system to the liver and lungs where they enter the respiratory system. The larvae are coughed up and swallowed, returning to the small intestine where they mature and start egg production 3-5 weeks after infection. If the infective eggs are ingested by older calves (more than 4 months of age) that possess immunity, the majority or all of the larvae that undergo somatic migration become arrested in organs and tissues. During pregnancy these larvae become reactivated and prenatal infection of the foetus is possible, but the majority of larvae are concentrated in the udder and new-born calves are usually infected through colostrum and milk. Following infection via this route, the larvae do not migrate in the hosts, but remain in the small intestine. This reduces the length of the prepatent period and eggs may be present in feces 18-21 days after infection. Whereas transmission through colostrum and milk is the major route of infection of calves in Southeast Asia, studies in the southern part of Africa have indicated that the ingestion of infective eggs from the environment is the most common route of infection there.

2. 2. 2 Trematodes

According to Hansen and Perry (1994), all the trematode species which are parasitic in livestock belong to the subclass Digenea. In general, these trematodes, known commonly as flukes, are dorso-ventrally flattened, some

being leaf-shaped and some long and narrow; the gastro-intestinal flukes have thick fleshy bodies. The schistosomes, which also belong to this group, are elongated and almost roundworm-like in appearance. The flukes that parasitize livestock are hermaphrodites (except the schistosomes) but they have the ability to reproduce asexually and multiply in aquatic or amphibious snails, which they require as intermediate hosts in order to complete their life cycles. Most flukes are very discriminating in their choice of snail as intermediate host and the geographic distribution of trematode species is dependent on the distribution of suitable species of snails.

A large number of gastro-intestinal trematode species (paramphistomes) have been described. They are usually thick, short, 4-12 mm, fleshy, maggot-like worms. They may infect all ruminants but young calves and lambs are the most susceptible. The infections are very common in Africa, Asia, Oceania, Eastern Europe, Russia and some of the Mediterranean countries. Not all the species are pathogenic, but clinical outbreaks of paramphistomiasis have been caused by *Paramphistomum microbothrium* (Africa), *Cotylophoron cotylophorum (Asia), P. ichikawar, C. calicophorum* (Australasia) and *P. cervi* (Europe).

Paramphistomes require an aquatic snail as an intermediate host and the pre-parasitic stages of the life cycle (miracidia and stages in the snail) are very similar to those of *Fasciola hepatica* and *F. gigantica*. The metacercariae encysted on the herbage are ingested and young flukes are released in the duodenum of the final host. They attach to - or invade - the duodenal mucosa,

usually in the proximal 3 m of the gut. The immature flukes re-emerge/detach from the mucosa 10-30 days after initial infection and migrate towards the rumen and reticulum, where they attach to the mucosa and mature into egg-producing adult parasites. The pre-patent period is reported to vary from approximately 56 days in cattle to around 70 days in sheep and goats. The parasites appear as reddish/pink clusters between the papillae of the rumen and reticulum. Adult paramphistomes may survive for many years in the rumen of the host.

Fasciola hepatica and *F. gigantica* have similar life cycles. The adult flukes inhabit the bile ducts of the final host (cattle, buffaloes, sheep, and goats). The hermaphroditic parasite produces eggs which are expelled with the bile into the intestine and shed in the feces. The eggs embryonate and hatch in water or wet pastures, releasing a free-swimming miracidium. The ciliated miracidia actively seek and penetrate suitable intermediate hosts and undergo several stages of development by asexual multiplication. Five to seven weeks after infection of the snail the tadpole-like motile cercariae emerge from the snail and swim until they make contact with herbage. They then encyst on blades of grass close to streams or in low-lying damp pasture areas. Infection of the final host occurs by ingestion of herbage contaminated with the encysted metacercariae. After ingestion, the young flukes are released from the cysts in the small intestine. They penetrate the intestinal wall and migrate through the abdominal cavity and the liver capsule into the liver parenchyma. Following the penetration of the

capsule the immature flukes migrate through the liver tissues for about 6-8 weeks and then enter the bile ducts where they mature and commence egg production (Hansen and Perry, 1994; Kaufman, 1996).

Schistosomes are elongate, sexually differentiated (an exception among the trematodes) flukes which live in the circulatory system of their hosts. The flattened male carries the female in a special ventral groove. The males are 4-22 mm and the females from 12-28 mm in length. Several different species exist. These include *Schistosoma bovis* in central, eastern and West Africa, the Mediterranean area and the Middle East; *S. mattheei* in central, southern and eastern Africa; *S. intercalatum* in central Africa; and *S. japonicum* in the Far East (a species infecting humans but which may also cause schistosomiasis in ruminants and other host species). *S. nasalis* is found in the veins of the nasal mucosa of livestock in the Indian subcontinent. Infection rates of 40-50% have been reported in buffaloes and cattle. Like many of the other trematodes, Schistosomes require an aquatic or amphibious snail as an intermediate host in order to complete their life cycle. The adult parasites live in the mesenteric veins of the final host. During the period of egg-laying, the female parasite enters the small vessels of the gut wall. The eggs, which have a sharp spine, penetrate the wall, enter the intestinal lumen and are passed out in the faeces. Different snail species act as intermediate hosts. The development in the snail is similar to that of other trematodes. The infective forms released from the snails are free-swimming, fork-tailed cercariae. Infection of the final host takes place

when the animal is drinking from a contaminated water source. Infection occurs either via skin penetration by the parasite, or by penetration of the digestive tract after ingestion of cercariae with the water. The immature flukes migrate through the lungs and the liver to the mesenteric veins, where they mature.

