STUDIES ON GASTROINTESTINAL HELMINTHS OF SMALL RUMINANTS SLAUGHTERED IN DOGARAWA SLAUGHTER SLAB IN ZARIA, NIGERIA.

BY

JAMES GANA JOSIAH

DEPARTMENT OF VETERINARY PARASITOLOGY AND ENTOMOLOGY

AHMADU BELLO UNIVERSITY, ZARIA

NIGERIA.

MAY, 2014

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BY

James Gana JOSIAH, *B Sc. Zoology (UniJos) 2005; PGDE (NTI KAD) 2009*

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DEPARTMENT OF VETERINARY PARASITOLOGY AND ENTOMOLOGY,

AHMADU BELLO UNIVERSITY, ZARIA,

NIGERIA.

MAY, 2014

DECLARATION

I declare that the work in this thesis, entitled "**Studies on gastro-intestinal helminths of small ruminants slaughtered in Dogarawa slaughter slab Zaria, Nigeria**" has been performed by me in the Department of Veterinary Parasitology and Entomology, Ahmadu Bello University, Zaria under the supervision of Dr. H. J. Makun, Dr. P. N. Chiezey and Prof. L. B Tekdek. The information derived from the literature has been duly acknowledged in the list of references provided. No part of this thesis was previously presented for another degree or diploma at any University.

James Gana JOSIAH _____ _____

Sign Date

CERTIFICATION

This thesis, **entitled "Studies on gastro-intestinal helminths of small ruminants slaughtered in Dogarawa slaughter slab, Zaria, Nigeria"** by Josiah Gana James meets the regulations governing the award of the degree of Master of Science of the Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

Dr. H. J. Makun. _____ _____
Chairman, Supervisory Committee Sign Date

Dr. P. N. Chiezey. _____ _____
Member, Supervisory Committee Sign Date

Prof. L. B Tekdek. _____ _____
Member, Supervisory Committee Sign Date

Dr. A. J Natala. _____ _____
Head, Department of Veterinary Parasitology and Entomology Sign Date
Ahmadu Bello University, Zaria

Prof. A. A. Joshua. _____ _____
Dean School of Postgraduate Studies Sign Date
Ahmadu Bello University, Zaria

DEDICATION

This thesis is affectionately dedicated to the Almighty God and to my dear parents whose prayers will always remain with me.

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ABBREVIATIONS

ED – Early Dry

EPG – Egg Per Gram of faeces

ER – Early Rain

FEC – Faecal Egg Counts

GIN – Gastro-intestinal Nematode

GIT – Gastro-intestinal Tract

L_1 - First-stage larvae

L_2 - Second-stage larvae

L_3 - Infective third-stage larvae

L_4 - Fourth-stage larvae

LD – Late Dry

LR – Late Rain

MAFF – Ministry of Agriculture Fisheries and Food

MED – Ministry of Economic Development

PGE – Parasitic Gastroenteritis

SEA- Small East African

ABSTRACT

Gastrointestinal helminths have been recognized as a major constraint to both small and large-scale small ruminant production in developing countries. This study was aimed at evaluating the current status of gastrointestinal tract (GIT) parasites and the risk factors associated with it in Zaria, Nigeria. A cross- sectional study was carried out in sheep and goats from November, 2011 to October, 2012. Three hundred GIT with corresponding faecal and blood samples were also collected from 200 goats and 100 sheep respectively at necropsy and examined by the Hansen and Perry method. The egg per gram of feaces was determined by the modified McMaster techniques. Faecal sample examination revealed an overall helminth prevalence of 77.3% (232/300) in small ruminants with 82% of sheep and 75% of goats harbouring at least one or more helminth egg types. Four helminth egg types were recovered with Strongyle egg type (71% in sheep and 62% in goats) being the most prevalent followed, respectively by Moniezia (15% in sheep and 15% in goats), Strongyloides (8% in sheep and 8.5% in goats) and Trichuris (4% in sheep and 6% in goats) egg types. Mean faecal egg counts were generally moderate in both sheep and goats. The mean egg counts per gram of faeces in sheep for Strongyloides, Strongyle, Moniezia and Trichuris were 4208±343.1 (20-28000), 2966±435.7(20-13320), 718±244.1(40-2800) and 90±23.80(60-160) respectively. The mean egg counts per gram of faeces in goats for Strongyloides, Strongyle, Moniezia and Trichuris were 2603±138.8 (20-5000), 1301±189.9 (20-12080), 1247±442.8 (20-10000) and 138.8±30.39 (60-360) respectively. The prevalence and counts of Strongyle egg types showed a definite seasonal sequence that corresponded with the relative humidity and rainfall pattern in the study area during the period. The other egg types encountered during the study did not show much variation with the season of the year. Examination for adult helminths in-situ revealed that 157 (78.5%) of goats and 85(85%) of sheep harboured at least one adult helminth given an overall prevalence of 80.67% of small ruminants. Five genera of adult helminths recorded were Haemonchus, Trichostrongylus, Oesophagostomum, Trichuris and Moniezia. Adult worm burdens were generally low. The mean worm burden for Haemonchus was 145.6 ±48.99, with a range of 1 to 4100. Haemonchus spp burden showed seasonal variation that corresponded with the rainfall pattern in the study area during the period. Haemonchus demonstrated arrested development during early dry, late dry and late rainy seasons of the study period. Correlation between EPG and PCV, adult worm burdens and PCV and Adult worm burden and EPG were all highly significant ($P<0.0001$). The correlation between EPG and worm burden was positive ($r=+0.3860$), while the correlation between EPG and PCV; worm burden and PCV were negative (-0.2789 and -0.2632 respectively). Bile collection revealed the presence of Fasciola spp and Dicrocoelium spp with an overall prevalence of 8.6% in small ruminants. This study has revealed an all-year round helminth infections in small ruminants, which may impact negatively on productivity. The study further demonstrated a significantly negative correlation between adult worm burden and PCV as well as EPG. Thus, further studies on these correlation under experimental condition is recommended.

CHAPTER ONE

INTRODUCTION

1.1 General Background to the Study

Small ruminants, especially sheep and goats, constitute an important source of animal protein to many Nigerians. A lot of socio-economic importance is therefore attached to ownership of these animals that, in some cases, may be the only realizable wealth of a rural household (Omeke, 1988).

The world's total numbers of goats and sheep were 861.9 and 1078.2 million, respectively, i.e. there is about one goat to approximately 1.25 sheep (FAOSTAT, 2008). In Nigeria, the total numbers of goats and sheep were 53.8 and 33.9 million, respectively (FAOSTAT, 2008). This constitutes 6.2% and 3.1% of the world total population of goats and sheep respectively (FAOSTAT, 2008).

Sheep and goats harbour a variety of gastrointestinal tract (GIT) parasites, many of which are shared by both species. Among these parasites, helminths such as nematodes (roundworms), cestodes (tapeworms), and trematodes (flukes) are the most important as they affect the growth as well as the production of the animals. Gastrointestinal nematodes of the *Trichostrongylidae* family are perhaps the most important parasites of small ruminants world-wide, causing significant morbidity and loss of production (Bagley, 1997; Pawel *et al.*, 2004).

Gastrointestinal nematodes of small ruminants are roundworms parasitizing the abomasum, small intestine and large intestine. Infection usually occurs primarily through contaminated feed and water, enhanced by poor hygiene (Gatongi, 1996).

Intestinal helminthosis has for many years been recognized as a major problem in livestock rearing (Barger, 1997). Most goats infected have been shown to be asymptomatic or produce only mild symptoms, as a result of which infections are often overlooked till serious complication or chronic clinical signs occur (Rausch and Jentoft, 2002).

Gastrointestinal nematodes could be harmful to the infected animals and cause economic loss due to mortalities and reduced weight gain (Menkir *et al*., 2007; Vlassoff *et al*., 2001). Gastrointestinal nematodes also cause hypoproteinemia, impaired digestive efficiency and pathogenic complications such as anaemia, diarrhoea, oedema and recumbency which will lead to lowered productivity, retarded growth rate and even death of lambs (Holmes, 1986; Sykes, 1994; Forse, 1999; Al-Shaibani *et al.,* 2009). The loss through reduced productivity is related to reduction of food intake, stunted growth, reduced work capacity, cost of treatment and control of helminthosis (Pedreira *et al.,* 2006; Odoie *et al.,* 2007; Chaudhary *et al*., 2007).

The severity of infections depends on the genera of helminth parasites involved, animal species, the number of infective stages on pasture, an alteration in host susceptibility, the introduction of susceptible stock into an infected environment, the introduction of infections into an environment, ineffective parasite removal from the host animals due to poor drug administration techniques, and local environmental conditions such as humidity, temperature, rainfall, vegetation and management practices (Fakae, 1990a; Hansen and Perry, 1994; Sykes, 1994; Nwosu *et al.,* 1996 a,b; Urquhart *et al.,* 1996).

Several studies carried out on gastrointestinal helminthosis of small ruminants in many African countries showed that the prevalence of the infections varies from place to place. Studies on seasonal incidence of GI helminthosis are carried out to find the time in which infection with infective larvae begins, rises to a peak and decline so that the treatment can be timed to prevent severe infection as well as reduce contamination of pastures with eggs and larvae. Comprehensive studies are required to know the level of GIT helminths in small ruminants in Zaria, Northern Nigeria and factors contributing to their prevalence.

1.2 Statement of Research Problems

Gastrointestinal trichostrongyles of which *Haemonchus contortus* ranks highest in importance globally (Perry *et al.,* 2002; Tariq *et al.,* 2010) are recognized as a major constraint to both small and large-scale small ruminant production in developing countries, leading to significant economic losses (Martinez-Gonzalez *et al*., 1998). These nematodes *(Haemonchus, Trichostrongylus and Cooperia*) cause impaired digestion and also affect the absorption of minerals particularly calcium and phosphorus (Speedy, 1992).

Surveys indicated that up to 95% of sheep and goats in the tropics are infected with helminths with *Haemonchus* and *Trichostrongylus* being the main genera involved (Rey, 1991). Mortality rates in herds may exceed 40% while weight losses of up to 6-12 kg/year/animal may occur (IEMVT, 1980).

In Nigeria, the economic loss due to helminthosis in small ruminants alone has been estimated to be at least 144 million naira annually, through death, weight loss and liver condemnation (Akerejola *et al., 1979*).

Fabiyi (1970) carried out a survey on the incidence of goat helminth parasites in Zaria area of Nigeria. The result revealed the presence of 12 species of nematodes, 4 cestodes, and 4 trematodes with various percentages. Ajanusi and Chiezey (2005) also carried out a study on prevalence of *Haemonchus contortus*, *Anaplasma ovis* and *Theileria ovis* infections in goats in Zaria and obtained a prevalence of 89.1%, 9.2% and 3% respectively. These reports indicate a high prevalence of gastrointestinal parasitism in goats which may be contributing to low productivity of these animals.

Fabiyi's survey was done over three decades ago. Besides, the studies of Fabiyi (1970) and Ajanusi and Chiezey (2005) were restricted to goat helminths. There is therefore a need to conduct a more comprehensive survey on prevalence of gastrointestinal helminths of small ruminants in Zaria, Northern Nigeria. Information that will be generated from the studies can contribute to the understanding of the epidemiology of helminth infections in the area of study for proper control measures.

1.3 Justification of the Study

In Nigeria, gastro-intestinal nematode parasitic infection is one of the major health problems. Gillian *et al.* (2004) reported that nematode infections affect the health of millions of people and animals, causing huge economic loss in livestock farming. Previously, Mulugeta *et al.* (1989) reported that infection is enormous in small domestic ruminants, causing major production loss.

The animal protein intake in Nigeria is 3.24 g/day falls far below the FAO recommended value of 34g per day (Shaib *et al.*, 1997). Since small ruminants contribute an estimated 35% of the total meat supply in Nigeria (Brinkmann and Adu, 1977; Adu and Ngere, 1979), efforts at increasing the protein intake should partly be directed at steps aimed at increasing livestock production (Jibril *et al.*, 2010). Besides, an increase in livestock production will translate into an improve in livelihood of the populace since a number of people are involved in the livestock industry (maintenance, transportation, slaughtering and trading) (Jibril *et al.*, 2010).

There is dearth of information in Zaria as regards the overall prevalence of GI parasite infections of small ruminants and the relationship between actual worm burden, faecal egg counts, and PCV. Studies carried out by Fabiyi (1970) in Zaria on goats need to be revalidated as a result of tremendous changes in the climate and husbandry practices of livestock in Zaria. The present study is therefore aimed at determining the current status of GI helminth infections of goats and sheep slaughtered in Dogarawa slaughter slab in Zaria, Northern Nigeria. The knowledge of the relationship between faecal egg counts, actual worm burden and PCV will provide useful information for Veterinarians. The research work will also provide baseline data on burdens of gastrointestinal helminth infections in sheep and goat which can be useful for comparison with data from other climatic areas. The information will also be of value in control measures of helminthosis in Zaria.

1.4 Aim of the Study

The aim of the study is to evaluate the current status of GIT helminth infections of small ruminants in Zaria, Nigeria.

1.5 Specific Objectives

Specific objectives were:

1. To determine and compare the distribution of GIT helminths of small ruminant slaughtered in Dogarawa slaughter slab in Zaria by species, age, sex of the host and season of the year.
2. To determine the faecal egg counts of GI helminths in small ruminants meant to be slaughtered in Dogarawa slaughter slab in Zaria.
3. To determine the relationship between worm burden, faecal egg counts and PCV of small ruminants slaughtered in Dogarawa slaughter slab in Zaria.
4. To determine the prevalence and seasonal occurrence of arrested L_4 larvae of *Haemonchus contortus* in abomasums of small ruminants slaughtered in Dogarawa slaughter slab in Zaria.

1.6 Research Questions

The following research questions have been formulated to guide the study.

1. What adult helminth parasites are present in GIT of small ruminants?
2. Is the distribution of GIT helminths in small ruminants affected by the season of the year or species, age and sex of the host?
3. Is there correlation between adult worm burden, faecal egg counts and PCV in small ruminants?
4. At what month(s) of the year do larvae of *Haemonchus contortus* go into hypobiosis in small ruminants?

1.7 Scope and Limitation of the Study

This study was restricted to sheep and goats slaughtered in Dogarawa slaughter Slab in Zaria, Northern Nigeria. Liver and lung were not collected during the study as a result of financial constraint. Adult female and male species of helminth parasites encountered during the survey were not counted separately but were only noted. Faecal samples were not cultured for L_3 identification of nematode species eggs since adult worm nematodes were identified to generic level.

CHAPTER TWO

LITERATURE REVIEW

2.1 Helminths

The name ‘‘helminth” is derived from the Greek word ‘‘helmins” or ‘‘helminthos”, meaning a worm, and is usually applied only to the parasitic and non-parasitic species belonging to the phylum Platyhelminthes (such as flukes and tapeworms) and the phylum Nemathelminthes (roundworms and their relatives). The Annelida (earth worms, leeches) are basically different from both the Platyhelminthes and *N*emathelminthes and are not regarded as helminthes, though some (e.g. leeches) may be parasitic and others (e.g. earthworms) may serve as intermediate hosts for helminths (Soulsby, 1986; Urquhart *et al.,* 1996).

Therefore, helminth infections, or helminthoses, thus refer to a complex of conditions caused by parasites belonging to the class Nematoda, Cestoda and Trematoda. Although all grazing sheep and goats may be infected with helminths, low worm burdens usually have little impact on animal health. With heavier worm burdens

however, clinical signs such as weight loss, diarrhoea, anaemia, or sub-mandibular oedema (bottle jaw) may develop (Sissay, 2007).

Domesticated animals harbour a wide range of parasites, the most important of which are helminths. Helminth parasites are by far the most serious cause of production losses in farm ruminants (Familton and McAnulty, 1997) and the nematodes are the most important of these. Internal parasitism is the major disease syndrome of pastoral ruminants simply because environments which favour pastoralism also favour the survival and development of the free-living stages of helminth parasites (Sykes, 1997). This review is confined to helminth parasites of sheep and goats. The internal parasites of concern fall into three groups: nematodes (roundworms); cestodes (tapeworms) and trematodes (flukes), with the nematodes being by far the most important. Goats can be infected with many of the same worms as sheep, and they can transmit them to each other (Mason, 1997b; Pomroy, 1997a).

2.2 Aetiology of Helminthoses

Helminthosis is a widespread infection of small ruminants in the sub-Saharan region. Nematodes, trematodes and cestodes are the three major classes of parasitic helminths of economic and zoonotic importance affecting goats and sheep in this region (Anene *et al.,* 1994).

The Nemathelminthes (nematodes) include several superfamilies of Veterinary importance. These are Trichostrongyloidea, Strongyloidea, Metastrongyloidea, Ancylostomatoidea, Rhabditoidea, Trichuroidea, Filarioidea, Oxyuroidea, Ascaridoidea and Spiruroidea. The GI nematodes of greatest importance in small ruminants are members of the Order Strongylida, which contains the first four

superfamilies, but the most important species belong to the superfamily Trichostrongyloidea. All grazing sheep and goats are infected with a community of these strongylid nematodes, whose combined clinical effect is the condition known as parasitic gastroenteritis (PGE) (Zajac, 2006).

The most common species of nematodes associated with parasitic gastro-enteritis in small ruminants in most sub-Saharan countries are *Haemonchus contortus, Oesophagostomum columbianum* and *Trichostrongylus colubriformis. Trichostrongylus axei, Bunostomum trigonocephalum, Cooperia curticei, Trichuris ovis, Trichuris globulosus, Strongyloides papillosus, Gaigeria pachyscelis* and *Chabertia ovina* also contribute to the syndrome (Soulsby, 1982; Chiejina, 1986; Hansen and Perry, 1994; Nwosu *et al.,* 1996a,b; Lughano and Dominic, 1996). In winter rainfall and cool highland areas, *Ostertagia circumcincta* and *Nematodirus filicollis* are also involved in the pathogenesis of parasitic gastro-enteritis in goats and sheep (Bekele *et al.,* 1992; Tembely, 1995; Tembely *et al.,* 1997). Lungworms such as *Dictyocaulus filaria, Muellerius capillaries* and *Protostrongylus rufescens* cause parasitic bronchitis particularly in young animals (Alemu *et al*., 2006).