2. 2. 3 Cestodes

According to Hansen and Perry (1994), cestodes in ruminants can conveniently be classified into two distinct groups; one in which ruminants act as the final host (the intestinal and hepatic cestodes) and one in which cattle, buffaloes sheep and goats act as the intermediate hosts for the larval stages *(Cysticercus, Coenurus* and hydatid cysts) of various tapeworm species. In the latter group, the adult parasites live in the small intestines of domesticated and wild carnivores *(Taenia ovis, T. hydatigena, T. multiceps, Echinococcus granulosus)* and man (*T. saginata).*

The group of intestinal tapeworm comprises species of the genera *Moniezia* (cosmopolitan), *Thysaniezia* (Africa) and *Avetellina* (Africa, Asia). The life cycles of these tapeworms are indirect and herbage mites of the family *Oribatidae* act as intermediate hosts (Kaufman, 1996). The mites, which are soil-inhabiting, surface during the night and early morning to feed on manure. During their feeding they accidentally ingest eggs of the intestinal tapeworms present in the manure, and the larval stage called a cysticercoid develops in the mites. Ruminants become infected by ingesting herbage containing mites carrying the infective stage of the parasite.

The hepatic tapeworm, *Stilesia hepatica* (Africa) occurs in the bile ducts of ruminants and is very common in certain parts of Africa. It is believed that certain antelope species act as a reservoir of this infection. The life cycle is similar to that described for the intestinal tapeworms; ruminants become infected by ingesting infected herbage mites. The parasite occurs in animals of all ages.

Cysticercus bovis is the larval stage of *T. saginata*, a tapeworm of man. Tapeworm segments containing thousands of eggs are passed in faeces or shed from the intestine of a parasitized individual. If the eggs are ingested by a receptive intermediate host, the embryos migrate through the blood stream and become disseminated throughout the body. Usually only the embryos which reach the striated muscle tissues will develop further, but viable cysts have been identified in other organs and tissues. Development takes 3-5 months and the majority of cysts remain viable (and thus infective) for 1-2 years. Man becomes infected by ingesting live cysts in raw or undercooked meat. Following infection of man an adult tapeworm develops in the intestine within 3 months.

Cysticercus ovis is the larval stage of *T. ovis*, a tapeworm of dogs and other carnivores. The development cycle is similar to that of *C. bovis*. Although the cysts are found in the muscles of sheep, this parasite is not considered of public health importance because man cannot become infected with *T. ovis*. The most common sites of infection are the heart and the diaphragm, but other muscle groups may also be affected. The detection of the cysts usually results in

condemnation of the meat for aesthetic reasons. Some reports indicate that massive infestations can kill animals.

Abdominal cysticercosis of ruminants is caused by *C. tenuicollis,* the larval stage of *T. hydatigena,* a dog tapeworm. This parasite is cosmopolitan in its distribution. The adult tapeworms live in the small intestines of dogs and other carnivores and segments containing numerous eggs are passed in the faeces. After disintegration of the segments, eggs can be disseminated by wind and by insects contaminating the pasture. Ruminants then become infected by ingesting eggs. The embryos penetrate the wall of the digestive tract and migrate to the liver, where they migrate through the liver surface to enter the abdominal cavity. The fully developed cyst is a large (5 cm or more in diameter), soft, semi-transparent bladder within which the invaginated head of the tapeworm is clearly visible. The final host becomes infected by ingesting the-cysts.

Hydatidosis or larval echinococcosis is the cystic stage of *Echinococcus granulosus,* a very small tapeworm of dogs and other canids. This parasite has a cosmopolitan distribution and is very common in parts of Africa, Latin America and some countries of Southeast Asia.

There are several types of life cycle involving different mammalian species. One cycle involves domesticated ruminants and dogs; another cycle involves wildlife species, for example the warthog-lion cycle in Africa. Other cycles involve domesticated animals and wildlife, such as the dromedary camel-jackal cycle in some regions of sub-Saharan Africa.

The gravid segments of the *E. granulosus* tapeworm are excreted in the faeces of dogs and the eggs released from the segments are very resistant to adverse climatic conditions. They may be carried by wind in dust or be mechanically transported by flies. Following ingestion of the eggs by the intermediate hosts, which include man, domesticated animals and numerous wild mammals, the embryos emerge and migrate to the blood stream through which they are carried to various organs and tissues in which the hydatid cysts develop. Hydatid cysts are most commonly found in the liver and the lungs. The embryos grow slowly into large fluid filled cysts, 5-10 cm or more in diameter. Hydatid cysts are lined with a thin layer of germinal epithelium. After 5 months this germinal layer is capable of producing tapeworm scolices, which can be found individually in the fluid of the cyst as "hydatid sand". It also produces brood capsules which consist of several scolices held together by a thin membrane. Part of the germinal epithelium may occasionally form daughter cysts with a germinal layer of their own. In some cysts the germinal layer does not produce infective protoscolices and brood capsules; these cysts remain sterile. The final host acquires the infection by eating viscera containing fertile hydatid cysts. Cysts maintain their infectivity for several weeks after the death of the intermediate host and carrion feeders are therefore considered important in disseminating this infection.

2. 3 Pathogenesis of GI parasites

Pathogenesis of GI parasite species varies greatly and also depends on parasite load and mode of transmission. Damaging effects caused by GI parasites include irritations of the mucosa and destruction of intestinal cells, blood consumption by haemophagous parasites, irritation of the lung tissue during migration of larvae and loss of nutrients. An animal will show the symptoms of diseases only when parasite load become excessive or when an animal's natural immunity to disease become suppressed. Main symptoms to be observed include diarrhoea, weight loss, growth retardation, oedema, anaemia, a marked decrease in milk production, rough hair coat, dehydration and death (Hansen and Perry, 1994; Perry *et al*., 2002; Fikru *et al*., 2006).

2. 4 Diagnosis of GI parasites

The diagnosis of GI parasites is based on demonstrating the presence of parasite eggs or larvae, in fecal samples, or the presence of parasites recovered from the digestive tracts or other viscera of the animals (Bassert and McCurnin, 2010). Fecal examination by means of the modified McMaster technique for the enumeration of worm eggs and larval differentiation by fecal culture methods are the most common routine means for the diagnose helminthosis in ruminants. The strongylid nematode genera produce eggs that are similar in appearance and cannot be easily discriminated, which means that genus identification cannot accurately be made by fecal examination alone. To identify nematodes in fecal samples, fecal cultures are required to yield L3 larvae, which generally can be differentiated to genus level (Kassai, 1999; Van Wyk *et al*., 2004).

Nematodirus, *Strongyloides* and *Trichuris* species have eggs that can be differentiated by their distinct morphological features. Identifying of parasites is crucial for control programs; some methods most commonly used for that are summarized below.

2. 4. 1 Fecal direct smear

The procedure of this method is by taking a small portion of feces and examined under a microscope, the method is so fast but has a low sensitivity, thus the method recommended only for use if no other techniques are available (Simonsen *et al*., 1986). This method is widely used in health facilities; smears are very easy to prepare and the slides can be read immediately under a microscope. This technique is a good mean for detecting motile parasite stages such as protozoan trophozoites and helminth larvae frequently passed in the semi-formed and loose to fluid feces of animals.

2. 4. 2 Simple test tube flotation

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

2. 4. 3 Fecal sedimentation

This technique is a qualitative method for detecting trematode eggs in the feces (Hansen and Perry, 1994). Most trematode eggs are relatively large and heavy compared to nematode eggs. The method based on the removal of feces debris

and then the concentration of the eggs in a container. This method is suitable for field studies of its easiness and accuracy. Other concentration techniques are formal ether and acid ether which involve on fat, fecal debris and mucus removal by centrifugation. In developed countries, the formol-ether technique is the concentration method of choice, even for tropical countries, this technique is recommended as the best overall method to concentrate parasites in feces (Cheesbrough, 1991). In which about one gram of feces is emulsified in a formol-water solution, the suspension is sieved and ether is added, after centrifugation of this mixed suspension, the sediment is examined for eggs, cysts and larvae, the formol detergent concentration technique is a valid alternative if a centrifuge is not available. These techniques are more expensive because of consuming equipments and chemicals, so generally not suitable for large epidemiological studies (Salih, 1989).

2. 5 GI parasites control

In most semi arid and arid regions of sub-Saharan Africa, ruminants play a vital role in rural economies through the provision of meat, milk, household income, manure and skin (De-Castro, 1997; Mulugete *et al*., 2011) and it is well recognized that in resource-poor regions of the world, helminth infections of ruminants are major factors responsible for economic losses through reduction in productivity and increased mortality (Perry *et al*., 2002; Nwafor, 2004).

To control the GI parasites, different options are available; management and medication have an important influence on parasite concentration, pasture

management should be the primary tool to control and prevent internal parasites, dewormers must be used in full dose and the labels must be read accurately, rotational grazing must be practiced to prevent overgrazing the pasture, get rid of snails since they are the carries of liver fluke larvae. stocking rate must be reduced because the more animals in a camp, the more densely the larvae will be deposited, strict quarantine is necessary before introducing new animal into the herd, animals within the farm that have got heavy loads of parasites must be culled and it is very important to keep deworming records, to accurately be precise about the deworming intervals (Nguyeni *et al*., 2005; Githioria *et al*., 2006; Van Metre, 2010; Sultan *et al*., 2016).

2. 6 Dewormers

Many effective dewormers include Ivermectin, Levamisol, Thiabendazole, Albendazole, morantel tartrate, fenbendazole and Oxfendazole are approved and available for treating internal parasites in ruminants (Papich, 2015). Methods of dosing vary, and this gives the choice of how treatment done. For convenience, several products are available; in blocks, cubes, pellets and mineral mixtures. Full dose of a dewormer should always be used to ensure maximum kill (Kaplan, 2004).

Chapter three

Materials and methods

3. 1 Study area

The study was conducted in the local abattoir of Shendi, a city situated on the east bank of the River Nile, northern Sudan, geo-coordinately between 16°40'52"N and 33°25'7"E. The area has a semi arid climatic feature with a very short rain period in August of a mean precipitation 29.3 mm, and an annual temperature ranging from 28 - 41°C.

The vegetation of the area is poor and sparse in the desert zones, it is virtually absent except along the banks of the River Nile and water sources where ephemeral herbs and grasses occur after the occasional rainfall. The inhabitants of the area are diverse in occupation ranging from trading, farming to fishing activities.

3. 2 Ethical considerations

Before the study initiation, endorsements were obtained from the Ministry of Animal Resource of the River Nile State and the authority of Shendi city abattoir for sample collection.

3. 3 Collection of fecal samples

Fecal samples were collected twice a week, from September 2015 to October 2016, from the rectum and small intestine of the slaughtered ruminants at the abattoir of Shendi, early between 6:00AM and 7:00AM. The collected samples

were kept in separate clean 60-ml plastic containers with lids and clearly labeled with a specific number and data pertaining to the animal age, gender, origin of area imported and sampling time (month/year) were recorded. The samples were transferred to the Laboratory of Zoology, University of Shendi in an ice-cooled box, where they were examined immediately for helminth eggs and worms or stored at refrigerated temperature (4 °C) for a maximum of one day before processing. The age of each animal was determined by dental inspection, whereby animals having temporary incisors (milk teeth) were classified as young, and those with permanent incisors were recorded as adults.

3. 4 Fecal examination and helminth eggs count

3. 4. 1 Flotation technique

Numbers of fecal nematode eggs were determined using a McMaster technique (Hansen and Perry, 1994), where samples were examined by placing approximately 4 grams of feces into a beaker supplied with 56 ml of a kitchen salt/sugar solution as a flotation fluid. The composition was then mixed thoroughly; thereafter filtered using a fine strainer into a new clean beaker. Part of the top surface of the filtered material (fecal suspension) was taken using a Pasteur pipette into a McMaster counting chamber and allowed it to stand for 5 minutes. Thereafter, examined under a binocular microscope at 10×10 and 10×40 magnification. Parasites were identified on the basis of egg color, shape, contents, and size using keys given by Foreyt (2001); thereafter they were photographed using a digital camera. Eggs were counted and the counts

multiplied by 50 to obtain the total number of eggs per gram (epg) of fecal matter (Hansen and Perry, 1994).