All of the trematode species that are parasitic in small ruminants belong to the subclass Digenea. The most important of these species in Africa are the liver flukes: *Fasciola hepatica, F. gigantica, Dicrocoelium* spp., *Schistosoma* spp and *Paramphistomum* spp. *Fasciola gigantica* is the commonest species associated with fasciolosis in most sub-Saharan countries. *Fasciola hepatica* has also been shown to be a significant cause of fasciolosis in highland areas of Kenya, North-Eastern and South-Western Tanzania, Ethiopia, Lesotho the Republic of South Africa and Nigeria. Clinical

paramphistomosis in small ruminants is caused by *Paramphistomum micobothrium.* *Schistosoma bovis* is the main cause of clinical schistosomosis in small ruminants, although *Schistosoma mattheei* has also been implicated ((Soulsby, 1986; Anon., 1994; Hansen and Perry, 1994; Urquhart *et al*., 1996; Lughano and Dominic, 1996; Okaiyeto *et al*., 2012).

The most important cestode parasites of small ruminants, both in terms of public health and Veterinary medicine, belong to the family Taeniidae. *Stilesia hepatica* and *Moniezia expansa* are the common parasitic cestodes encountered in goats in the sub-Saharan region (Urquhart *et al.,* 1996). *Stilesia hepatica* causes biliary fibrosis and is an important cause of liver condemnation in abattoirs in Kenya and Tanzania. *Moniezia expansa* infection is very common in kids and heavy infection with the parasite causes unthriftiness (Fabiyi, 1970). The significance of *Stilesia globipunctata* and *Avitellina centripunctata* infections in small ruminants in sub-saharan Africa has not been well documented. The presence of larval cestodes such as those of *Echinococcus granulosus (*hydatid cyst), *Taenia ovis* (*Cysticercus ovis*), *Taenia multiceps* (*Coenurus cerebralis*) and *Taenia hydatigena* (*Cysticercus tenuicollis*) in tissues or organs leads to condemnation of the affected tissues/organs. The migration of *Coenurus cerebralis* through the brain can cause meningo-encephalitis while the presence of many hydatid cysts in the lung may be associated with respiratory problems (Lughano and Dominic, 1996).

2.3 Nematodes (roundworms)

2.3.1 General morphology

In general, the nematodes are the most numerous animals on earth (Smyth, 1962; Jasmer *et al.*, 2003). Nematodes make up a large assemblage of worms of relatively simple structure with a widespread distribution, their cylindrical, non-segmented bodies distinguishing them easily from other helminthes. They occur in fresh water, in the sea, in the soil, and are amongst the most successful parasites of plants and animals (Smyth, 1962). The body of nematodes is elongated, cylindrical and tapered at the extremities. The body is also unsegmented and covered with cuticle which is thick and continuous with the cuticular lining of the buccal cavity, the oesophagus, the rectum and the distal portions of the genital ducts (Jacobs *et al*., 2003).

Roundworms consist of an external membrane, a cortex, a matrix and fibre stratum (Soulsby, 1986), divisible into nine distinct layers. The cuticle consists of an underlying sub-cuticle layer, the hypodermis, which consists of cells in the free-living form and a syncytium containing a number of nuclei in the parasitic forms. This layer has the longitudinal lines located, dorsally, ventrally and laterally. The lateral line contains the longitudinal canals of the excretory system (http://www.ucmp.berkeley.edu).

The muscular layer which follows next and lines the body cavity consists of a number of cells having a basal contractile portion which is transversely striated and a cytoplasmic portion which contains the nucleus and is connected to the nerve trunks running in the dorsal or ventral line. The mouth is anterior and usually surrounded by three lips, one dorsal and two ventral. In other forms there are only two lips or lips may disappear completely as in *Strongyloides*. The mouth may lead into a buccal capsule which has thick cuticular walls and may contain special teeth, or into the

pharynx, which is usually cylindrical and surrounded by muscular tissue, or directly into the oesophagus. The oesophagus of nematode parasites shows variations in structure that are used for the classification of species (Sandground, 1925). The oesophagus is a strongly muscular organ lined with a cuticle which divides the wall into one dorsal and two ventral sectors. The wall of the oesophagus contains three glands, which secrete digestive enzymes. The intestine is a simple tube with a non-muscular wall composed of a single layer of columnar cells standing on a basal membrane. It leads to the rectum which is lined with cuticle and to the genital duct ending with a cloaca. The part of the body behind the anal or cloacal opening is called the tail (Soulsby, 1986).

2.3.2 Nematodes of the abomasum

2.3.2.1 Haemonchus contortus

Haemonchus contortus, also known as red stomach worm, wire worm or Barber's pole worm, is a very common parasite and one the most pathogenic nematode of ruminants. Adult worms are attached to abomasal mucosa and feed on the blood (Burke and Joan, 2005).

The oocyte is yellowish in colour. The egg is approximately 70–85 μm long by 44 μm wide, and in the early stages of cleavage contain between 16–32 cells. The adult female is 18–30 mm long and is easily recognized by its trademark “barber pole” coloration. The red and white appearance results from the white ovaries that coil

around the blood-filled intestines. The presence of a large flap covering the vulva anteriorly is a characteristic feature of the female (Soulsby, 1986).

The male adult worm is much smaller, about 10–20 mm long, and displays the distinct feature of a well-developed copulatory bursa, containing an asymmetrical dorsal lobe and a Y shaped dorsal ray. Spicules are 0.46 to 0.51 mm long, each terminating in a small barb. Buccal capsule when present is reduced or rudimentary and there are usually no teeth in the buccal capsule but a minute dorsal lancet (Ukoli, 1984).

2.3.2.2 Trichostrongylus axei ('stomach hair worm')

Trichostrongylus axei occurs commonly in ruminants, often in association with *Haemonchus* and *Ostertagia*, and also in other host species, such as horses, but appears to be relatively non-pathogenic. Adult *T. axei* are very small, (smaller than *Haemonchus* and *Ostertagia*), slender, hair-like and reddish-brown with small anterior ends and no buccal cavity. Males measure 4 - 7 mm long and females are 5 - 8 mm. Often, eggs can be observed in the body of the worm (Love and Hutchinson, 2003). Eggs are most often 73 to 95 um in length and about 40 um in width. Male worms can be recognized by their asymmetrical dorsal ray and two short, nearly equal spicules. *Trichostrongylus axei* may also occur in small intestine (Soulsby, 1986).

2.3.3 Nematodes of the small intestines

2.3.3.1 Trichostrongylus spp

The species of this genus are small, slender, pale reddish-brown worms without a specially - developed head-end. There is no buccal capsule. The excretory pore is usually situated in a conspicuous ventral notch near the anterior extremity. The male

bursa has long lateral lobes, while the dorsal lobe is not well defined. The ventral rays of the male bursa are separated widely and the ventro-ventral ray is conspicuously thinner than the latero- ventral, which runs parallel with the lateral rays. The postero-lateral ray diverges from the other lateral rays and lies near to the externo-dorsal ray. The dorsal ray is slender and cleft near its tip into two branches which have short digitations. The spicules are stout, ridged and pigmented brown, and a gubernaculum is present. The vulva opens a short distance behind the middle of the body and the uteri are opposed (amphidelph). The eggs are oval, thin-shelled and segmented when they are laid (Soulsby, 1986). Species of the genus include the following:

T. colubriformis: (syn. *T. instabilis*) occurs in the anterior portion of the small intestine and sometime also in the abomasum of sheep, goats, cattle, camel and various antelopes. Male measures 4 - 5.5mm, female 5-7 mm and the male spicules are equal in length, measuring 0.135 -0.156 mm long. The eggs measure 79 - 101 by 39 - 47um (Soulsby, 1986).

T. capricola: occurs in the small intestine of sheep and goats. Spicules equal, 0.13-0.145mm long (Soulsby, 1986).

T. vitrinus: occurs in the small intestine of sheep, goats, rabbit, camel and man. Spicules are equal, measuring 0.16-0.17mm long. The eggs measure 93-118 by 41- 52 um (Soulsby, 1986).

Other species are: *T. falculatus, T. probolurus, T rugatus, T. longispicularis* and *T drepanoformis* (Soulsby, 1986; Love and Hutchinson, 2003).

2.3.3.2 Strongyloides papillosus

The parasitic and free-living stages differ in morphology (Viney and Lok, 2007), and the shape varies distinctly in different developmental stages. The parasitic female of *S. papillosus* is 3.5 - 6 mm in length and 0.05 - 0.06 mm in diameter and has a blunt-ended tail. They parasitize the proximal small intestine, deep in the mucosal crypts, and so are usually overlooked at necropsy except by the most diligent pathologist (Love and Hutchinson, 2003). The filariform oesophagus is 0.6 - 0.8 mm in length (Soulsby, 1982). The uterus is amphidelphic and opens at the vulva which is positioned at approximately two thirds of the body length (Levine, 1968; Viney and Lok, 2007). The parasitic female of the genus contains no male gonads, and parasitic males do not exist. The parasitic females produce the eggs by mitotic parthenogenesis.

The free-living male and female have an oesophagus of the rhabditiform type. The free-living male is 700 - 825 μm in length. The tail is short and conical, with 1 or 2 pairs of preanal and 1 or 2 pairs of postanal papillae; the spicules are short; and a gubernaculum is present. The free-living female is 640- 1,200 μm in length. The posterior end has a three-part tail end; the vulva is near the middle of the body and there are three spear like structures around the mouth cavity of the adult free - living stage of *S. papillosus* (Tanaka, 1966).

The copulation of free-living adults may occur several times. Up to 35 eggs are produced after each mating, and the total number is about 180 eggs per worm (Soulsby, 1982). The typical *Strongyloides* egg is ellipsoidal, thin-shelled, embryonated when shed and 40 - 60 x 20 - 36 μm in size (Levine, 1968). Larvae that hatch from the eggs are termed homogonic rhabditiform larvae and the larvae hatched from the eggs of free-living female adult are termed heterogonic rhabditiform larvae

(Bowman, 1999). The length of the first stage larva (L_1) is about 260 - 300 μm, the length of the second stage larva (L_2) is about 500 - 540 μm. The infective stage (L_3) is approximately 500 μm long. It is slimmer and longer than first- and second stage larvae and the oesophagus of third-stage larvae is filariform instead of rhabditiform as in first- and second stages (Viney and Lok, 2007). Moreover, one of the main characteristics of the filariform larvae of *Strongyloides papillosus* and *S. stercoralis* is the split, three-part tail end (Tanaka, 1966)

2.3.3.3 Cooperia Spp

Species of this genus, which are usually found in the small intestine, rarely in the abomasum of small ruminants, are relatively small worms of a reddish colour when fresh. The cuticle of the anterior extremity frequently forms a cephalic swelling and the rest of the cuticle bears fourteen to sixteen longitudinal ridges which are transversely striated. The male bursa has a small dorsal lobe. The latero-ventral ray is thicker than the ventro-ventral and divergent from it, but its tip again approaches the latter. The spicules are stout, relatively short, pigmented brown and usually have a ridged, wing-like expansion at the middle. An accessory piece is absent. The vulva may be covered by a flap and is situated behind the middle of the body (Soulsby, 1986)

The genus contains two species:

Cooperia curticei: Occur in sheep and goats. Male measures 4.5- 5.4 mm, female 4.7- 5.9 mm long. Spicules measure 0.135 - 0.145mm long.

C. punctata: Occurs in cattle and rarely in sheep. Male measures 4.7-5.9 mm., female 5.7- 7.5 mm long. Spicules measure 0.12- 0.15 mm long.

2.3.3.4 Bunostomum trigonocephalum

Is a hookworm which occurs in the small intestine (ileum and jejunum) of sheep and goats in many parts of the world. Male measures 12 – 17 mm., female 19 – 26 mm long. The anterior end is bent in a dorsal direction, so that the buccal capsule opens antero-dorsally; it is relatively large and bears at its ventral margin a pair of chitinous plates. There are no dorsal teeth in the buccal capsule. The bursa is well developed and has an asymmetrical dorsal lobe. The spicules are slender, measuring 0.6 – 0.64 mm long. The vulva opens a short distance in front of the middle of the body. The eggs measure 79 – 97 by 47- 50 u (usually 92 by 50 u), the ends are bluntly rounded and the embryonic cells are darkly granulated. The eggs can be differentiated from those of other worms in fresh sheep faeces (Soulsby, 1986).

2.3.3.5 Gaigeria pachyscelis

The only known species of this hookworm occurs in the duodenum of sheep and goats in India and Africa. Male measures up to 20 mm., female up to 30 mm long. In general it resembles *Bunostomum trigonocephalum.* The buccal capsule contains a large dorsal cone, but no dorsal tooth and a pair of subventral lancets which have several cusps each. The male bursa has small lateral lobes joined together ventrally and a voluminous dorsal lobe. The spicules are slender with recurved unbarbed ends; they are 1.25 - 1.33 mm long. The eggs measure 105- 129 by 50 – 55 u and have blunt ends (Soulsby, 1986).

2.3.4 Nematodes of the large intestine

2.3.4.1 Oesophagostomum Spp

Adult worms of all *Oesophagostomum* spp. exhibit a cephalic groove by its proximal gut as well as a visible secretory pore, or stomum, at the same level of the oesophagus. Like other nematodes, *Oesophagostomum* spp. contain a developed, multi-nucleate digestive tract as well as a reproductive system. Their developed buccal capsule and club-shaped oesophagus are useful for distinguishing *Oesophagostomum* spp. from hookworms (Elmes, 1953; Verweij *et al.*, 2007).

Both sexes of adults have a cephalic inflation and an oral opening lined with both internal and external leaf crowns. Female adults which have a length range of 6.5 – 24 mm, are generally larger than their male counterparts, with a length range of 6 - 16.6 mm. Males can be distinguished by their bell-like copulatory bursa, located in the tail, and their paired rod- like spicules (Ziem, 2006).

Eggs are ovular in shape and range from 50 to 100 um in size; they closely resemble those of hookworms, which renders diagnosis via stool analysis useless in areas co-infected with both *Oesophagostomum* and hookworm (Ziem, 2006). *Oesophagostomum columbianum* (the nodular worm) occurs in the colon of sheep and goats.

2.3.4.2 Trichuris spp

Trichuris ovis occurs in the caecum of sheep, goats, cattle and many other ruminants. The male of *T ovis* is 50-80 mm long. The anterior end constitutes three-quarters of the length. The female is 35 - 70 mm long, of which the anterior end forms two-thirds to four-fifths. The fully-evaginated spicule is 5 - 6 mm long. The sheath bears an oblong swelling a short distance from its distal extremity and is covered with minute spines which decrease in size towards the distal extremity. The eggs are brown, barrel-shaped, with a transparent plug at both poles, and measure 70 - 80 by 30 - 42 um, including the plug. They contain an unsegmented embryo when laid (Soulsby, 1986).

Trichuris globulosa: occurs in the cecum of the sheep, goats, camel, cattle and other ruminants. The male is 40 - 70 mm long and the female 42 - 60 mm and the anterior part constituting about two-thirds to three-quarters of the length. The spicule measures 4.2 - 4.8 mm and its sheath bears a terminal, spherical expansion on which the spines are larger than on the remaining portion. The eggs measure 68 by 36 um and are similar to those of *T. ovis (*Soulsby, 1986).

2.4 Morphology of Trematodes

2.4.1 *Dicrocoelium dentriticum*

Dicrocoelium dentriticum.(syn *D. lanceolatum*) occurs in the bile ducts of sheep and goats. The fluke is 6 - 10 mm long and 1.5 - 2.5 mm wide. The body is elongate, narrow anteriorly and widest behind the middle. The cuticle is smooth. The oral sucker is smaller than the ventral. The testes are slightly lobed and lie almost tandem, immediately posterior to the ventral sucker, with the ovary directly behind them. The vitelline glands occupy the middle third of lateral fields. Behind the gonads the central field is occupied by the transverse coils of the uterus, filled with brown eggs. The eggs

measure 36-45 by 22-30 um and are operculate (Soulsby, 1982; Janovy and Roberts, 2005).

2.4.2 *Fasciola hepatica*

The adult worm measures averagely 30 mm in length and 13 mm in width. *Fasciola hepatica* is one of the largest flukes in the world. The adult worm has a very characteristic leaf shape with the anterior end being broader than the posterior end and an anterior cone-shaped projection. The fluke possesses a powerful oral sucker at the end of the anterior cone and a ventral sucker at the base of the cone which allows it to attach to the lining of the biliary ducts. The ventral sucker is as large as the oral sucker. The cuticle is armed with sharp spines.

The testes are much branched, filling the median field in about the second and third quarters of the body. There is well developed cirrus, and the cirrus-sac also encloses the prostate and seminal vesicle. The ovary is situated to the right of the middle, anterior to the testes and is branched. The vitelline glands consist of fine follicles filling the lateral fields and the ducts of the follicles unite to form two transverse ducts, which pass inward to open into a median yolk reservoir, from which a duct passes to ootype. The uterus lies anterior to the testes. The eggs are operculated and average 140 μm in length and 75 μm in width (Soulsby, 1986)

2.4.3 *Fasciola gigantica*

Fasciola gigantica is a *c*ommon liver fluke of domestic animals which resembles *F. hepatica* but is readily recognised by its larger size being 25 - 75 mm in length and up to 12 mm in breadth. The anterior cone is smaller than that of *F. Hepatica* and their

shoulders are not as prominent and the body is more transparent. The eggs measure 156 - 197 um by 90 - 104 um (Soulsby, 1986).

2.5 Morphology of Cestodes

2.5.1 *Moniezia* spp

Moniezia expansa and M. benedeni are two cestode species found in the small intestine of numerous herbivorous mammals (Schmidt, 1986). *Moniezia benedeni* occurs mainly in cattle. They are morphologically characterized by their interproglottidal glands (Spasskii, 1951).