3. 4. 2 Sedimentation technique

Numbers of fecal trematode eggs were determined using a sedimentation technique, where samples were examined by placing approximately 3 grams of feces into a beaker supplied with 40-50 ml clean tap water and mixed thoroughly with a stirring device; thereafter the fecal suspension was filtered through a fine strainer into a new clean beaker. The filtered material was poured into a test tube placed in a test tube rack for 5 minutes. Then the supernatant was very carefully removed using a pipette and the sediment was resuspened in 5 ml water and allowed to sediment for 5 minutes. The supernatant was very carefully discarded using a pipette and the sediment was stained by adding one drop of methylene blue. Finally, the stained sediment was transferred to a McMaster counting chamber for microscopic examination. All parasite eggs found were photographed using a digital camera. During the two techniques, all adult or larval parasites recovered were washed thoroughly with saline and stored in 10% formalin in plastic transparent containers.

3. 5 Statistical analysis

The prevalence of infection was calculated as a percentage of D/N where D is the number of animals infected and N is the total number of animals examined. The association between independent factors (age, sex, season and place of the host import) and continuous dependent variables (egg numbers per gram) or

intensity of infection was calculated using one way analysis of variance (ANOVA). The association between the independent factors and the prevalence of the various parasites were evaluated using the Chi-square test (χ^2). The statistical software, SPSS 16.0 for Windows (SPSS Inc., Chicago, IL., USA) was used to conduct the data analysis and values were considered significant when $P < 0.05$.

Chapter four

Results

4. 1 Overall prevalence and intensity of GI helminth infection

Out of the 687 ruminant examined, 411 were found positive with one or more gastrointestinal (GI) helminth parasites, giving an overall prevalence of infection of 59.8% (38.5%, 61.7% and 67.4% in cattle, sheep and goats, respectively), while the overall mean intensity of infection or egg counts per gram (epg) was 548.23 (970.2, 451.8 and 536.3 in cattle, sheep and goats, respectively).

In the present study, a total of 12 genera of GI helminth parasites were identified, of them 2 trematodes namely, *Fasciola* sp, *Paramphistomum* sp; 7 nematodes namely, *Haemonchus* sp, *Strongyloides* spp, *Trichostrongylus* sp, *Ostertagia* sp, *Ascaris* sp, *Nematodirus* sp and *Dictyocaulus* sp, and 3 cestodes namely, *Moniezia* sp, *Taenia* spp and *Dipylidium* sp. It was observed that the prevalence of *Taenia* spp parasite infection was the highest, whereas both *Trichostrongylus* sp and *Dictyocaulus* sp infections were lowest during the study period. Moreover, fecal sample examination showed that 6.6% of the examined animals had dual infection with most of the combinations being *Taenia* spp and *Strongyloides* spp. Figure (1) shows the egg of some helminth recovered.

4. 2 Prevalence and intensity of infection, according to the host age

The prevalence and intensity of GI helminth parasites in relation to the slaughtered ruminants' age are shown in Table (2). As observed, the adult goats had recorded the highest prevalence of GI helminth parasites (69.7%), while the adult cattle recorded the lowest prevalence (21.3%); however, as a total, there was no statistical difference ($P > 0.05$) in the prevalence of infection between adult and young of the examined ruminants. On the other hand, the highest intensity of infection was recorded among the young cattle (1306.8 epg), while the lowest was recorded among the adult sheep (431.4 epg). As a total, there was a significant difference ($P < 0.05$) in fecal egg counts between adult and young of the examined ruminants.

4. 3 Prevalence and intensity of infection, according to the host sex

The distribution of GI helminth parasites of the ruminants examined according to their host sex is shown in Table (2). The results indicated that male goats had the highest prevalence of infection (67.9%), while the fale cattle had the lowest (36.8%). There was a significant difference ($P < 0.05$) between males and females of the examined ruminants as a total in the prevalence of infection. Female cattle had higher total egg output, and there was a significant difference between males and females of the examined ruminants ($P < 0.05$).

Table 1: Infection parameters of GI helminth, according to age and sex of the ruminants slaughtered in Shendi abattoir (n = 687), September 2015- October 2016. (P = prevalence of infection; No. exam. = number examined)

Variables	Cattle			Sheep			Goats		
	No. exam.	P %	Mean intensity	No. e.xam.	P %	Mean intensity	No. exam.	P %	Mean intensity
Age									
Young	60	60*	1306.8*	62	61.3	506.5*	150	64.7	624.2
Adult	75	21.3	598.3	165	61.8	431.4	175	69.7	459.8
Sex									
Male	97	39.2	650.4	148	62.8#	444.6	134	67.9	650.4#
Female	38	36.8	675	79	59.5	465.9	191	67	508.9

*: $P < 0.05$ compared with adult; #: $P < 0.05$ compared with female.

4. 4 Prevalence and intensity of infection, according to the place of the host import

Regional analysis indicated that goats from the River Nile, Blue Nile and West Sudan acquired more infection than other ruminants examined. While in the White Nile and East Sudan, infection was among the only group examined, cattle (Table 2). Differences in prevalence of infection among ruminant examined according to regions was found statistically significant ($P < 0.05$).

There was a significant difference ($P < 0.05$) in fecal egg counts among the examined ruminants according to region of the source, where cattle from the White Nile were found to acquire the highest intensity of egg output, while goats from the Blue Nile had the lowest (Table 2).

4. 5 Prevalence and intensity of infection among host, according to seasons

The results indicated that higher prevalence of GI helminth infection among the ruminant slaughtered were during the rainy season (August - October) than in the dry season (Table 2). The difference between the two seasons in the prevalence of infection was found to be statistically significant ($P < 0.05$).

The mean egg output of GI helminth among the ruminant examined were relatively higher during the dry season compared with the rainy season (Table 2), and this difference was found to be statistically significant ($P < 0.05$).