Moniezia expansa is commonly known as sheep tapeworm or double-pored ruminant tapeworm. It is a large tapeworm inhabiting the small intestine of ruminants such as sheep and goats. It has been reported from Peru that pigs are also infected (Gomez-Puerta *et al.,* 2008). *Moniezia expansa* has a typical cestode body, consisting of the anterior scolex, followed by the neck and a highly extended body proper, the strobilus. It is an extremely long tapeworm, and can reach an enormous length up to 6 – 10 m. The scolex bears four large suckers, which are the holdfast organs to the host. There are no rostellum and rostellar hooks, and the suckers are devoid of spines (Mehlhorn, 2008). The segment are broader than long and each contains two sets of genital organs. The ovaries and the vitelline glands form a ring on either side, medial to the longitudinal excretory canals, while the testes are distributed throughout the central field or they may be concentrated towards the sides. At its posterior border each proglottid contains a row of interproglottidal glands, arranged around small pits. The eggs are somewhat triangular in shape, containing a well-developed pyriform apparatus and measure 56 - 67 um in diameter (Soulsby, 1986).

2.6 Life Cycle of Helminths

2.6.1 Life cycle of gastrointestinal nematodes

To develop effective and sustainable control programmes against helminth parasites, it is important to have a good knowledge of their life cycles both within and outside the host animal (Familton and McAnulty, 1997; Vlassoff *et al*., 2001).

With the exception of *Nematodirus*, the gastrointestinal nematodes have a similar basic life cycle with no intermediate hosts. The adult nematodes inhabit various regions of the gastro-intestinal tract. The mature parasites (worms) breed inside the host and lay eggs which pass through the host and are shed in the faeces. After the eggs pass out of the host, they hatch into first-stage larvae (L_1) and moult into second-stage larvae (L_2) under appropriate conditions of temperature and humidity. The larvae need moisture to develop and move. During this time the larvae feed on bacteria. The L_2 larvae moult into infective larvae (L_3). When the last moult is completed, the L_3 larvae have a protective cuticle around them. Consequently they cannot feed and rely on stored energy sources. Development ceases until the L_3 larva is ingested by its potential future host. These larvae are about 1 mm in length and many migrate out of the faeces and swim in moisture on to the herbage (Brunsdon *et al*., 1975; Vlassoff, 1982, 1998; Familton and McAnulty, 1997; Pomroy, 1997a; Vlassoff *et al*., 2001; Sissay, 2007).

When an animal (sheep or goat) grazes, they may ingest the infective larvae along with the grass. Upon ingestion by the susceptible host, the protective covering of the L_3 is removed through a process called exsheathment. The exsheathing fluid is

produced by the host and exsheathment occurs in the part of the GIT that is immediately anterior to the helminth's predilection site. They thereafter, moult into the fourth-stage larvae (L_4) within 2-3 days, remaining for further 10 - 14 days to moult into young adult parasites (Soulsby, 1986; Hale, 2006; Coffey *et al.,* 2007). Thus, after ingestion, the L_3 of *Haemonchus spp* and *Trichostrongylus axei* develop through the fourth (L_4) and fifth (L_5) stage and mature into adults in the abomasum while the maturation of *T. colubriformis* and *Oesophagostomum spp* occur in the small and large intestine respectively.

Nematodirus, Trichuris, Bunostomum, Gaigeria and *Strongyloides* species are exceptions to the lifecycle described above. The third stage larvae of *Bunostomum, Gaigeria* and *Strongyloides spp* enter the host mainly by skin penetration, although infection through ingestion is also possible. After skin penetration they are carried into the venous circulation through the heart and the lungs. The larvae penetrate the alveoli, are coughed up and swallowed. They pass to the small intestine where further development and maturation occur. The larva of *Trichuris ovis* is contained within the egg and the infective L_1 is released when the egg is ingested by the host (Soulsby, 1986; Urquhart *et al.,* 1996). The prepatent period for most gastro-intestinal trichostrongyles is about 21 days.

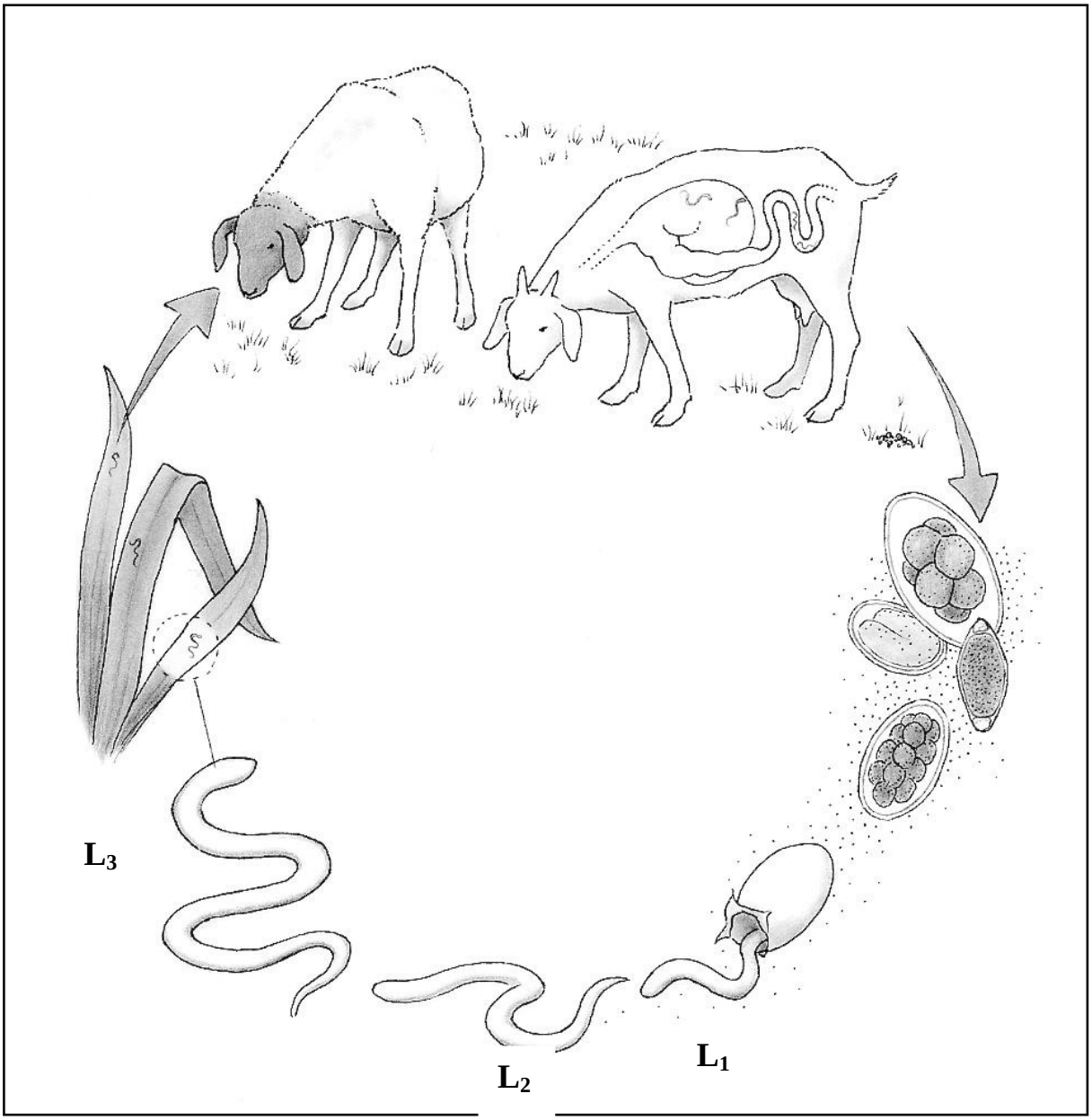

Figure 1.1: Principal life cycle of nematode parasites (after Mekonnen, 2007) L_1, L_2 and L_3 stand for first, second and third larvae stage.

2.5.1.1 Lungworms

Adult *Dictyocaulus* spp are found in the trachea or bronchi where eggs are produced. The eggs are coughed up and swallowed. Hatching of eggs occur in the air passages or

in the intestines and it is the L_1 which is found in the host faeces. Under suitable conditions of temperature and moisture, the L_1 moults into L_2 and L_3 stages.

Infection is acquired through the ingestion of L_3. The L_3 migrate through the intestinal wall and enter the mesenteric lymph nodes where they moult into L_4. The L_4 passes through the lymphatic and venous circulation to the heart and then through the pulmonary circulation to the lungs where they enter the alveoli. Maturation occurs in the bronchi or trachea and the mature worms start to produce eggs. Adult *Muellerius Capillaria* is found in the alveoli and pulmonary parenchyma while *Protostrongylus rufescens* lives in bronchi and their life cycles are similar to that of *Dictyocaulus spp* (Lughano and Dominic, 1996).

2.6.2 Life cycle of Trematodes

The life-cycles of important trematode species (*Fasciola hepatica*, *F. gigantica Paramphistomum* spp. and *Dicrocoelium* spp.) of small ruminants all involve intermediate hosts such as different species of aquatic or terrestrial snails, and ants for *Dicrocoelium* spp (Brunsdon *et al*., 1975; Urquhart, *et al.,* 1996; Charleston, 1997b; Southey and Hosking, 1998). The trematodes are hermaphrodites, possessing both male and female sex organs.

Liver flukes live up to three years and can produce 10,000 eggs per day. Adult *Fasciola spp* lay eggs in the bile ducts and the eggs are transported to the gall bladder through the bile. When the gall bladder contracts, the eggs enter the duodenum and then are expelled from the host with the faeces. These eggs hatch into miracidia in water under favourable condition. The life cycle depends on water and a temperature of 10°C or more: optimum rates of development (9 - 10 days) occur around 25 - 27°C

(Charleston, 1997b). At 15°C development takes a month. The ciliated larvae (miracidia) are quite mobile in water and can only develop further inside a particular species of fresh water snail (Family Lymnaeidae) found in pools, dams, drains, marshy areas and slow flowing streams. They must find the snail host and infect within 24 hours.

The miracidia actively penetrate snail hosts and develop through the sporocyst, redia and cercaria stages. Development in the snail is temperature-dependent and takes a minimum of five weeks at 25 - 27°C - usually much longer (2-3 months or more) under field conditions. The level of multiplication in the snail depends on how well-fed and how heavily infected it is, but, theoretically, one miracidium can give rise to several hundred cercariae (Charleston, 1997b).

The cercariae leave the snail hosts, encyst onto herbage just below the water level and become metacercariae, which are the infective stages for susceptible hosts. Upon ingestion by the susceptible host, the metacercariae excyst in the abomasum to release the young juvenile flukes which upon getting to the small intestine, bore through the intestinal wall into the body cavity and migrate to the liver preferring the ventral (left) lobe. They then take several weeks (5 - 8) migrating through the liver parenchyma tissue before entering the bile duct where the trematode matures into egg-laying adults. The development process inside the host takes at least two months before eggs appear in the host's faeces, at which stage the flukes are not fully grown or fully productive. The prepatent period of *F. gigantica* in goat is about 90-100 days and may be shorter under heavy infections (Lughano and Dominic, 1996).

The transmission of *Paramphistomum* spp is similar to that of *Fasciola* spp. However, after excystation and attachment in the duodenum, the immature Paramphistomes migrate up the alimentary tract and finally attach to the epithelium of rumen and reticulum. The prepatent period is 4-5 months (Lughano and Dominic, 1996).

The life cycle of *Schistosoma spp* is similar to that of *Fasciola spp* but when the eggs are passed out in the faeces of the host, they already contain a miracidium which hatches shortly if environmental conditions are optimum. There are no rediae or metacercariae stages in the life cycle of *S. bovis.* The cercariae are the infective stages and infection occurs through skin penetration or ingestion. The cercariae are carried through the lymphatic and blood systems to the mesenteric veins where they mature and commence to produce eggs 6-8weeks after infection (Urquhart, *et al.*, 1996; Lughano and Dominic, 1996).

2.6.3 Life cycle of gastrointestinal cestodes

There are two species of tapeworm: *Moniezia expansa* most common in sheep and goats; *Moniezia benedeni* most common in cattle. Tapeworms of sheep, goats, cattle and deer have a simple lifecycle that also involves an intermediate host (Brunsdon *et al*., 1975; FECPAK, 2001a; Southey and Hosking, 1998; Pomroy, 1997b). The adult worms live in the host's small intestine and eggs pass out in the faeces. The adult tapeworm consists of a head (scolex), with four suckers, followed by a body (strobila) which may reach 5 or 6 m in length and 15 mm in width, consisting of a ribbon of segments (proglottids). New segments continually form behind the scolex. These develop and mature, producing large numbers of microscopic eggs, and break off the hind end of the tapeworm. The segments may be seen singly or in pieces of strobila up

to several centimeters in length passing out with the faeces. The eggs, each of which contains an embryo (oncosphere), may be expelled from the segment before or after it has passed. They only develop into larval stages when eaten by common species of mites (oribatid mites) in pasture, where it develops in 15 - 30 weeks in the body cavity to the larval or cysticercoid stage which is the infective stage. The mites in turn are eaten by the ruminant and the adult cestodes subsequently develop in the gut growing to maturity in 5 - 6 weeks (Lughano and Dominic, 1996).

2.7 Epidemiology of Helminths

Epidemiology is defined as the study of the dynamic changes which occur both within the host and within the environment. Understanding epidemiology allows us to appreciate the complexity of developing control programmes which work (Familton and McAnulty, 1997; Vlassoff *et al*., 2001).

2.7.1 Epidemiology of gastro-intestinal nematodes

A study of epidemiology necessitates an intimate knowledge of the life cycle of a parasite. The epidemiology of gastrointestinal nematode (GIN) infections is influenced by environmental factors (particularly rainfall and temperature), management systems used for the animal, host factors and parasite factors (Familton and McAnulty, 1995).

Osakwe and Anyigor (2007), also identified five major factors that have been associated with the prevalence of the parasites namely: poor system of management, illiteracy, lack of deworming progammes, non-commercial purpose of keeping goats and very old farmers in the business. Over 90% (up to 99%) of the total parasite population exists outside the ruminant host (Familton and McAnulty, 1995, 1996,

1997; Vlassoff, 1998) as eggs or larvae in the faeces or in the soil. Even under arid Australian conditions, only 3% of the population in a haemonchosis outbreak lived within the host animal (Le Jambre, 1978).

The important facts of epidemiology of GIN infections have been well described by several workers in various geographical zones of the world, such as Gambia (Fritsche *et al.,* 1993), Saudi Arabia (El-Azazy, 1995), the Plateau areas of

Togo (Bonfoh *et al*., 1995), the Senegal tree-cropping pasture zone (Ndao *et al*., 1995), Peninsular Malaysia (Dorny *et al*., 1995), France (Hostel *et al*., 2001), America (Miller *et al*., 1998), Sweden (Lindgvist *et al.,* 2001; Waller *et al.,* 2004), Central Kenya (Nginyi *et al*., 2001), the Coastal Savannah regions of Ghana (Agyei, 2003), South Africa (Tsotetsi and Mbati, 2003), Semi-arid area of Kajiodo district of Kenya (Ng'ang'a *et al.,* 2004) and Nigeria (Fakae, 1990b). The epidemiology of nematode helminths is affected by several factors.

2.7.1.1 Environmental factors

In Nigeria, helminth parasites of small ruminants are ubiquitous in all of the agro-climatic zones with prevailing weather conditions that provide favourable condition for their survival and development. The effect of environmental factors on survival and development of larvae on pasture has been documented (Eysker and Ogunsusi, 1980). The three most important factors influencing egg hatching, development and survival of nematode larvae are rainfall/moisture, oxygen, and temperature (Familton and McAnulty, 1997).

2.7.1.2 Climatic factors

Rainfall or moisture**:** is the most important factor which influences the survival, development, dissemination and availability of free living stages of helminths. Moisture facilitates horizontal and vertical migration of nematode larvae in the environment.

Optimal levels of moisture and oxygen probably occur at different times within the decaying faeces, and may account for the different time periods over which eggs hatch and larvae develop (Familton and McAnulty, 1997). In moist environments a larger proportion of the eggs will develop to the infective larval stage. In very dry summers, larvae may develop successfully to the infective stage in faeces, but do not emerge until moisture levels are optimal. Infected faeces continue to be passed by the host, so that when moisture is available, pasture contamination by larvae can rise very rapidly (Michel, 1982). In dry conditions, the surface of the faeces desiccates providing a protective crust which prevents drying out of the interior of the faecal mass and also prevents release of the infective larvae (Gronvold, 1989). This situation may continue until water breaks down the crust allowing larval release.

Temperature has a big influence on egg hatching, larval development and the subsequent survival of the pre-parasitic stages (Vlassoff, 1982). The preferred developmental conditions of different nematode species vary and are reflected in their distribution and relative abundance from season to season and year to year (Vlassoff, 1982; Vlassoff *et al.*, 2001).

For successful development of eggs and pre infective stages into L_3 larvae in faeces, they must survive a range of climatic conditions (Vlassoff *et al*., 2001). Optimal development occurs between 15°C and 30°C, but development will take place at

varying rates within the temperature range of 4°C to 35°C if moisture is present (Vlassoff, 1982). Eggs of *Haemonchus*, *Trichostrongylus*, *Ostertagia* and *Chabertia* spp develop to L_3 larvae most rapidly at mean monthly air temperatures of 15°C - 24°C. Below 10°C, development is slow, and most eggs fail to hatch.

Eggs and larvae of most species of gastro-intestinal parasites of sheep (with the exception of *Haemonchus contortus*) tolerate cold temperatures but their metabolic rate is reduced (Familton and McAnulty, 1997; Pomroy, 1997a).

Some strongylid/trichostrongylid larvae such as *Trichostrongylus colubriformis* and *Oesophagostomum columbianum* are known to be resistant to dessication and this ability enables them to survive under extremely low or high temperature.

Oxygen is necessary for the development of eggs and lack of oxygen inhibits hatching, subsequent larval development and larval activity (Familton and McAnulty, 1997).