Table 2: Infection parameters of GI helminth, according to season and place of import of the ruminants slaughtered in Shendi abattoir (n = 687), September 2015- October 2016. (P = prevalence of infection)

Variable	Cattle			Sheep			Goats		
	No. exam.	P %	Mean inten.	No. exam.	P %	Mean inten.	No. exam.	P %	Mean inten.
Place of source									
River Nile	86	33.7	710.3	168	55.4	423.7	290	65.2	550.7
White Nile	4	75	1666.7	0	0	0	0	0	0
Blue Nile	0	0	0	18	94.4	482.4	7	100	364.3
West Sudan	35	40	1207.1	41	73.2	436.7	28	82.1	432.6
East Sudan	10	60	925	0	0	0	0	0	0
Season									
Rainy	70	41.4	586.2*	127	70.1*	359.6*	100	78*	412.2
Dry	65	35.4	1241.3	100	51	612.7	225	62.7	635.1

*: $P < 0.05$ compared with dry season.

4. 6 Prevalence and intensity of infection of the identified helminth species

The highest prevalence of infection during the study period was scored by the cestode worm, *Taenia* spp while the nematodes, *Trichostrongylus* sp and *Dictyocaulus* sp recorded the lowest prevalence of infection. On the other hand, the nematode *Trichostrongylus* sp recorded the highest calculated mean intensity of egg output (Table 3).

Table 3: Prevalence, mean intensity and intensity range of infection of GI helminth species in ruminants (n = 687) slaughtered at Shendi abattoir, September 2015- October 2016.

Helminth species	Prevalence %	Mean intensity	Intensity range
Fasciola sp	4.4	421.7	100-1200
Paramphistomum sp	1.7	408.3	150-1200
Haemonchus sp	1.2	331.3	150-450
Strongyloides sp	14.8	567.2	100-2500
Trichostrongylus sp	0.1	2000	2000
Ostertagia sp	0.4	300	150-400
Ascaris sp	3.3	582.6	100-2500
Nematodirus sp	2.5	426.5	100-1200
Dictyocaulus sp	0.1	150	150
Moniezia sp	5.2	441.7	100-1500
Taenia sp	25.3	613.4	100-3000
Dipylidium sp	0.6	362.5	250-550

4. 7 Parameters of helminth species, according to ruminant species

The highest prevalence of helminth infection among cattle, sheep and goats examined was the cestode *Taenia* sp while the trematode *Fasciola* sp recorded the lowest infection among cattle, *Haemonchus* sp recorded the lowest infection among sheep and both *Trichostrongylus* sp and *Dictyocaulus* sp were recorded the lowest infection among goats. At the same time these three groups were found free from infection of some helminthes (Table 4). On the other hand, the trematodes: *Strongyloides* spp recorded the highest mean intensity of egg output among cattle, and *Paramphistomum* sp among sheep while the nematode *Trichostrongylus* sp recorded the highest mean of the egg output (Table 4).

Table 4: Infection parameters of GI helminth species, according to the ruminant species (n = 687) slaughtered at Shendi abattoir, September 2015- October 2016. (P = prevalence of infection)

Helminth species	Cattle			Sheep			Goats		
	No. infect.	P %	Mean inten.	No. infect.	P %	Mean inten.	No. infect.	P %	Mean inten.
Fasciola sp	2	1.5	275	12	5.3	412.5	16	4.9	446.9
Paramphistomum sp	0	0	0	7	3.1	500	5	1.5	460
Haemonchus sp	0	0	0	2	0.9	300	6	1.8	341.7
Strongyloides sp	9	6.7	1133.3	36	15.9	450	57	17.5	562.3
Trichostrongylus sp	0	0	0	0	0	0	1	0.3	2000
Ostertagia sp	0	0	0	3	1.3	300	0	0	0
Ascaris sp	11	8.1	881.8	4	1.8	450	8	2.5	350
Nematodirus sp	0	0	0	6	2.6	450	11	3.4	413.6
Dictyocaulus sp	0	0	0	0	0	0	1	0.3	150
Moniezia sp	0	0	0	18	7.9	438.9	18	5.5	450
Taenia sp	26	19.3	1005.8	52	22.9	486.5	96	29.5	582.3
Dipylidium sp	4	2.9	362.5	0	0	0	0	0	0

4. 8 Prevalence of helminth species, according to the ruminant species sex

The cestode *Taenia* spp was the most prevalent GI helminth among male and female of the ruminants examined. However, there was a fluctuation in the least prevalence of helminth species infection, according to the sex of the ruminants examined (Table 5).

Table 5: Prevalence of GI helminth species infection, according to sex of the ruminant species (n = 687) slaughtered at Shendi abattoir, September 2015-October 2016.

Helminth species	Prevalence % in cattle		Prevalence % in sheep		Prevalence % in goats	
	Male (n=97)	Female (n=38)	Male (n=148)	Female (n=79)	Male (n=134)	Female (n=191)
Fasciola sp	2.1	0	5.4	5.1	4.5	5.2
Paramphistomum sp	0	0	3.4	2.5	1.5	1.6
Haemonchus sp	0	0	1.4	0	1.5	2.1
Strongyloides sp	5.2	10.5	16.9	13.9	18.7	16.8
Trichostrongylus sp	0	0	0	0	0.7	0
Ostertagia sp	0	0	1.4	1.3	0	0
Ascaris sp	9.3	5.3	1.4	2.5	2.2	2.6
Nematodirus sp	0	0	3.4	1.3	3.7	3.1
Dictyocaulus sp	0	0	0	0	0	0.5
Moniezia sp	0	0	7.4	8.9	4.5	6.3
Taenia sp	19.6	18.4	22.3	24.1	30.6	28.8
Dipylidium sp	3.1	2.6	0	0	0	0

4. 9 Prevalence of helminth species, according to the ruminant species age

The cestode *Taenia* spp was the most prevalent GI helminth among young and adult cattle. However, the nematode *Strongyloides* spp was the most prevalent helminth among young and adult of both sheep and goats examined (Table 6).

Table 6: Prevalence of GI helminth species infection, according to the sex of ruminant species (n = 687) slaughtered at Shendi abattoir, September 2015-October 2016.

Helminth species	Prevalence % in cattle		Prevalence % in sheep		Prevalence % in goats	
	Young (n=60)	Adult (n=75)	Young (n=62)	Adult (n=165)	Young (n=150)	Adult (n=175)
Fasciola sp	3.3	0	6.5	4.8	4.7	5.1
Paramphistomum sp	0	0	0	4.2	0	2.9
Haemonchus sp	0	0	0	1.2	1.3	2.3
Strongyloides sp	11.7	2.7	16.1	15.8	14.7	20
Trichostrongylus sp	0	0	0	0	0.7	0
Ostertagia sp	0	0	1.6	1.2	0	0
Ascaris sp	13.3	1.3	1.6	1.8	3.3	1.7
Nematodirus sp	0	0	3.2	3.6	2.7	4
Dictyocaulus sp	0	0	0	0	0.7	0
Moniezia sp	0	0	12.9	6.1	4.0	6.9
Taenia sp	28.3	12	25.8	21.8	32.7	26.9
Dipylidium sp	3.3	2.7	0	0	0	0

4. 10 Prevalence of helminth species, according to season of host examination

The cestode *Taenia* spp was the most prevalent GI helminth throughout the year among the ruminants examined. However, there was a fluctuation in the least prevalence of the other helminth species, according to season of samples collection and examination (Table 7).

Table 7: Prevalence of GI helminth species infection among ruminant (n = 687) slaughtered at Shendi abattoir, according to season of examination, September 2015- October 2016.

Helminth species	Prevalence % in cattle		Prevalence % in sheep		Prevalence % in goats	
	Rainy (n=70)	Dry (n=65)	Rainy (n=127)	Dry (n=100)	Rainy (n=100)	Dry (n=225)
Fasciola sp	2.9	0	4.7	6	8	3.6
Paramphistomum sp	0	0	3.1	3	0	2.2
Haemonchus sp	0	0	1.6	0	4	0.9
Strongyloides sp	8.6	4.6	20.5	10	20	16.4
Trichostrongylus sp	0	0	0	0	0	0.4
Ostertagia sp	0	0	2.4	0	0	0
Ascaris sp	5.7	10.8	0.8	3	6	0.9
Nematodirus sp	0	0	2.4	3	3	3.6
Dictyocaulus sp	0	0	0	0	0	0.4
Moniezia sp	0	0	12.6	8	9	4
Taenia sp	18.6	20	22	24	24	32
Dipylidium sp	5.7	0	0	0	0	0

4. 11 Prevalence of helminth species, according to the place of host import

The cestode *Taenia* spp was the most prevalent GI helminth among the ruminants examined from the River Nile, West and East Sudan regions. While, the nematodes *Strongyloides* sp and *Ascaris* sp beside the cestode *Taenia* sp were recorded the highest prevalence of infection among ruminants imported from the White Nile region. In the same context, the trematode *Fasciola* sp and the cestode *Moniezia* sp were recorded the highest prevalence of infection among ruminants imported from the Blue Nile region (Table 6).

Table 8: Prevalence of GI helminth species infection among ruminant (n = 687) slaughtered at Shendi abattoir, according to the place of host import, September 2015- October 2016.

Helminth species	Prevalence % by place of the host import				
	River Nile (n=544)	White Nile (n=4)	Blue Nile (n=25)	West Sudan (n=104)	East Sudan (n=10)
Fasciola sp	4.2	0	24	0.9	0
Paramphistomum sp	1.3	0	0	4.8	0
Haemonchus sp	1.3	0	4	0	0
Strongyloides sp	13.4	25	20	22.1	0
Trichostrongylus sp	0.2	0	0	0	0
Ostertagia sp	0.4	0	0	0.9	0
Ascaris sp	3.3	25	0	3.8	0
Nematodirus sp	2.6	0	12	0	0
Dictyocaulus sp	0.2	0	0	0	0
Moniezia sp	4	0	24	7.7	0
Taenia sp	25.7	25	12	24	50
Dipylidium sp	0.6	0	0	0	10