2.7.1.3 Management systems

Management systems for animals have a strong influence on the epidemiology of gastro-intestinal nematodes. High stocking density increases the contamination of the environment with nematode eggs or larvae and thus makes the infective stages to be more accessible to susceptible animal. High stocking rates and intensive management with little or minimal rotational grazing, are associated with high pasture contamination and outbreaks of clinical helminthosis. On the other hand, low stocking rates and extensive management systems in the traditional husbandry systems preclude a build-up of high worm burdens. The concentration of animals at watering points

particularly during the dry season may also result in massive contamination of pastures with eggs or larvae leading to out breaks of parasitic gastro-enteritis. Tethering of goats and sheep during the wet season which is common in many agro-pastoral societies have been reported to result in increased environmental contamination with infective larvae and incidence of clinical disease. Outbreaks of parasitic gastro-enteritis in such systems have been reported in Tanzania, Nigeria, Kenya and Cameroon (Connor, 1985; Ndamukong, 1987; Chiejina *et al.*, 1988; Okon, 1988; Fakae,1990b; Hansen and Perry, 1994).

However, if tethered animals are moved each day to fresh ground and the number of animals in the area is small, the risk of helminthosis is reduced. Similarly, if animals are totally confined and fed on diets free of infective helminth larvae the risk of helminthosis is reduced.

2.7.1.4 Anthlminthic treatment

Anthelminthic treatment reduces the prevalence and severity of gastro-intestinal nematode infections and may significantly influence their epidemiology. However, the effectiveness of anthelmintic treatment regimes depends on a thorough knowledge of other factors which influence the epidemiology of nematodosis. Indiscriminate use of anthelmintics may result in the development of resistant nematode strains and this problem is increasing in importance across the sub-Saharan region (Ikeme, 1997).

2.7.1.5 Host factors

The incidence rate and severity of infection with gastro-intestinal nematodes can be influenced by host factors such as age, breed, sex, nutrition, physiological state and presence or absence of intercurrent infection.

Age: A number of authors have demonstrated an increased prevalence in young animals. Asanji and Williams (1987), stated that young animals are highly susceptible due to immunological immaturity and immunological unresponsiveness. Urquhart *et al*. (1996); Taswar *et al*. (2010) and Dagnachew *et al*. (2011), have documented that adult animals develop acquired immunity against helminth infections as they get mature due to repeated exposure and this will help expel the parasite before it establishes itself in the GIT. For instance, kids and lambs are known to be more susceptible than adult and there is a tendency for the worm burdens in goats and sheep to decrease with increasing age (Schmidt and Robberts, 1985; Schmidt *et al.,* 2000; Nwosu *et al*., 2006). On the contrary, there are instances where younger animals were reported to be resistant to parasitic infection (Taswar *et al*., 2010).

Genetics: There is an increasing evidence for genetic variation in resistance to nematodes in sheep and goats (Baker *et al.,* 1998, 2001; Bishop and Morris, 2007). Genetic variation for resistance to GI parasites has been established between breeds (Pralomkarn *et al*., 1997; Baker *et al.,* 1998, 2001; Costa *et al.,* 2000; Chauhan *et al*., 2003) and within breeds (Morris *et al.,* 1997; Mandonnet *et al.,* 2001; Rout *et al*., 2002; Chauhan *et al*., 2003).

Some breeds of goats and sheep are known to be genetically resistant to gastro-intestinal nematode infections than others. It has been demonstrated in Kenya that the Small East African (SEA) goats are more resistant to *H. contortus* infection than their crosses with the Toggenburg and the Galla goats. Sheep also develop a strong natural immunity around 12 months of age. Goats acquire a lower level immunity to gastro-intestinal parasites. This can result in goats having greater populations of adult

parasites with high egg output (Macaldowie *et al.,* 2003). The West African Dwarf goats and sheep are known to be resistant to gastro-intestinal nematode (Lughano and Dominic, 1996).

Sex: Most of the researchers have observed higher rates of nematode infection/worm burden in female hosts compared to the males (Maqsood *et al.,* 1996; Komoin *et al.,* 1999; Valcarcel and Romero, 1999). However, Gulland and Fox (1992), reported that prevalence and intensity of infection (faecal egg counts) were higher in males than females, except during the lambing periods, and decreased with age in both sexes. Sex is a determinant factor influencing prevalence of parasitism (Maqsood *et al*., 1996) and females are more prone to parasitism during pregnancy and peri-parturient period due to stress and decreased immune status (Urquhart *et al.,* 1996). Dagnachew *et al*. (2011) reported a higher prevalence of helminth infection in females.

Physiological status: The physiological status of the animal may influence its susceptibility of gastro-intestinal nematode infections. Hormonal changes during late pregnancy and lactation lower the resistance of the host to nematodes and consequently result in the establishment of higher worm burdens (Coop *et al.,* 1990). Prolactin and glucocorticoids are considered to be modulators of periparturient egg rise in goats and sheep. The increase in the fecundity of adult worms already in the alimentary tract and non-specific immunological loss of resistance by does and ewes as a result of stress associated with lambing and kidding are also considered to be responsible for the post parturient rise in faecal egg count in does and ewes. On the other hand, oestrogens have been found to be responsible for the resistance of female hosts to gastro-intestinal nematodes (Lughano and Dominic, 1996).

Nutrition: Poor nutrition lowers the resistance of the animal, thus enhancing the establishment of worm burdens and increasing the pathogenicity of the parasites. It is well known that adequately fed animals are more able to tolerate parasitism than animals on a low plane of nutrition (Knox and Steel, 1996; Waruiru *et al*., 2004; Knox *et al*., 2006). Thus, small ruminants affected by blood-sucking parasites, such as *H. contortus*, may be able to maintain their haemoglobin levels as long as their iron and protein intakes are adequate. However, if the animals' iron reserves and protein intake are reduced then their haemopoeitic systems become exhausted, and they may die (Abbott *et al*., 1986; Gibbs and Barger, 1986; Rowe *et al.*, 1988; Vatta *et al*., 2002).

Consequently, worm burdens tend to be higher in poorly-fed than in well-fed animals. In Nigeria, Sierra Leone and Kenya, malnutrition during the dry season has been found to lower the resistance of goat and sheep to *H. contortus* infection resulting in heavy mortalities while restricted feeding due to tethering during the rainy season has been associated with high nematode burdens and mortality of goats (Lughano and Dominic, 1996).

2.7.1.6 Parasite factors

The intrinsic multiplication rate of the nematode species determines the rate of establishment and size of nematodes burden in the host. The multiplication rate is determined by the fecundity of the adult worms, the prepatent period and the survival and the development rate of the parasite in the environment. For example, *H. contortus* and *Oesophagostomum columbianum* have a high biotic potential such that establishment of these nematodes occurs very rapidly as long as environmental factors

are favourable. *Trichostrongylus spp* has a lower biotic potential and hence its establishment is lower (Lughano and Dominic, 1996).

2.7.2 Epidemiology of Trematodes

Unlike gastro-intestinal nematodes, trematodes have indirect life cycles and intermediate hosts play an important role in their epidemiology. Therefore, factors determining the availability, development and survival of intermediate hosts in the environment will also influence the level and severity of trematode infections (Lughano and Dominic, 1996).

The intermediate host for *Fasciola gigantica* is the aquatic snail, *Lymnaea natalensis* which is predominant in Nigeria (Ukoli and Asumu, 1979) although *Lymnaea truncatula* has also been found to serve as an intermediate host of *F. gigantica* in East and Central African highlands. The optimum temperature range for the survival and development of *L. natalensis* is 15 - 26^{o}C while temperature below 10^{o}C inhibits the development and reproductive activity of the snails. *L. natalensis* requires clean, clear and unpolluted permanent water bodies with abundant vegetation such as lakes, slow-moving rivers, irrigation ditches and water tanks (Lughano and Dominic, 1996).

Light, suitable temperature (20-25^{o}C) and availability of oxygen are essential for the hatching of *Fasciola* spp eggs. No development occurs below 10^{o}C and higher temperature (greater than 35^{o}C) result in death of the larvae. The humid environment of most sub-saharan countries is favourable for the embryonation and hatching of *Fasciola* spp eggs throughout the year. The development of miracidia in the snail host is also temperature-dependent. Faeces and manure pats can acts as reservoirs of the infection. It has been found that the concentration of animals at watering points during

the dry season is a favourable factor for the transmission of *F. gigantica* leading to outbreaks of fasciolosis. The risk of exposure of grazing animals to infection is greatly influenced by the proportion of the grazing area that is snail habitat (Charleston, 1997b).

The incidence of fascioliasis varies with the seasons (Suarez and Busetti,1995) and depends on the level of agricultural activity, nutritional deficiency, pasture management, micro and macro climate of the area, presence of intermediate host (water snail) and vectors in the area as well as the immunological status of the host (Harris and Charleston, 1974; Onyali *et al*., 1990). The prevalence of fascioliasis due to *Fasciola gigantiga* in many parts of the world has been reviewed by Coyle (1961). In Africa, Megard (1975) gave the prevalence rates in Kenya (33%), Sudan (37%), Cameroon (45%), Ethiopia (30 – 90%), Uganda (10%), Central African Republic (62%) and Rwanda (50%).

In Nigeria, there are few reports on the prevalence of fascioliasis, in spite of the well known economic importance of the disease in livestock (Ogunrinade, 1980). The existing accounts of the disease in Nigeria are based on local surveys on the incidence of fascioliasis in some areas of the country and often cover only a few months of the year (Ogunrinade and Ogunrinade 1980). For instance, Ferguson (1964), determined the incidence of fascioliasis in Birnin- Kebbi, Maiduguri, Kano and Kaduna. Babalola and Schillhorn van veen (1976), determined the incidence of the disease in Zaria, while Ikeme and Obioha (1973); Uzoukwu and Ikeme (1978) recorded the prevalence rate of fascioliasis in cattle slaughtered in some parts of eastern Nigeria.

Ozung, *et al*. (2011), carried out a study on the prevalence rate of fascioliasis in Ikom abattoir of Cross River State in Nigeria for a five-year period; the prevalence of 7.35%, 18.58% and 5.77% for cattle, goats and sheep respectively, giving a total of 31.70% recorded. Olupinyo and Ajanusi (2005) also carried out a prevalence study on *Fasciola* species and *Dicrocoeliun* species in Sheep and goats slaughtered at abattoir Zaria. The prevalence of *Fasciola* species *was* 21% in sheep and 8% in goats while for *Dicrocoelium* spp both sheep and goats had a prevalence of 5% each.

The epidemiology of *Paramphistomum microbothrium* is similar to that of *F. gigantica* although other species of snail such as *Planorbis* spp and *Bulinus* spp serve as intermediate hosts.

The epidemiology of *Schistosoma* spp is similar to that of *F. gigantica*. *Bulinus* spp is the common intermediate host for *S. bovis* and *S. mattheei* in Africa. In Tanzania, *Bulinus africanus* is the main intermediate host for *S. bovis.*

2.7.3 Epidemiology of Cestodes

Tapeworms were considered as the most common aggressive parasites causing outbreaks and constituted a big problem in sheep-raising countries (Hassanain and Abdel Rahman, 2000; Mazyad and El-Nemr, 2002; Agyei, 2003; Moazeni and Nili, 2004; Haridy *et al.*, 2004; Chilton *et al*., 2007). The cestodes, *Moniezia expansa, Stilesia hepatica, Stilesia globipunctata* and *Avitellina centripunctata* have indirect life cycles and the intermediate hosts are the soil-inhabiting oribatid mites such as *Oribatula* spp, *Galumma* spp and *Peloribates* spp (Schuster, 1998).

Ingestion of eggs by infected mites is accidental as they are not coprophagous. Larvae (hexacanth embryo) still within the egg are ingested and leave the egg and make their way into the body cavity of the mites where they develop into cysticercoids which are the infective stage for ruminants. Oribatid mites are a very diverse group with 127 species included in 27 families being implicated as intermediate hosts for *Moniezia* and related cestodes (Pomroy, 1997b). However, oribatid mites do vary in their susceptibility and not all species are suitable as intermediate hosts.

The number of mites on herbage has been found to correlate positively with temperature, relative humidity, rainfall and soil moisture on the day of collection (Pomroy, 1997b). The development rate of cysticercoids in mites depends on temperature and host species and can be as short as 28 days. *Moniezia* eggs have been shown to survive up to four days exposure to direct sunlight, 20 days at about 0°C and at least seven months between 5 - 80°C. The longest report of infectivity being maintained on pasture appears to be 22 months (Pomroy, 1997b). The prevalence and intensity of infection will vary with season, host, age and availability of the infected mites. Birds may also be involved in the dissemination of tapeworm eggs.

2.8 Hypobiosis in Parasitic Nematodes

Successful transfer from an infected host to a susceptible one represents a most important achievement in the parasitic way of life. Any developmental adaptation which serves to facilitate this process is, therefore, extremely important in the epidemiology of these infections (Gibbs, 1986).

Hypobiosis or facultative arrested development represents such an adaptation which, by facilitating persistence of the larval forms for prolonged periods in the host, enables the parasite to capitalize on optimal opportunities for transfer. The phenomenon appears to be widespread among parasitic organisms and it has been particularly well studied in the parasitic nematodes of domestic animals (Gibbs, 1986).

The term hypobiosis, which literally means a slowing down of life processes, was first suggested by Gordon (1973) to include such terms as arrested, retarded, inhibited, or suppressed development when these are applied to worms that have not completed their development in the host within the commonly accepted development interval for the species.

Gastro-intestinal nematodes can survive harsh conditions by hypobiosis or arrested development of larvae (usually L_3 or early L_4) within the host. In the absence of hypobiosis, nematodes survive in hosts during the hot and dry season as adults. The humid tropical climate is favourable for the survival, development and transmission of gastro-intestinal nematodes throughout the year (Chiejina *et al*., 1988).

2.8.1 Types of hypobiosis

Horak (1981) has suggested that there are basically two types of arrested development in parasitic nematodes which he termed non-specific and seasonal arrested development. Non- specific arrest could occur at any time and its causes could either be host-related or parasite-related factors which affect the immediate environment of the nematode, causing inhibition in development.

Seasonally arrested development, on the other hand, represents an annual event during the same season and is dependent upon nematodes being adapted to a particular environment and being responsive to external environmental stimuli acting upon the infective larvae which result in arrest at a later stage of development. However, this phenomenon is not exclusive to the parasitic nematodes. A strictly analogous modification of development has been described with some of the free-living nematodes, in particular *Caenorhabditis elegans.* In this species a type of hypobiotic larva is produced in response to an unfavourable stimulus in the environment of the free-living nematode (Gibbs, 1986).

2.8.2 Initiating factors in arrested development

Epidemiological and experimental evidence has identified three factors responsible for the initiation of arrested development (Michel, 1976; Armour, 1980; 1982; Gibbs, 1986). They are:

1. Seasonal influences on infective larvae on pasture.
2. Host immune responses inhibiting the normal development of the parasitic phase of the life cycle.
3. An overcrowding effect whereby the presence of adult worms causes the "feedback" inhibition of incoming infective larvae which go into arrest until the adult worm population decreases in number or is eliminated.

2.8.3 Seasonal arrest (Hypobiosis)

Hypobiosis is the term most often used for arrested development that has a seasonal basis. It is a biologically important feature since it seems to be of particular

importance in nematodes with relatively short adult life spans. In these species, hypobiosis is initiated by an environmental signal received by free-living L_3s. When these L_3s subsequently infect a host, they do not develop continuously through to adults but instead, are arrested in host tissues either as exsheathed L_3s or as early L_4s (Michel *et al*., 1975; Ogunsusi and Eysker, 1979; Chiejina *et al*., 1988; El-Azazy, 1995; Eysker, 1997). This suspension of development helps some nematode parasites to survive the dry seasons. Resumption of development usually coincides with the onset of the rainy seasons, the most favourable period for larval development and transmission on pasture (Agyei *et al.*, 1991; El-Azazy, 1995; Tembely, 1998). The stimuli for the onset of arrested development in tropical areas, which are linked to the dry conditions, are in contrast to those stimuli (e.g. falling temperatures) for nematode parasites of ruminant livestock found in temperate zones (Levine, 1978; Allonby and Urquhart, 1975; Vercruysse, 1985; Chiejina *et al*., 1988; El-Azazy, 1995).

Gatongi *et al*. (1998), conducted a study in a semi arid area of Kenya and reported higher proportion of hypobiotic larvae recovered during the dry season of a year, indicating that hypobiosis was an important phenomenon in the survival of *Haemonchus contortus* during drier months as over 90% of *H. contortus* in the abomasal contents with only 10% found in mucosal digest in both sheep and goats. Similar results were reported by Eysker and Kooyman (1993) and Jacquient *et al.* (1995).

In Nigerian Derived Savannah, seasonal changes and hypobiosis in *H. contortus* infection indicated greater gastro-intestinal nematode infection rates during the rainy season rather than the dry season (Fakae, 1990b)

Some studies suggested that hypobiosis of *H. contortus* in the Tropical and sub-Tropical regions of the world are very limited or have variable results. For example no hypobiosis was detected in Egypt (El-Azazy, 1990), where as low levels of hypobiosis were observed in Zimbabwe (Pandey, 1990) and Eastern Nigeria (Chiejina *et al*., 1988). High levels of hypobiosis were reported in Northern Nigeria (Van Geldorp and Schillhorn Van veen, 1976; Ogunsusi and Eysker, 1979). It appears that seasonal hypobiosis is an important option for the life cycles of a number of nematodes of grazing animals, particularly ruminants. This is particularly true of the trichostrongyles such as *Ostertagia, Haemonchus, Trichostrongylus, Cooperia* and *Dictyocaulus* spp as well as *Oesophagostomum* spp and also, the small strongyles of horses (Colin, 1998-http://cal.vet.upenn.edu/projects/merial/nematodes/nems_9.htm)

2.8.4 Immune arrest

Another form of arrested development is also recognized and is due to the influence of immune response. As animals graze, they continually ingest infective third stage larvae which develop to adults in the normal prepatent period. As the grazing season progresses these animals develop a strong immune response to nematode infections and one of the manifestations of the immune response is the inhibition of larvae inside the host. Larvae infecting a host are more likely to undergo arrest if there is already an established population of adult worms in that host. In sheep, goats and pigs maturation of these immunologically arrested larvae appears to be linked with parturition. An inhibition of the immune response, specifically associated with

gut-dwelling nematodes, is related to serum levels of prolactin. Immune competence is restored when prolactin levels drop, at weaning, and worm burdens are usually

expelled as a consequence of the restored immune response (Gibbs, 1986; Colin, 1998- http://cal.vet.upenn.edu/projects/merial/nematodes/nems_9.htm)

2.8.5 Quiescence

Hypobiosis and immunological arrest of parasitic larvae should be distinguished from other forms of developmental arrest seen in paratenic and intermediate hosts during the life cycles of many nematodes, particularly the ascarids and spirurids. This form of arrested development is often called quiescence since it is an intrinsic part of the life cycle, is not an option and is not triggered by extraneous influences (Colin, 1998)

2.8.6 Significance of hypobiosis in the biology of nematodes

The significance of arrested development to the parasitic nematode has been the subject of much speculation. Whatever the triggering mechanisms are that initiate developmental arrest and induce resumption of development, the phenomenon has considerable biological importance to nematodes that incorporate it into their life cycle options. It also has considerable epidemiological implications to nematode hosts and must be considered when devising methods for prevention and control of nematode infections and disease. There are several reasons why arrested development is important (Brunsdon, 1980; Gibbs, 1986; Colin, 1998)

1. Arrested development ensures survival of nematodes during times when conditions are hostile to their survival in the external environment.