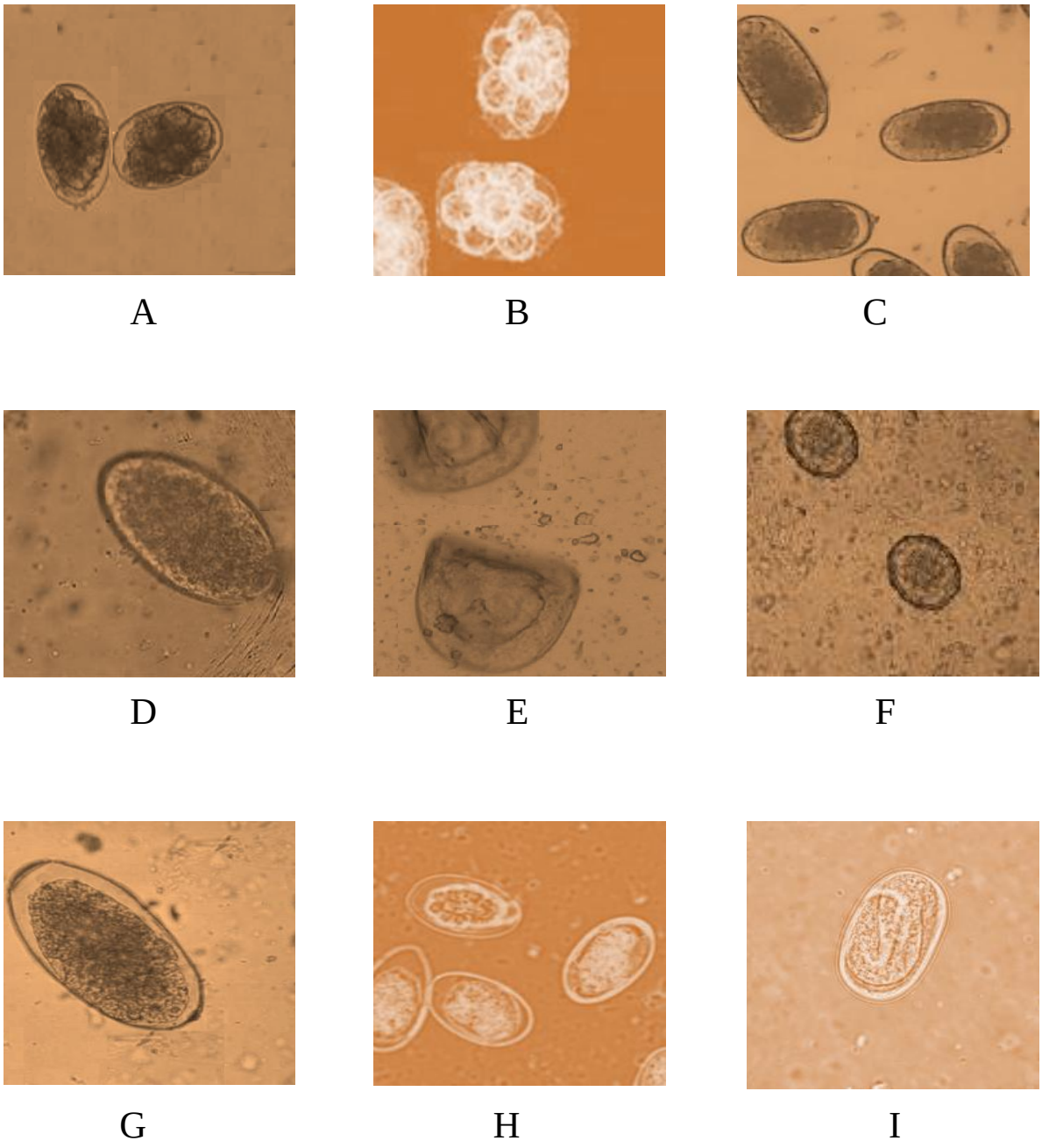

Fig. 1. Eggs of some GI helminth recovered during the present study (A): *Ostertagia* sp; (B): *Dipylidium* sp; (C): *Nematodirus* sp ; (D): *Paramphistomum* sp;(E): *Moniezia* sp;(F): *Ascaris* sp;(G): *Fasciola* sp;(H): *Haemonchus* sp; (I): *Strongyloides* sp.

Chapter five

Discussion and recommendations

5. 1 Discussion

Helminth infections or helminthoses refer to a complex of condition caused by parasites of the Nematoda, Cestoda and Trematoda helminths. Results of the present study show that the ruminants slaughtered at Shendi abattoir from September 2015 to October 2016 were infected with a variety of GI helminth species with an overall prevalence of 59.8% and intensity of infection of 548.23 epg. This result confirms previous reports on the occurrence of GI helminth parasites in ruminants in Sudan (Atta El Manan, 1983; Ahmed, 2004; Elmahdi *et al*., 2004; Darien, 2008; Anon, 2011; Alkareem , 2012; Mohamed *et al*., 2013).

Generally, there are many associated risk factors influencing the prevalence of GI helminth including age, sex, weather conditions and husbandry or management practices (Valcarcel and Romero, 1999; Raza *et al*., 2007; Muhammad *et al*., 2010; Blackie, 2014). Moreover, the prevalence of infectious diseases in animals is related to other factors, including types of food and water, hygienic conditions, locations of pens, administration of drugs and the level of education and economic capacity of farmers (Islam and Taimur, 2008; Khan *et al*., 2010).

Although there was no statistical difference in the prevalence of infection between adult and young of the examined ruminants in this study. However, a

relatively high prevalence recorded in adult than young could be attributed to their longer exposure degree to parasites in pastures. Young animals were found to have lower prevalence rates of GI helminth parasites compared to the adult. This result is not conformed to some previous findings (Almalaik *et al*., 2008; Kanyari, 2009; Awraris, 2012; Shitta, 2013). However, young animals are more susceptible to infection than adults due to their low levels of immunity (Ploeger *et al*., 1994; Kanyari *et al*, 2009; Radostits *et al*., 2010).

The results of the present study showed that male ruminants had significantly higher prevalence of GI helminth than their female counterpart. Although, many previous studies concluded that there were no sex-related differences in the prevalence of GI helminth in ruminants and especially cattle (Fikru *et al*., 2006; Bilal *et al*., 2009; Coelho *et al*., 2012). However, some studies showed a significant difference in GI helminth infection between male and female of goats and sheep (Yohanna *et al*., 2012, Hadiza and Halima, 2014; Ibrahim *et al*., 2014), with infection being higher in females, because pregnancy might have lowered their immunity.

Regional analysis indicated that the non-local ruminants had higher prevalence of GI helminth infection than their local counterpart or that from the River Nile region. This could be due to the difference in the sample size taken, the prevailing environmental conditions of host source, poor animal husbandry practices and the availability of intermediate hosts. Analysis indicated that goats from the River Nile, Blue Nile and West Sudan acquired more infection than

other ruminants examined. While in the White Nile and East Sudan, infection was among cattle group. Differences in prevalence of parasites may be due to variations in geographical and climatic conditions (Nwosu *et al*., 2007). Moreover, the number of infective larvae ingested by the host, besides overstocking of animals may have a role in increasing and spreading of infections.

The results of this study indicated that higher prevalence of helminth infection was during the rainy season. This is likely due to the availability of a wide grazing area within the place of the host import which increased their chances of picking up the cyst, ova, larvae or the intermediate host of these GI helminth that were attached to the pastures. In addition, the meteorological parameters such as temperature, humidity and rainfall of the grazing area and grazing behavior of the host are also highly favorable for parasites transmission (Rahman, 1992; Waruiru *et al*., 2000; Dhoot *et al*., 2002; Al-Shaibani *et al*., 2008; Dagnachew *et al*., 2011). Moreover, susceptibility to infection is influence by some factors like age, species, health status and previous exposure to parasites (Bekele *et al.,* 1987; Richard *et al.,* 1990; Vlassoff *et al.,* 1999). In contrast, the prevalence and intensity of various GI parasites infection are severely affected during drought conditions and higher temperatures lead to desiccation of parasite eggs or larvae (Hansen and Perry, 1994; Kaufman, 1996; Nwosu *et al*., 2007; Ohaeri, 2012).