1. Resumption of development of large numbers of larvae in a host may produce serious outbreaks of disease.

2. Development of adults from arrested larvae will produce significant contamination of pastures with nematode eggs at a time when environmental conditions are, once again, favourable for development of pre-parasitic stages to infective larvae. This contamination which begins at the start of the grazing season and reaches a peak several weeks later is particularly dangerous for young, immunologically naive animals grazing pastures for the first time.
3. Hypobiotic larvae are depressed metabolically and hence may be less susceptible to some anthelmintics. Clearly the choice of drugs to be used in a nematode control program will be influenced by the role of arrested development in specific nematode life cycles and by the susceptibility of arrested larvae to the range of available anthelmintics.

2.9 Clinical and Pathological Features of Helminth infections

2.9.1 Parasitic gastro-enteritis

The major parasites associated with parasitic gastro-enteritis in small ruminants in sub-saharan Africa are *Haemonchus contortus, Trichostrongylus colubriformis, Oesophagostomum columbianum.* Other nematodes of lesser importance are *Trichostrongylus axei, Bunostomun trigonocephalum, Trichuris ovis, Cooperia* spp and *Strongyloides papillosus. Ostertagia ostertagi* and *Nematodirus fillicolis* are important in cooler highland areas (Lughano and Dominic, 1996). Parasitic gastro-enteritis is widely distributed in Nigeria and the prevalence and seasonal changes in the abundance of the causative parasites have been studied and reported from some geographical zones of the country (Chiejina, 1986; Nwosu *et al*., 1996a, b). Due to the differences in their predilection sites and pathogenetic mechanism, gastrointestinal

nematodes present with the differing clinical and pathological features that are manifested in parasitic gastro-enteritis.

2.9.1.1 Haemonchosis

Haemonchosis caused by *Haemonchus contortus* is a predominant, highly pathogenic and economically important parasitic disease of sheep and goats in Africa (Mortensen *et al.*, 2003). The pathogenesis of haemonchosis is related to the blood sucking habit of the parasite. It has been estimated that each worm sucks about 0.05 ml of blood per day by ingestion or seepage from lesions (Urquhart *et al.*, 2000).

Perry *et al.* (2002), identified haemonchosis as one of the top ten constraints to sheep and goats rearing in East Africa. Studies carried out by Molalegne *et al.* (2011) in Ethiopia showed infection of sheep and goats by *Haemonchus* with prevalence of 75.9% and 55.9% respectively indicating that haemonchosis undoubtedly has an impact on the health and productivity of these animals.

In addition, studies conducted by Ajanusi and Chiezey (2005), in Zaria, Nigeria, showed the prevalence of *Haemonchus contortus* in goats to be 89.1%. The mean PCV of infected goats were negatively correlated with worm burdens, showing that *Haemonchus* was responsible for the low PCV in animals with high worm burdens. On the basis of clinical signs, haemonchosis may be divided into three syndromes; hyperacute, acute and chronic haemonchosis in goats and sheep.

Hyperacute haemonchosis: Occurs when there is a sudden massive challenge of susceptible animals with infective larvae resulting in severe blood loss due to haemorrhagic gastritis. The syndrome is of short duration and is characterised by

sudden death although in some animals, dark-coloured faeces may be seen before death. Faecal egg counts of up to 400,000 per gram may be encountered in the affected animals. However, hyperacute haemonchosis is not very common in the field infection (Taylor *et al.,* 1990).

Acute haemonchosis: Occurs when animals are exposed to a continuous larval challenge leading to gastritis associated with hypoproteinemia and generalised sub-mandibular oedema called "bottle jaw". Other signs include weakness, pallor of the mucous membrane, lethargy or agalactia which may lead to starvation and death of kids. Dark-coloured faeces are often observed. Self-cure may occur at any stage of the diseases. The syndrome is more common when young susceptible animals become infected (Ukoli 1984; Taylor *et al.,* 1990).

Pathologically, acute haemonchosis is characterised by a pale carcass. The abomasal mucosa is petechiated and oedematous with many parasites on its surface and contents. There is a marked expansion of the bone marrow throughout the medullary cavity which may extend up to the epiphyses (Lughano and Dominic, 1996).

Chronic haemonchosis**:** Is the common form of field infection. The syndrome is caused by gradual intake of infective larvae and the course of disease may take 2- 6 weeks. It is a chronic gastritis with chronic blood loss, rough hair coat and stunted growth. Chronic haemonchosis is aggravated and often confused with malnutrition (Soulsby, 1986, Lughano and Dominic, 1996).

At necropsy, chronic haemonchosis is characterised by pallor of carcass, hyperplastic thickening of the abomasal wall, chronic expansion of the bone marrow and resorption

of the cancellous and cortical bones. In terminal stages the bone marrow reverts to white colour due to exhaustion (Ndamukong, 1987).

2.9.1.2 Trichostrongylosis

Trichostrongylosis is commonly a disease of young animals. The penetration of larvae and adult worms into the intestinal mucosa results in desquamation of the latter causing a malabsorption syndrome and hence a protein-losing gastro-enteropathy and hypoalbuminemia. Heavy infections cause acute enteritis which is characterised by dark-coloured diarrhoea and foul - smelling faeces. There may be sudden death without evidence of anaemia or emaciation but weakness of the legs is a frequent feature. Most commonly, trichostrongylosis is a chronic wasting disease characterised by loss of appetite, emaciation, loss of weight, dry skin, diarrhoea, oedema and atrophy of skeletal muscles or myocardium (Lughano and Dominic, 1996).

At necropsy, the acute disease is characterised by a swollen and haemorrhagic or catarrhal intestinal mucosa and, worms may be found in the mucosal scrapings. The chronic disease is characterised by an emaciated carcass, fatty degeneration and, a thickened, inflamed and ulcerated intestinal mucosa (Ndamukong, 1987; Lughano and Dominic, 1996).

Histopathologically, chronic infection with *T. colubriformis* is characterised by marked villous atrophy, flattening of the intestinal mucosa and osteoporosis. The clinical pathology is characterised by hypoalbuneamia, hyperglobulinaemia and hypophosphataemia (Lughano and Dominic, 1996).

2.9.1.3 Oesophagostomosis

The pathogenicity of *Oesophagostomum columbianum* is related to the migration of larvae in muscularis mucosa of the large intestine resulting in a fibroblastic response around the larvae forming fibrous nodules. The extensive nodular formation interferes with digestion, absorption and bowel movement. Mucoid diarrhoea or sometimes constipation, emaciation, general weakness, dry skin, prostration and death are the common clinical features. The diarrhoea often coincides with the emergence of larvae from the nodules. The nodules are frequently invaded with pyogenic bacteria which cause suppuration. Rupture of the nodules may cause peritonitis and multiple adhesions (Lughano and Dominic, 1996).

At post mortem examination, the most severe form of the disease is characterised by ulcerative colitis. The adult worms cause thickening of the bowel wall, congestion and production of excessive amount of mucus. In primary infection, adult worms are found in the lumen of the large intestine where they are often covered with mucus and there may be few nodules. In super-infection, there is an extensive nodular formation with marked emaciation and severe fatty degeneration. Abscesses with greenish or yellowish pus may also be present (Reid, 1973; Lughano and Dominic, 1996).

2.9.1.4 Bunostomosis

Bunostomosis is characterised by progressive anaemia, emaciation, weakness or paresis, submandibular oedema, dark coloured faeces, prostration and death. At post mortem examination there is hydrothorax, hydropericardium and pin-point haemorrhages in the small intestine or blood in its content (Hammond and Sewell, 1990; Lughano and Dominic, 1996).

2.9.1.5 Other gastro-intestinal nematodes

Other gastrointestinal nematodes such as *Cooperia* spp, *T. ovis* and *S. papillosus* have limited pathogenicity. Their clinical and pathological features are often masked with the more pathogenic species. However, heavy challenge with these parasites particularly in young animals may be associated with anorexia, weight loss, moderate anaemia and imflammation of the intestinal mucosa (Hammond and Sewell, 1990; Lughano and Dominic, 1996).

2.9.2 Trematode infections

2.9.2.1 Fasciolosis

Fasciola gigantica infection is associated with a clinical disease in goats and sheep even when the fluke burden is light. It has been found that as few as 42 flukes can cause clinical fasciolosis in goats (Lughano and Dominic, 1996). The disease is more severe in goats than in sheep. Three syndromes; acute, subacute or chronic fasciolosis may occur.

Acute fasciolosis: occurs when there is an acute traumatic hepatitis caused by the migration of larvae through the parenchyma leading to extensive destruction and marked haemorrhage. The haemolytic crisis results in progressive weakness, pallor of mucous membranes, enlargement of the liver and abomasal distension (Theodorus *et al*., 2002). Anorexia, paresis prior to death and anasarca are observed in terminal stages of the acute disease in goats. At necropsy, acute fasciolosis is characterised by the presence of a blood-tinged fluid in the peritoneal cavity, fibrinous exudates covering the liver surface, hepatomegaly and numerous haemorrhagic and friable tracts in the liver parenchyma. The gall bladder is also enlarged. Immature flukes can

be expressed from the cut liver surface. Adhension of the liver to the diaphragm or other internal organs may occur (Robert, 2011).

Subacute fasciolosis: is associated with ingestion of a large number of metacercariae over a long period of time. The syndrome is characterised by anorexia, rough hair coat, slight abdominal distension, pallor of mucous membrane, disinclination to move and emaciation (Scott *et al.,* 2005).

Chronic fasciolosis: is a persistent wasting disease characterised by emaciation, anaemia and submandibular oedema (Okaiyeto *et al*., 2012). At post mortem examination, fibrosis and thickening of the bile ducts resulting from cholangitis is evident. The bile ducts may be blocked with flukes and desquamated epithelial cells. The damaged parenchyma becomes indurated and flukes may be seen in the bile ducts with granulomata often being observed around fluke remnants. Calcification of the bile duct walls which is commonly observed in cattle is not a feature of fasciolosis in small ruminants (Radostits *et al.,* 2000; Talukder, *et al*., 2010). *Fasciola hepatica* produces a disease similar to *F. gigantica.*

2.9.3 Cestode infections

The pathogenic effects of *Moniezia* spp are limited and the parasite is considered to be non-pathogenic. However, heavy infections in young animals may cause anorexia, weight loss, moderate anaemia, inflammation of the intestinal mucosa and sometimes obstruction of the intestines. Whether the intestinal cestodes are directly responsible for production losses is still a controversial issue and the pathogenicity of these parasites has not yet been established conclusively (Lughano and Dominic, 1996).

Stilesia hepatica occurs in the bile ducts of small ruminants and its economic importance is associated with condemnation of the affected livers. Migration of *C. cerebralis* in the brain may cause meningo-encephalitis while massive numbers of cysts of *E. granulosus* in the lungs may cause respiratory problems. Other cestodes have limited clinical significance in small ruminants (Lughano and Dominic, 1996).

2.10 Diagnosis of Helminth Infections in Small Ruminants

The diagnosis of helminth parasites of small ruminants is based on demonstrating the presence of helminth eggs, or larvae, in faecal samples, or the presence of parasites recovered from the digestive tracts or other viscera of the animals. The following are the routine diagnostic procedures for helminth infections of small ruminants.

2.10.1 Simple flotation

This is one of the simplest methods of diagnosis of helminthosis. It is qualitative but it is a concentrated method. The principle of faecal flotation is based on the fact that there are differences in the specific gravity of parasite eggs, cysts, and larva and that of faecal debris. The faeces are mixed in a solution of about 1. 2 specific gravity. Many ova are less than 1. 2 specific gravity and will float to the top of the solution where they are collected. Most faecal debris is greater than 1. 2 specific gravity and will sink to the bottom of the tube. Parasite ova numbers found on this test are no indication of the actual worm burden the animal carries, since some worm species are more prolific ova producers than others. Some ova do not float because they are large

and heavy, or dense, and will sink with the faecal debris. Ova that may be missed with this technique are Physaloptera (stomach worm), many flukes, and some tapeworms. Most faecal flotations are either some kind of salt or sugar solution and include Sheather's sugar solution, zinc sulfate, sodium nitrate, Sodiuim chloride, and magnesium sulfate (Zajac and Conboy, 2006).

2.10.2 Sedimentation

This is an ideal method for the concentration of all types of eggs and oocysts. It is especially used in the recovery of trematode eggs in faeces and in bile (Soulsby,1986 ; Olupinyo and Ajanusi, 2005). The procedures include

1. Break 5-10g of faeces in water.
2. Sieve into a suitable container e.g a urine conical flask or a beaker
3. Leave on the bench for 30-60 minutes.
4. Gently decant supernatant.
5. Examine the whole deposit for parasites. Use Pasteur pipette and rubber teat for taking the samples.

2.10.3 FAMACHA eye-colour scores

In areas where haematophagous (blood-sucking) worm species, particularly *H. contortus*, are prevalent, estimation of clinical anaemia by examining ocular mucous

membranes of sheep and goats using the FAMACHA© chart (Bath *et al*., 1996) is becoming a common diagnostic procedure. This procedure of estimation of clinical anaemia can give a relatively reliable approximation of the haematological status of sheep and goats suffering from the haematophagous worm infections, especially at lower haematocrit values (Van Wyk and Bath, 2002).

2.10.4 Other methods

Other methods used in the diagnosis of helminth infections include immunodiagnosis and enzyme assays. However, these methods are used where laboratory facilities are adequate and are of limited use in direct field investigation of helminthoses (Lughano and Dominic, 1996)

CHAPTER THREE

MATERIALS AND METHOD

3.1 Study Area

The study was carried out in Dogarawa (Trading) slaughter slab in Zaria of Kaduna state, Northern Nigeria from November 2011 to October 2012. Zaria is located within latitude 11^0 7' N and longitudes 07^0 4 E. It is characterised by a tropical climate with two main seasons; a rainy season (May to October) and a dry season (November to April). The monthly mean temperature records show a range from 13.8 to 36.7^{0}C and an annual rainfall of 1092.8 mm (as cited by Agbogu *et al*., 2006). It has an estimated population of 547,000 and a population growth rate of 3.5% per annum (MED, 1996).

Approximately 40-75% of the population's lively-hood is from agriculture (ABU, 2000).

Animals reared in the area include cattle, sheep, goats and poultry. The small ruminants reared in this area are mostly managed under the extensive system. Although this system of management is cheap and less labour-intensive, it is characterized by low productivity and high losses due to accidents, diseases and theft (Ajala and Gefu, 2003). Small ruminants are usually bought by butchers from livestock traders in Zaria environs, nearby villages and town markets to the Dogarawa slaughter slab slaughter.

Fig 3.1: Map of Kaduna State showing the study area

3.2 Study Design and Sample Size

A cross-sectional type of study was done. The sample size was calculated according to the formula given by Thrusfield (2005) by using 95% level of confidence and expected prevalence was 89.1% from previous study of Ajanusi and Chiezey (2005) and desired absolute precision of 5%. A sample size of 300 goats and sheep were arrived at as shown in the following calculation.

$$n = \frac{1.96^2 P_{exp}(1 - P_{exp})}{d^2}$$

Where n = sample size

P_{exp} = expected prevalence (89.1% of Ajanusi and Chiezey, 2005)

d = desired absolute precision of 5% (0.05).

$$n = \frac{1.96^2 \times 0.891\ (1 - 0.891)}{(0.05)^2}$$

$$n = \frac{3.8416 \times 0.891(0.109)}{0.0025}$$

$$n = \frac{0.3731}{0.0025}$$

n= 150 samples approximately

Note: one hundred and fifty was multiply by 2 to avoid sampling error. Therefore, Three hundred samples were collected. Two hundred from goats and one hundred from sheep.

3.2.1 Sampling procedure

The simple random sampling method was used. Whole gastrointestinal tract (abomasum, small intestine and large intestine), blood, faecal sample and bile samples

of the same animal were collected from each of 200 goats and 100 sheep. Proportionate sample method was used to select goats and sheep. As most of them were obtained from different markets, it was difficult to trace the exact origin of the animals. The age of the animals were estimated by their dentition (Steel, 1996; Gatenby, 1991) and sexes determined by their genitalia. In this study, animal less than two years were considered young while those above two years were considered adult. This was for convinience since small ruminants slaughter in Dogarawa slaughter slab is mostly a yerar and above. Twenty to thirty samples for both goats and sheep were collected per month over a period of 12 months.

3.3 Sample Collection and Examination

3.3.1 Worm recovery

Following slaughter and evisceration, the entire gastro-intestinal tract of animal was isolated in situ. Each compartment was ligated with rope/string at both ends to separate it from the next in order to avoid leakage and mixing of contents. Each GIT was collected into a labelled polythene bag as soon as possible, and transported to the Helminthology laboratory in the Department of Veterinary Parasitology and Entomology, Ahmadu Bello University (ABU), Zaria immediately for examination. Worm collection, identification and counting were made in accordance with procedures and techniques described by Hansen and Perry (1994).

The abomasum, small and large intestine were placed on a clean tray separately and each was opened on the tray with the help of a gut runner or scissor. The contents were then washed several times using tap water, paying particular attention to cleaning between the folds of the mucous membranes. The contents were washed using tap water into a bucket to recover smaller parasites. Finally the total volume of each content and washings in the bucket were made up to a total volume of 2 litters by pouring additional water. The parasites were recovered by passing the content through a sieve of 100 μm diameter mesh and were later back-washed into another container. The entire washings from the abomasums, small and large intestines were completely examined individually for worms. The parasites were picked with wire loop with the aid of an illuminator (Picker x-ray in Veterinary Helminthology Laboratory ABU-Zaria) (Hansen and Perry, 1994; Taylor *et al*., 2007)

3.3.2 Recovery of immature stages of *Haemonchus contortus*

The recovery of immature stages of *H. contortus* from the mucosa of the abomasa of goats and sheep was performed, using the digestion technique (Ikeme, 1989; Umur, 1991). The abomasum mucosa was scraped with glass slides into a container. The scraping from the mucosa was added to digestion solution (0.5% Pepsin, 0.7% HCl in water) in a beaker and incubated for 4 hours at 42^{o}C. This was sieved through a 850 um mesh to remove fat. Immature stages were counted using a stereomicroscope.

3.3.3 Species identification

The worms were preserved in 10% formalin and were then poured into Petri dishes and examined under a stereomicroscope. Identification was made using keys

developed by various researchers (MAFF, 1986; Hansen and Perry, 1994). Some parasites were cleared with lactophenol for detailed morphological examination.

3.4 Faecal Samples Collection and Analysis

Faecal samples were collected directly from the rectum of the animals using clean disposable polythene gloves, as described by Pratt, (1985). These were taken to the Helminthology laboratory, Department of Veterinary Parasitology and Entomology ABU, Zaria, and processed immediately. After simple flotation, all nematode eggs were identified using a combination of keys given by Foreyt (2001). The nematode eggs present were identified in general terms as strongylid eggs, except for the eggs of *Moniezia, Strongyloides* and *Trichuris species*. The Faecal egg counts per gram were determined by the modified McMaster techniques using saturated solution of Sodium chloride as the floating medium (Hansen and Perry, 1994).

After centrifuging the 2 g of faeces twice in about 10 ml of flotation fluid, the fluid volume of the supernatant was made up to 12 ml by adding the flotation medium. The multiplication factor of 20 was calculated as follows:

Number of egg/g of faeces = x

Total volume of saturated solution of NaCl used=12 ml

Volume of the two McMaster slide wells=0.30 ml

$$X = \frac{\text{total volume of Nacl solution used}}{\text{Volume of the two McMaster slide wells x 2 g weigh of faeces}}$$

$$X = \frac{12}{0.30 \times 2} = 12/0.6 \quad X=20$$

Thus, the factor of 20 was multiplied with the total number of eggs counted in two chambers to get the number of egg per gram of faeces (Anon, 1977; Soulsby, 1986; Hansen and Perry, 1994).

3.5 Bile Collection and Processing

A total sample of 163 gallbladders of both goat (99) and sheep (64) slaughtered in Dogarawa abattoir were collected. The gallbladders were processed according to the method of Olupinyo and Ajanusi (2005). The gallbladder was split open in a large beaker. Thereafter, the beaker was filled to the brim with tap water and allowed to sediment. The supernatant was then decanted and the process repeated several times until all the bile was completely washed off. The sediment was then examined under light microscope for fluke eggs by transfering a few drops of the sediment at a time onto a clean microcope glass slide using a pasteur pipette. This process was repeated until all the samples were examined for the fluke eggs.

3.6 Blood Samples Collection and Analysis

Immediately following slaughter, 2 ml of blood were collected from the severed jugular vein of each animal into a labelled Bijou bottle containing ethylene diamine tetracetate (EDTA) as anticoagulant. The samples were taken to Veterinary Protozoology Laboratory to determine the Packed Cell Volume (PCV) as described by Hansen and Perry (1994).

3.6.1 Haematocrit (packed cell volume)

After gently mixing the blood, a 75× 1.5 mm capillary tube was filled with blood up to ¾ of its length by capillary action and one end sealed. Then, all of the blood-filled

tubes were centrifuged for 4 minutes at 16904.2 × g using a microhaematocrit centrifuge. Finally, each tube was placed in a micro-haematocrit reader, to determine the percentage of packed red cell volume (PCV) for each animal (Hansen and Perry, 1994; Urquhart *et al*. 1996).

3.7 Meteorological Data

The minimum and maximum temperature, rainfall and relative humidity as recorded were obtained from the Meteorological Station located in the College of Aviation, Zaria for every month of the period of study.

3.8 Data Analysis

The data obtained were reduced to Tables and charts. The percentage Prevalence of parasite species was calculated as number of individuals of a host species infected with a particular parasite species divided by the number of host examined times 100. Data obtained for egg and adult counts were expressed as mean± SEM. They were further subjected to t- test and analysis of variance (ANOVA) followed by Turkey's post hoc test where necessary. Chi- square and odds ratio were also used to test for association between the presence of helminth eggs and adult worms and variables like sex, age, species and seasons of the year. Value of $p< 0.05$ was considered significant. Pearson correlation was also used to test for relationship between PCV, egg counts and adult worm counts. GraphPad prism version 4.0 Windows from Graphpad Software, San Diego, California USA was used to analyze the data.

CHAPTER FOUR

RESULTS

4.1 Meteorological Data

Monthly mean minimum and maximum temperature, mean relative humidity and total rainfall during the study period are shown in Figs 4.1, 4.2, 4.3 and Appendix 4.1. The study area was tropical, humid and with average minimum temperature of 13.8°C in December and maximum of 37.1ºC in April. The mean relative humidity was highest

(83.8%) in the month of August and lowest (18.0%) in the month of March and with total annual rainfall of about 1417.3 mm.

The highest *Haemonchus* worm burdens were recorded in the month of September when the mean temperature, mean relative humidity and total rainfall were 24.9^{0}C, 81.1% and 224.1mm respectively. The least were recorded in the month of January when the mean temperature, mean relative humidity and total rainfall were 22.1^{0}C, 27.6% and 0.0mm respectively. The year was divided into four seasons. These were early dry (November, December and January), late dry (February, March and April), early rain (May, June and July) and late rain (August, September and October) seasons.

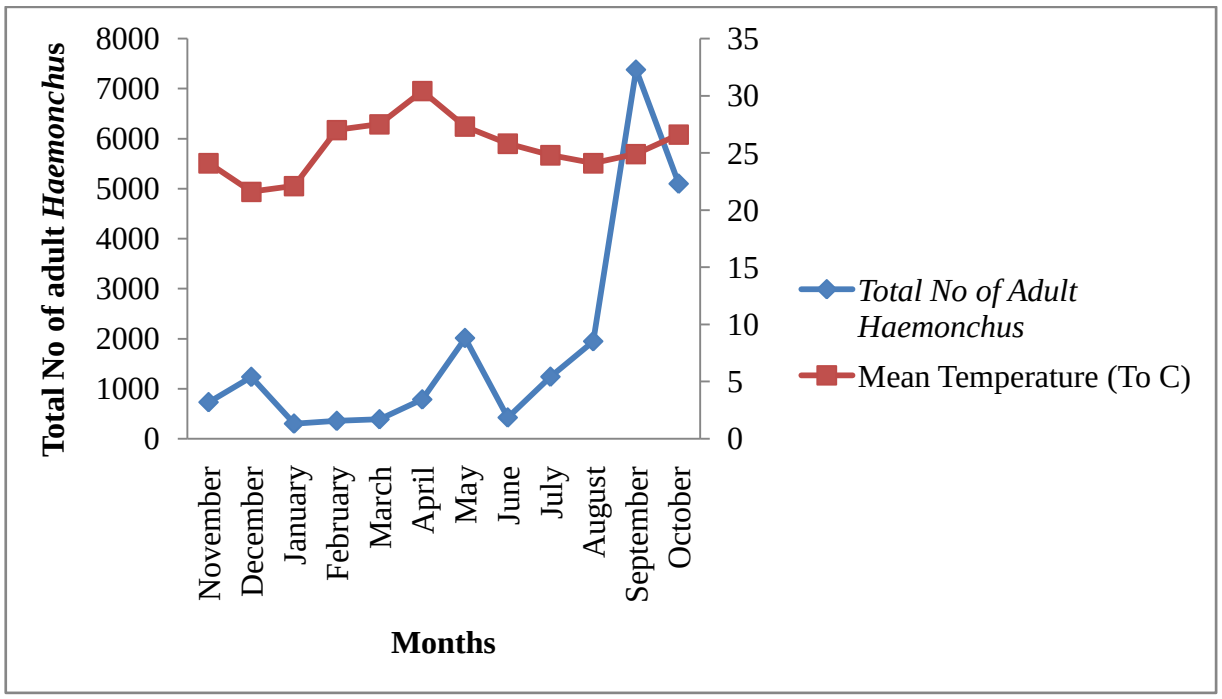

Figure 4.1: Monthly mean temperatures recorded in Meteorological Station in Zaria and total number of adult *Haemonchus* counts in small ruminants in Zaria, Nigeria.

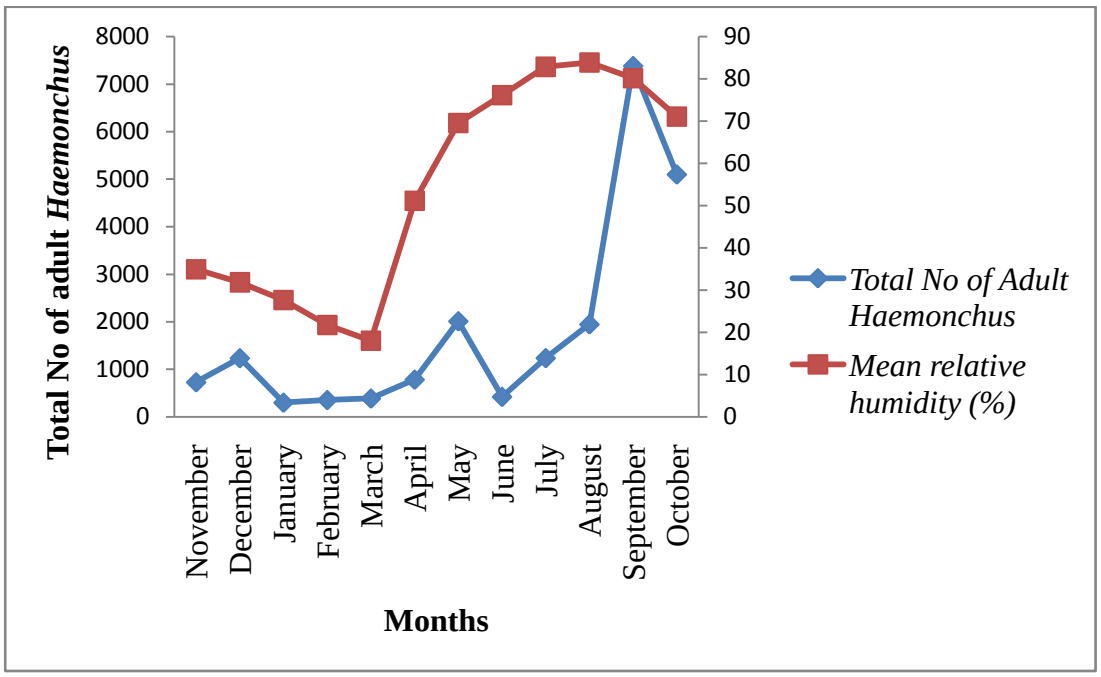

Figure 4.2: Mean Relative Humidity recorded in Meteorological station in Zaria and total number of adult *Haemonchus* counts in small ruminants in Zaria, Nigeria.

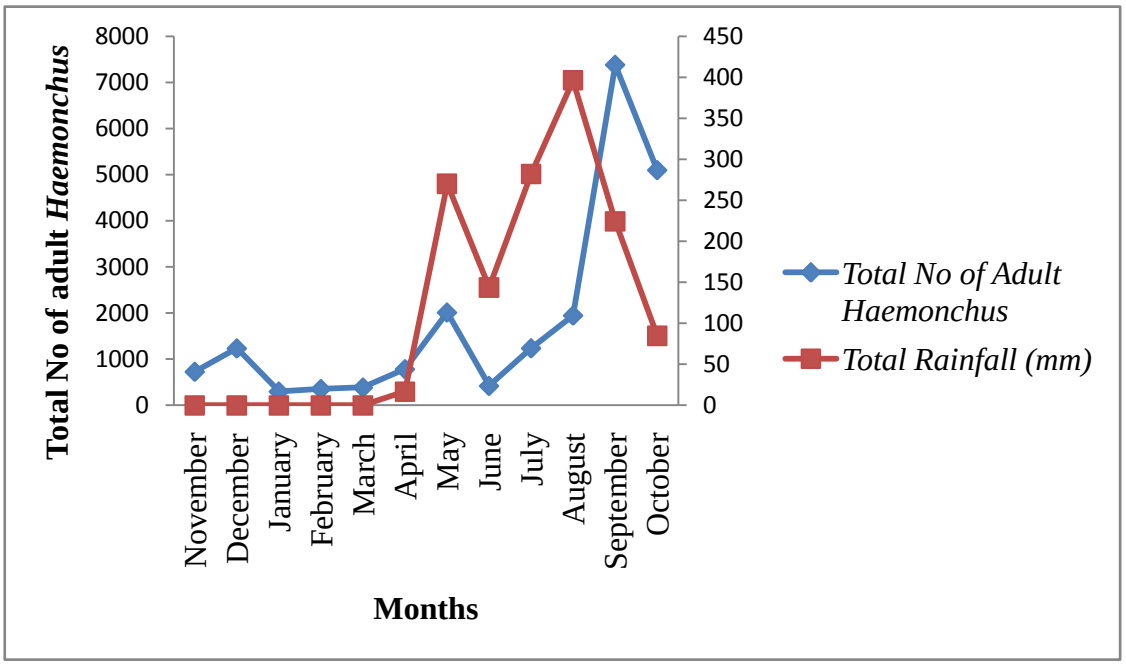

Figure 4.3: Monthly total rainfall recorded in Meteorological station in Zaria and total number of adult *Haemonchus* counts small ruminants in Zaria, Nigeria.

4.2 Overall Prevalence of Gastrointestinal Helminth Eggs in the Small Ruminants by Species, Sex and Age of Small Ruminants, and Season of the Year in Dogarawa slaughter slab in Zaria, Nigeria.

A total of 300 faecal samples from 200 goats and 100 sheep were examined for helminth eggs. The overall prevalence of helminth eggs in small ruminants is shown in Table 4.1. The overall prevalence of helminth eggs was 77.3%. The prevalence of helminth eggs was 75% in goats and for 82% in sheep. The difference in the two species of small ruminants was not statistically significant ($p>0.05$).

Overall, the prevalence of helminth eggs was 75.6% in the male and 82.7% in the female animals. The difference in prevalence rates were not significant ($p>0.05$). The overall prevalence of helminth eggs in young small ruminants was 77.9% and 76.9% in the adult. The difference in prevalence rates were not statistically significant ($p>0.05$). Adult small ruminants have almost similar risk of acquiring infection as the young ones. Considering the season, the overall prevalence were 68.9%, 77.8%, 85.4% and 75.7% during late dry, early dry, late rain and early rain periods respectively. The difference in rates were not statistically significant ($p>0.05$) even though the prevalence was higher in the late rain than other seasons.

Table 4.1: Overall prevalence of gastrointestinal helminth eggs in the small ruminants by species, sex and age of small ruminants, and season of the year in Dogarawa slaughter slab in Zaria, Nigeria.

Category	No. Examined	No positive (%)	X^2 (P- value)	Odds ratio
Species				
Goat	200	150(75)	1.864(0.1722)	1
Sheep	100	82(82)		1.5
Total	300	232(77.3)		
Sex				
Male	225	170(75.6)	1.625(0.2027	1
Female	75	62(82.7)		1.5
Total	300			
Age				
Adult	160	123(76.9)	0.04109(0.8394)	1
Young	140	109(77.9)		1.1
Total	300			
Season				
late dry	74	51(68.9)	6.410(0.0933)	1
Early dry	63	48(77.8)		1.4
late rain	89	76(85.4)		2.6
Early rain	74	56(75.7)		1.4
Total	300			

(P > 0.05)

4.3 Overall Prevalence of Adult Gastrointestinal Helminths in the Small Ruminants by Species, Sex and Age of Small Ruminants, and Seasons of the Year in Dogarawa Slaughter Slab in Zaria, Nigeria.

The results of necropsy examination in goats and sheep are shown in Table 4.2. From the gastro-intestinal tracts of 200 goats and 100 sheep examined for adult helminths, the overall prevalence of adult helminth was 80.7%. The prevalence of adult helminths in goats and sheep were 78.5% and 85% respectively. The difference in the two species of small ruminants was not statistically significant ($p>0.05$). Considering species as a risk factor, sheep were one- and- half times more at risk of infection with adult heminths than goats. The overall prevalence of adult helminths in small ruminants by sex was 89.8% in the male and 92% in the female. The difference in prevalence was not statistically significant ($p>0.05$), even though the prevalence was higher in the female than in male. Taking sex as a risk factor, females were more at risk of infection with adult heminths than males. The overall prevalence of adult helminths in small ruminants aged less than two years was 87.6% compared to 76.3% in the adult animals. The difference in prevalence was statistically significant ($p<0.05$). Taking age as a risk factor, young small ruminants were more than two times more at risk of infection with adult helminths than adults.

Considering the season, the overall prevalence were 86.5%, 90.5%, 92.1% and 91.9% during late dry, early dry, late rain and early rain respectively. The prevalence rates were not significantly different ($p>0.05$).

Table 4.2: Overall prevalence of adult gastrointestinal helminths in the small ruminants by species, sex, age of small ruminants and season of the year in Dogarawa slaughter slab in Zaria, Nigeria.