The results of this study showed that female cattle and sheep had higher total egg output. It is well known that the susceptibility of female ruminants to infection might be attributed to reduced immunity as a result of stress due to pregnancy and lactation. However, this result cannot be explained according to this reason, because the most of the studied animals were young. Moreover, the number of eggs detected in the feces depends on the consistency of the feces. Diarrhoeic faeces often contain lower numbers of eggs per gram than formed feces, due to the effect of dilution.

There was a significant difference in fecal egg counts among the age groups of the examined ruminants in the present study, where the young had the highest intensity of infection, while adults had the lowest. The high worm burden in young ruminants may be due to their limited previous exposure and immaturity of their immune system, resulting in a large proportion of ingested larvae developing into adults. In addition, the number of parasitic eggs varies according to species of worms, host species, body condition and immune status of the animal (Urquhart *et al*., 1996).

There was a significant difference in fecal egg counts among the examined ruminants according to region of the source. Cattle from the White Nile were found to acquire the highest intensity of egg output, while goats from the Blue Nile had the lowest. As mentioned above, helminth infection rates often differ from region to region and this refers mainly to the nature of the grazing lands along with the host grazing behavior.

The mean egg output of GI helminth among the examined ruminants was relatively higher during the dry season. This finding is in contrast with a previous report on cattle from West Africa that the worm numbers and egg excretion are seasonal, with higher numbers during the rainy season (Zinsstag *et al*., 1998). As a consequence, calves born during the rainy season are expected to be at a higher risk of infection with GI parasites than that born during the dry season. It has been reported that the maximum egg count and larval population of parasites are associated with wet seasons (Romero and Gruner 1984; Waruiru *et al*., 2000).

The most prevalent GI helminth parasites detected in the present study were the cestode, *Taenia* spp and the nematode *Strongyloides* spp. This result corroborates some findings in Africa (Kanyari, 2009; Mulugete *et al*., 2011). The high prevalence of strongyle nematodes may be due to their direct life cycle when favorable conditions are available upon pasture or farms of poor hygienic conditions. On the other hand, the nematodes, *Trichostrongylus* sp and *Dictyocaulus* sp recorded the lowest prevalence of infection. The highest prevalence of helminth infection among cattle, sheep and goats examined was the cestode *Taenia* sp while the trematode *Fasciola* sp recorded the lowest infection among cattle, *Haemonchus* sp recorded the lowest infection among sheep and both *Trichostrongylus* sp and *Dictyocaulus* sp were recorded the lowest infection among goats. The relative low prevalence of *Fasciola* spp among cattle may be due to the nature of the grazing lands where animals were

imported which does not favor propagation of the snail intermediate hosts. Although, *Haemonchus* spp are more prevalent in the tropical and warmer temperate zones (Sissay *et al*., 2007; Qamar *et al*., 2009), but it is proportion in this study was very low. This finding is not consistent with a previous study that sheep acquired more infection due to its ground grazing habit compared to goats (Javed *et al*., 1992).

On the other hand, the trematodes: *Strongyloides* spp recorded the highest mean intensity of egg output among cattle, and *Paramphistomum* sp among sheep while the nematode *Trichostrongylus* sp recorded the highest mean of egg output among goats. Although, the high egg output of female nematode may due to their high fecundity. But, the nematode *Trichostrongylus* spp are less fecund in egg production (Hansen and Perry, 1994). Therefore, this study finding of high egg output may due to high number of worms in the host intestine or abomasum.

The cestode *Taenia* spp was the most prevalent GI helminth among male and female of ruminants examined. This explains the high prevalence of this parasite across the country. However, there was a fluctuation in the least prevalence of helminth species infection, according to the sex of the ruminants examined. Likewise, the cestode *Taenia* spp was the most prevalent GI helminth throughout the year among the ruminants examined. However, there was a fluctuation in the least prevalence of the other helminth species, according to season of samples collection and examination.

The cestode *Taenia* spp was the most prevalent GI helminth among the ruminants examined from the River Nile, west and east Sudan regions. While, the nematodes *Strongyloides* spp and *Ascaris* sp beside the cestode *Taenia* sp were recorded the highest prevalence of infection among ruminants imported from the White Nile region. White Nile is characterized by a hot-humid condition, especially during rainy seasons that favor the survival of the infective larval stage of most of the parasites including *Strongyloides* spp. *Ascaris* spp spreads through eggs, and these well-protected eggs can easily withstand drying and can also survive for long periods. Therefore, when pasture polluted with this parasite eggs, it may become a source of infection.

In the same context, the trematode *Fasciola* spp and the cestode *Moniezia* sp were recorded the highest prevalence of infection among ruminants imported from the Blue Nile region. Higher prevalence of fasciolosis among ruminants of this region can be due to the availability of water pools or swampy areas which are very important habitats for the reproduction of the water snails, the intermediate hosts for such trematodes (Swarnakar and Sanger, 2014). Higher prevalence of the cestode *Moniezia* sp in this region could be due to high exposure to the intermediate host, oribatid mites on the pasture. Previous studies showed that the number of oribatid mites tends to increase during rainy seasons (Denergi and Alzued, 1992).

5. 2 Conclusion and recommendations

The result of this study clearly shows that the GI helminth parasites: *Fasciola* sp, *Paramphistomum* sp, *Haemonchus* sp, *Strongyloides* spp, *Trichostrongylus* sp, *Ostertagia* sp, *Ascaris* sp, *Nematodirus* sp, *Dictyocaulus* sp, *Moniezia* sp, *Taenia* spp and *Dipylidium* sp are prevalent in the Sudanese ruminants. Therefore, the health of human is at risk. This calls for more control and preventive measures including educating of farmers in the proper use of anthelmintic treatments. Moreover, to avoid infection at the abattoir, workers should take their drinks and meals away from the main work area to avoid possible contamination with parasites; wearing appropriate protective clothing and safe disposal of all contaminated waste, routinely medical checkup for possible infection and proper disposal of condemn organs.

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