Category	No. Examined	No positive (%)	X^2 (P- value)	Odds ratio
Species				
Goat	200	157(78.5)	1.806(0.1790)	1
Sheep	100	85(85)		1.6
Total	300	242(80.67)		
Sex				
Male	225	202(89.8)	0.3181(0.5727	1
Female	75	69(92)		1.3
Total	300			
Age				
Adult	160	122(76.3)	6.719(0.0095)	1
Young	140	123(87.6)		2.3
Total	300			
Season				
Late dry	74	64(86.5)	1.792(0.6166)	1
Early dry	63	57(890.5)		1.5
Late rain	89	82(92.1)		1.8
Early rain	74	68(91.9)		1.8
Total	300			

For species, Sex and Season ($P>0.05$) while Age ($P< 0.05$)

4.4 Prevalence and Mean Worm Counts of Adult Helminths Recovered From Small Ruminants Slaughtered at Dogarawa Slaughter Slab in Zaria, Nigeria.

The prevalence and mean worm count of helminth genera recovered from gastrointestinal tracts of the small ruminanta examined in the Dogarawa slaughter Slab in Zaria, Northern Nigeria are shown in Table 4.3, Figure 4.4 and Appendix 4.2.

Five different genera of parasitic helminths were recovered. These included *Haemonchus, Trichostrongylus, Oesophagostomum, Trichuris and Moniezia*.

Goats had prevalence of 78.5%, 15.5%, 13.5%, 47.5% and 21% for *Haemonchus, Trichostrongylus, Oesophagostomum, Trichuris and Moniezia* respectively while sheep had prevalence of 85%, 31%, 13%, 27% and 24% for *Haemonchus, Trichostrongylus, Oesophagostomum, Trichuris and Moniezia* respectively.

Considering the sex of small ruminants, male had prevalence of 78.9%, 26.7%, 12.4%, 43.6% and 22.2% for *Haemonchus, Trichostrongylus, Oesophagostomum, Trichuris and Moniezia* respectively while female had prevalence of 86.7%, 28%, 13.3%, 25.3% and 20% for *Haemonchus, Trichostrongylus, Oesophagostomum, Trichuris and Moniezia* respectively. In age, young animals had prevalence of 77.1%, 22.1%, 15%, 37.9% and 22.1% for *Haemonchus, Trichostrongylus, Oesophagostomum, Trichuris and Moniezia* respectively while adult animals had prevalence of 81.3%, 25.6%, 11.9%, 41.3% and 21.9% for *Haemonchus, Trichostrongylus, Oesophagostomum, Trichuris and Moniezia* respectively.

Table 4.3 Prevalence of each species of adult gastrointestinal helminths in the small ruminants by species, sex and age slaughtered in Dogarawa slaughter slab in Zaria, Nigeria.

Helminth spp	**Prevalence (%)**					
	Goats(200)	**Sheep (100)**	**Male (225)**	**Female (75)**	**Young (140)**	**Adult (160)**
Haemonchus spp	157 (78.5)	85 (85)	173 (78.9)	65 (86.7)	108 (77.1)	130 (81.3)
Trichostrongylus spp	35 (25.5)	31 (31)	60 (26.7)	21 (28)	31 (22.1)	41 (25.6)
Oesophagostomum spp	27 (13.5)	13 (13)	28 (12.4)	10 (13.3)	21 (15)	19 (11.9)
Trichuris spp	95 (47.5)	27 (27)	98 (43.6)	19 (25.3)	53 (37.9)	66 (41.3)
Moniezia spp	42 (21)	24 (24)	50 (22.2)	15 (20)	31 (22.1)	35 (21.9)

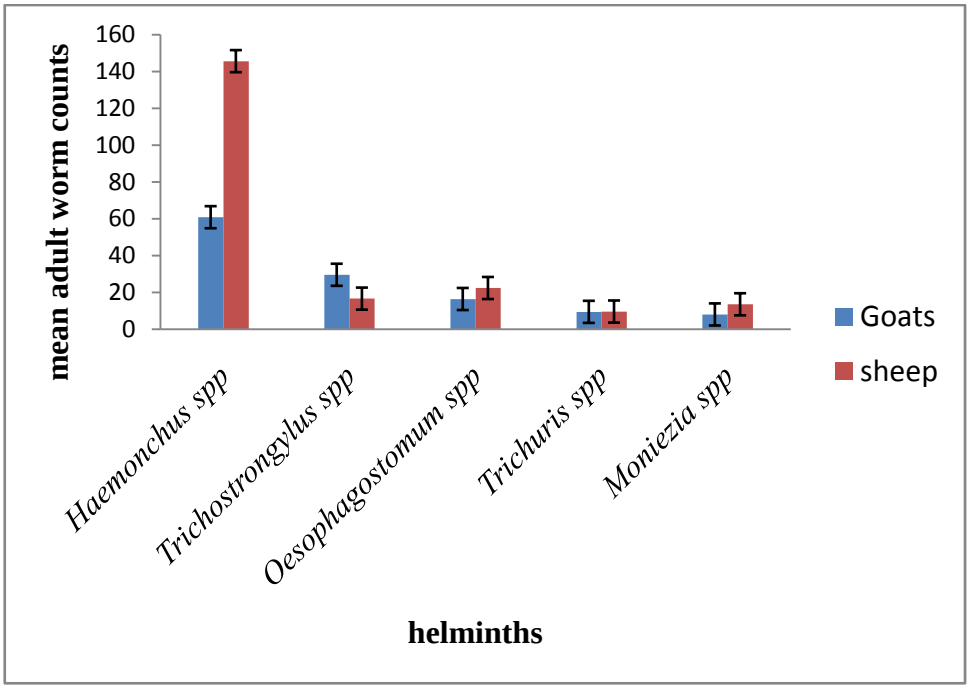

Figure 4.4: Mean adult helminths counts recovered from small ruminants by species in Dogarawa slaughter slab in Zaria, Nigeria

4.5 Mean Counts of Adult Helminths Recovered from Small Ruminants by Sex and Age of Small Ruminants Slaughtered in Dogarawa Slaughter Slab in Zaria, Nigeria.

The mean worm counts on sex and age of small ruminants are shown in Figures 4.5, 4.6 and Appendix 4.3. The mean worm counts of *Haemonchus* were higher in female (166.4±63.19) than in male (63.14±6.47), and the difference was statistically significant ($p< 0.05$). The mean worm counts of *Haemonchu*s were higher in adult (102.6±32.16) than in the young (79.13 ±9.16) of small ruminants, although there was no statistically significant difference ($p>0.05$) between the values.

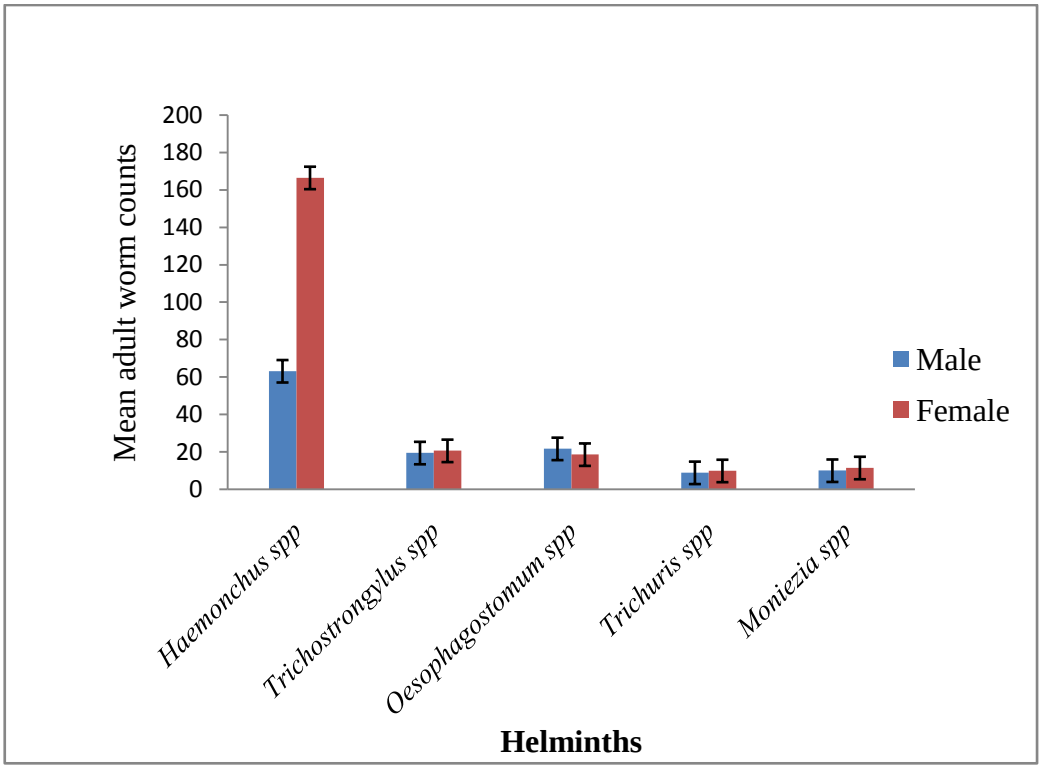

Figure 4.5: Mean counts of adult helminths recovered from small ruminants by sex slaughtered in Dogarawa slaughter slab in Zaria, Nigeria.

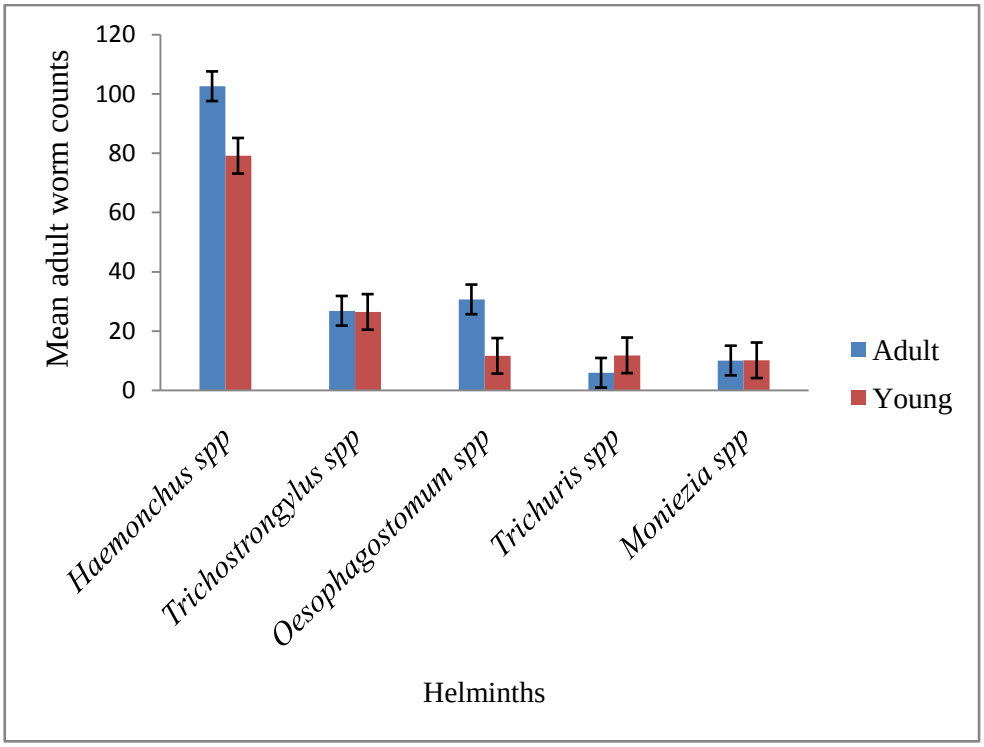

Figure 4.6: Mean counts of adult helminths recovered from small ruminants by age slaughtered in Dogarawa slaughter slab in Zaria, Nigeria.

4.6 Prevalence and Mean Egg Counts Per Gram of Faeces of Small Ruminants by Species, Sex and Age in Dogarawa Slaughter Slab in Zaria, Nigeria.

The prevalence and mean egg counts/g recovered from small ruminants are shown in Table 4.4, Figures 4.7, 4.8, 4.9. The types of helminth egg types recovered were those of Strongyle, *Strongyloides*, *Trichuris* and *Moniezia*. Faecal egg counts per gram of faeces showed the same trend irrespective of the species, sex and age of the small ruminants.

The mean strongyle egg count per gram of faeces was significantly higher ($p< 0.05$) in sheep (2966±435.7) than in goats (1301±189.9) and higher ($p< 0.05$) in females (2771±428.3) than in males (1537±224.6). There was no significant difference ($p> 0.05$) in the rate of egg detection in young and adult animals.

In both goats and sheep, the mean egg counts were highest in *Strongyloides* (2630±138.8 and 4208±343.1 respectively) and lowest for *Trichuris* (138.8±30.39 and 90.00±23.80 respectively). In adult animals, the mean egg counts were highest for *Strongyloides* (3012±2121) and lowest for *Trichuris* (53.20±12.42), while in the young animals, the mean egg counts were highest for strongyle (1797±300.9) and lowest for *Trichuris* (190.0±46.98). (Fig 4.7 -4.9)

Table 4.4 Prevalence of each helminth egg type recovered from small ruminants by species, sex and age slaughtered in Dogarawa slaughter Slab in Zaria, Northern Nigeria.

Helminth egg types	Prevalence (%)					
	Goats(200)	**Sheep(100)**	**Male (225)**	**Female (75)**	**Young (140)**	**Adult (160)**
Strongyles	124(62)	71(71)	136(60.4)	59(78.7)	94(67.1)	108(67.5)
Strongyloides	17(8.5)	8(8)	22(9.8)	5(6.7)	11(7.9)	13(8.1)
Trichuris	12(6)	4(4)	14(6.2)	1(1.3)	10(7.1)	5(3.1)
Moniezia	30(15)	15(15)	36(16)	9(12)	20(14.3)	23(14.4)

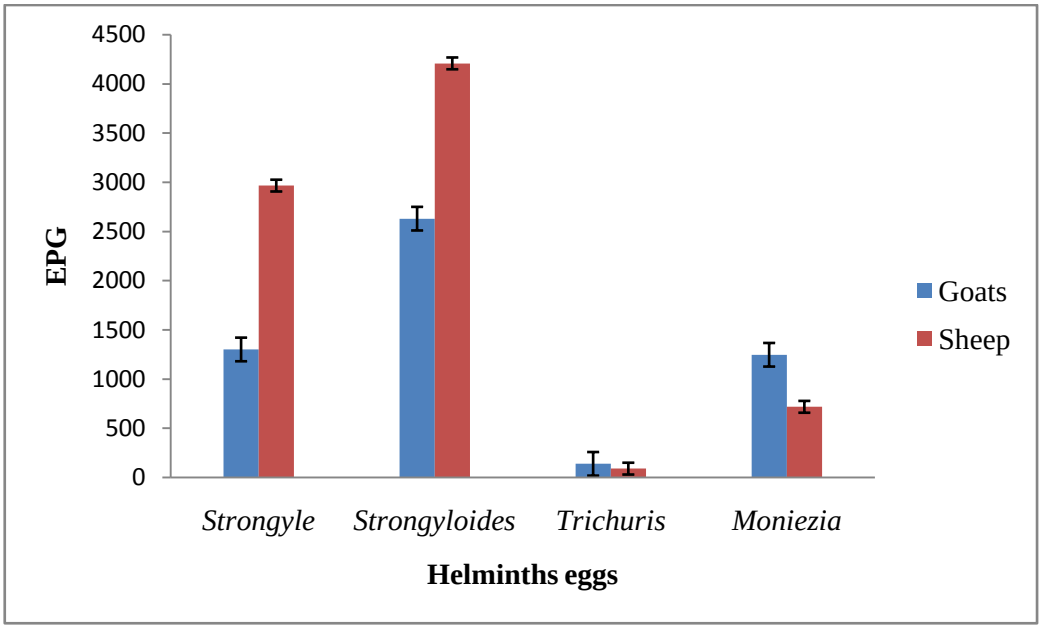

Figure 4.7: Mean egg counts per gram of faeces by species in small ruminants in Dogarawa slaughter slab in Zaria, Nigeria.

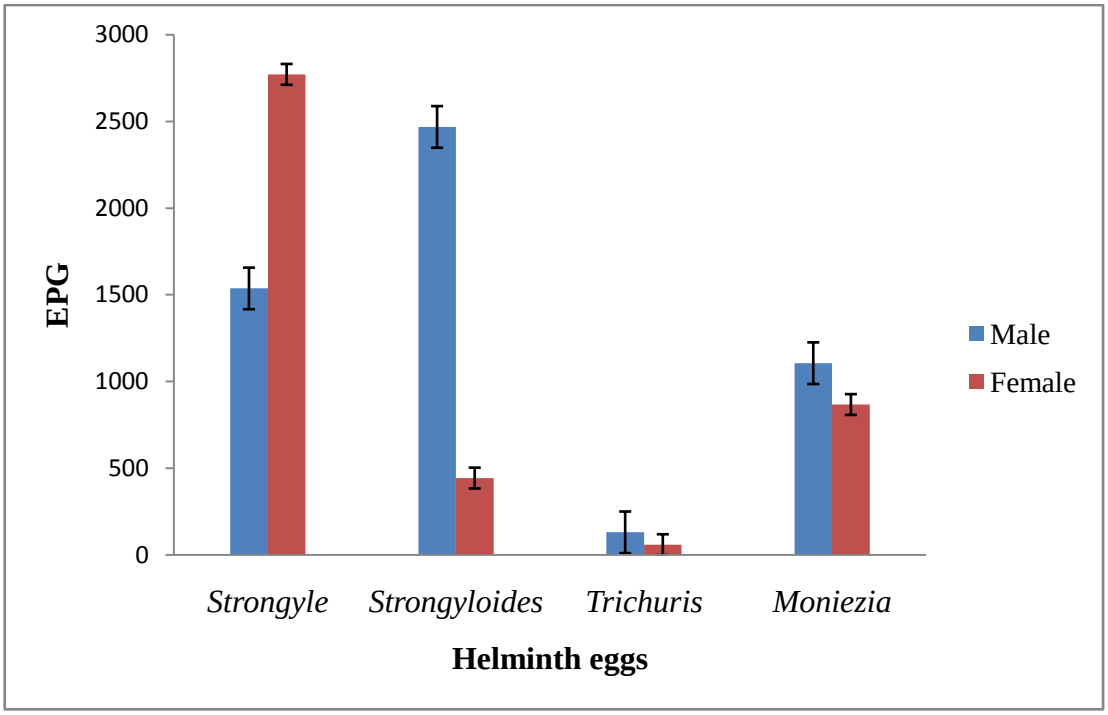

Figure 4.8: Mean egg counts per gram of faeces by sex in small ruminants in Dogarawa slaughter slab in Zaria, Nigeria.

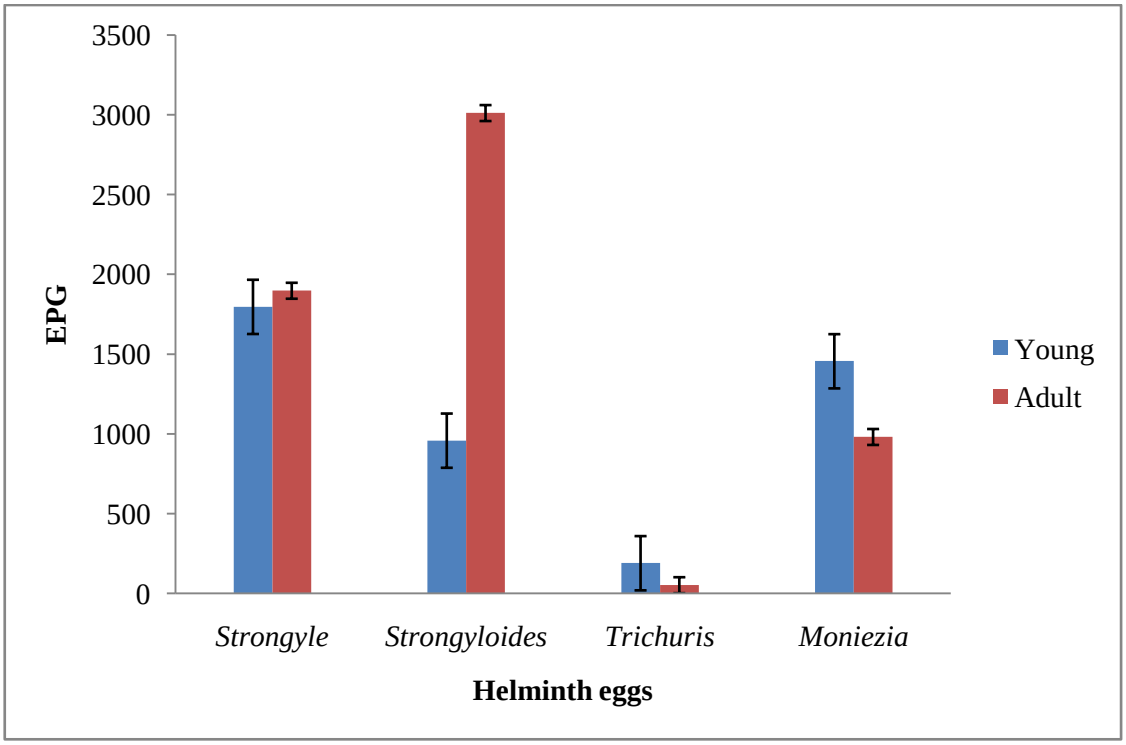

Figure 4.9: Mean egg counts per gram of faeces of young and adult small ruminants slaughtered in Dogarawa slaughter Slab in Zaria, Nigeria.

3.7 Seasonal Variation of the Mean Counts of Adult Worms Recovered From Sheep and Goats Slaughtererd in Dogarawa Slaughter Slab in Zaria, Nigeria.

The seasonal variations of the mean worm counts of helminths recovered at necropsy in Dogarawa Abattoir Zaria, Northern Nigeria are presented in Figures 4.10, 4.11 and Appendix 4.5, 4.6. The mean worm counts of *Haemonchus* spp attained the peak during late rainy season in both sheep (265.3±105.9) and goats (103.3 ± 15.69). The mean worm counts were significantly ($P<0.05$) higher during the late rain compared to the other seasons. The mean counts for *Trichostrongylus* followed a similar pattern. However, the mean worm counts of other helminthes genera recovered were in very low numbers, and this did not allow any meaningful comparison of seasonal pattern.

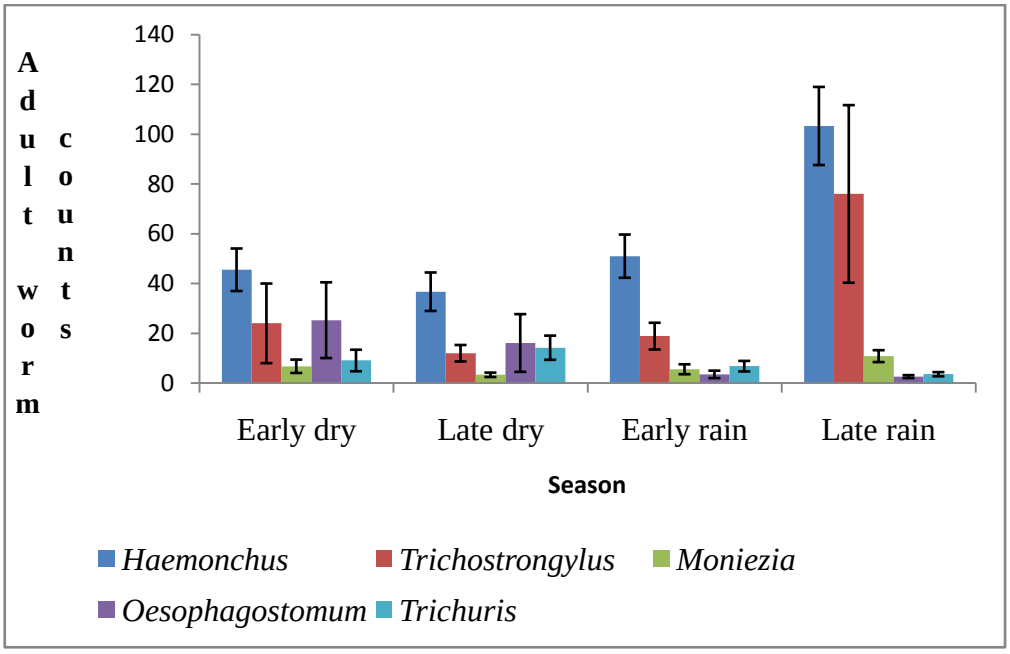

Figure 4.10: Seasonal variation of mean adult worm counts from goats slaughtered in Dogarawa slaughter Slab in Zaria, Nigeria.

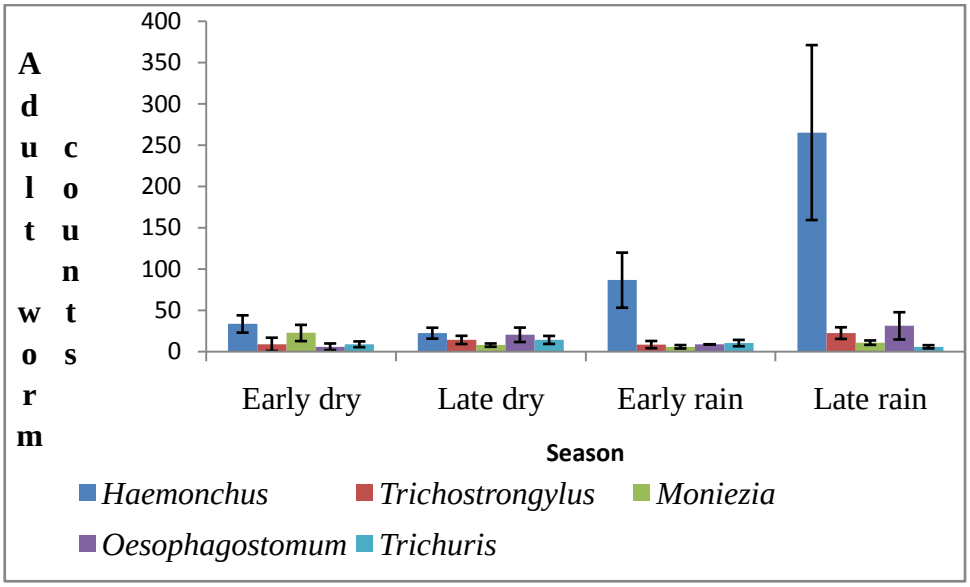

Figure 4.11: Seasonal variation of mean adult worm counts from sheep slaughtered in Dogarawa slaughter slab in Zaria, Nigeria.

4.8 Seasonal Variation of Mean Egg Counts Per Gram Recovered from Goats and Sheep in Dogarawa Slaughter Slab in Zaria, Nigeria.

Figures 4.12, 4.13 and Appendix 4.7, 4.8 showed seasonal variation of mean egg counts per gram recovered from goats and sheep. The mean counts of strongyle eggs in goats and sheep were higher during the late rainy season and lowest during the late dry season. The mean egg counts during this season was significantly ($P< 0.05$) higher compared to the counts for each of the other seasons. The other egg types encountered during the study did not show any definite seasonal variations though, *Strongyloides* was higher in sheep and goats during late rain season and early rain seasons respectively.

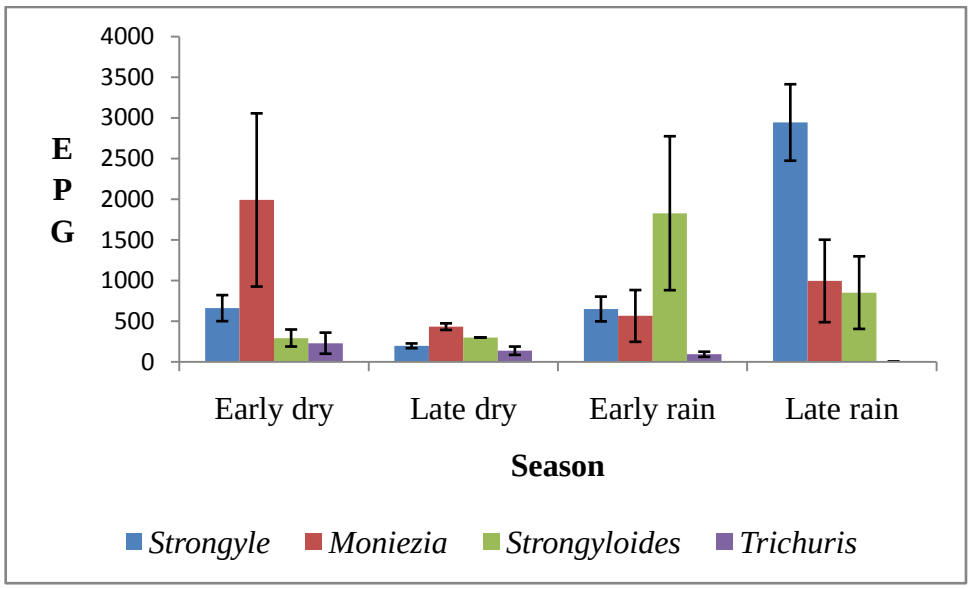

Figure 4.12: Seasonal variation of Egg per gram of faeces in goats in Dogarawa slaughter slab in Zaria, Nigeria.

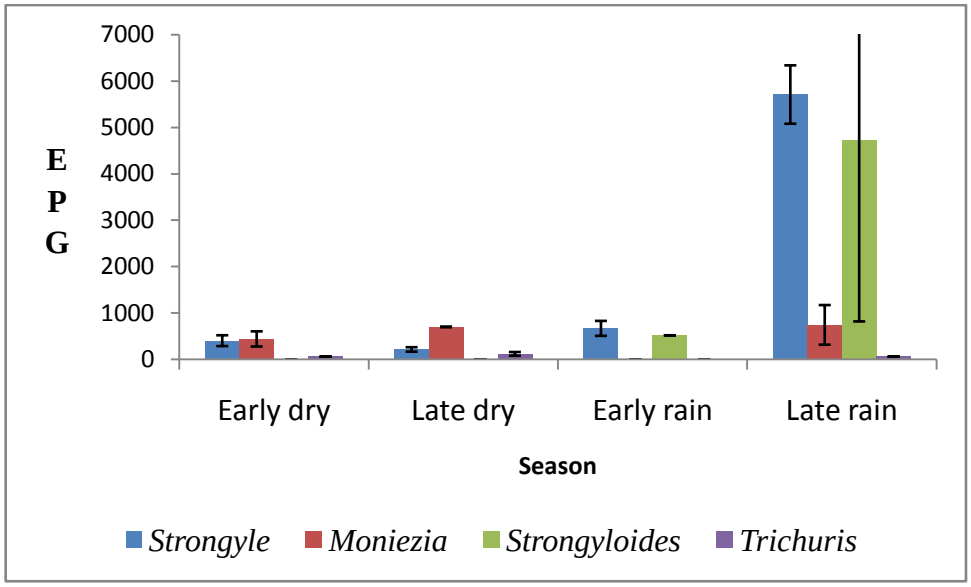

Figure 4.13: Seasonal variation of egg per gram of faeces in sheep in Dogarawa slaughter slab in Zaria, Nigeria.

4.9 Monthly Recovery of Total Number of Adult Helminths Count, Total Number of Adult *Haemonchus* Counts and Its Inhibited Larvae (L_4)

The total monthly recovery of inhibited larvae (L_4) and adult *Haemonchus* spp is shown in Tables 4.5 and 4.6, Figure 4.13 and Appendix 4.9. *Haemonchus* spp contributed 84.2% of the total adult helminth count (Table 4.5). The overall contribution of the mucosal larvae to the total worm burden of *H. contortus* in small ruminants in Dogarawa slaughter slab in Zaria, Nigeria was 1.1% (Table 4.6) with a statistical difference ($p<0.05$) between mean counts of adult *Haemonchus* and inhibited larvae. Adult *Haemonchus* counts were highest in the month of September and lowest in the month of January.

The contribution of arrested development in the population of the *Haemonchus* began to appear in November, December, January, February, March, April, September and October. The lowest conribution rate was recorded in the month of November and highest in February. But the highest total number of inhibited larvae of *Haemonchus* was recorded in the month of October. The inhibited development of *Haemonchus* followed a seasonal pattern which occur mostly during the late rainy season followed by late dry and early dry season respectively. There was no recovering of inhibited larvae in the months of May, June, July and August.

Table 4.5 Monthly contribution of *Haemonchus* spp count to total number of adult helminths

Months	Total No of adult helminths	Total No. of adult *Haemonchus* spp	Specific (%) contribution of *Haemonchus* spp to total adult helminths counts
November	1235	727	58.9
December	1503	1233	82
January	478	298	62.3
February	558	353	63.3
March	661	385	58.2
April	1322	782	59.2
May	2255	2010	89.1
June	557	420	75.4
July	1373	1236	90
August	2445	1945	79.6
September	7999	7377	92.2
October	5570	5096	91.5
Total	25956	21862	84.2

Table 4.6: Monthly Recovery of adult *Haemonchus* spp counts and its inhibited larvae (L_4) in Dogarawa slaughter Slab in Zaria, Northern Nigeria.

Months	**Total number of adult *Haemonchus* spp (%)**	**Total number of inhibited larvae (%)**	**Specific % contribution of L_4 to adult**
November	727 (3.3)	1 (0.4)	0.1
December	1233 (5.6)	17 (7.3)	1.4
January	298 (1.4)	21 (9.0)	6.6
February	353 (1.6)	46 (19.7)	11.5
March	385 (1.8)	23 (9.8)	4.6
April	782 (3.6)	4 (1.7)	0.5
May	2010 (9.2)	0 (0.0)	0.0
June	420 (1.9)	0 (0.0)	0.0
July	1236 (5.7)	0 (0.0)	0.0
August	1945 (8.9)	0 (0.0)	0.0
September	7377 (33.7)	14 (6.0)	1.9
October	5096 (23.3)	108 (46.2)	2.1
Total	21862 (100)	234 (100)	1.1

4.10 Monthly Mean of Total Adult Helminth Counts, Total Eggs Per Gram and Corresponding PCV in Small Ruminants slaughtered at Dogarawa slaughter Slab in Zaria, Nigeria.

Monthly Mean of adult worms and their corresponding egg per gram of faeces and PCV in small ruminants at Dogarawa slaughter Slab in Zaria, Northern Nigeria are shown in Table 4.7. The PCV had a weak negative correlation with adult worm counts and egg per gram of faeces at Pearson correlation coefficient of -0.2632 and -0.2798 respectively ($p<0.0001$) which was highly significant. The PCV value decreased, as the adult worm counts and egg per gram of faeces increased.

Adult worm counts were also correlated with egg per gram of faeces. There was weak positive correlation between adult worm counts and egg per gram of faeces at Pearson correlation coefficient of 0.3860 ($p<0.0001$). Meaning, that as adult worms increased, egg per gram of faeces also increased.

Table 4.7: Monthly Mean of total adult helminth counts, total eggs per gram and corresponding PCV in small ruminants at Dogarawa slaughter slab in Zaria, Nigeria.

Months	Mean Adult worms count	Eggs per gram of feaces	PCV (%)
November	112.3±34.79	358.2±206.2	34.55±0.878
December	55.67±13.83	1316±451.7	24.70±1.048
January	29.00±9.596	304.5±71.00	28.54±1.091
February	22.32±6.314	127.2±32.76	28.84±1.050
March	26.44±8.322	149.8±32.56	27.20±1.447
April	42.59±8.553	167.2±31.09	29.97±1.209
May	66.26±19.32	332.3±80.49	28.26±1.097
June	24.22±5.658	97.39±34.00	32.35±0.821
July	52.81±10.18	1253±321.7	27.27±0.681
August	90.56±15.89	3065±549.2	26.67±0.759
September	266.6±136.6	4401±126.8	27.97±1.528
October	174.1±29.88	4253±761.0	27.97±0.988

($P<0.0001$)

4.12 Prevalence of *Fasciola* and *Dicrocoelium* spp in Small Ruminants by Species, Sex and Age in Dogarawa slaughter Slab in Zaria, Nigeria.

Table 4.9 shows the Prevalence of *Fasciola* and *Dicrocoelium* spp in small ruminants by species, sex and age. The overall prevalence of *Fasciola* and *Dicrocoelium* spp in small ruminants was 8.6%.

Goats were found to have the prevalence rate of 10.1% and 2.0% for *Fasciola* spp and *Dicrocoelium* spp respectively, while sheep had 4.7% and 0.0% respectively. Considering sex, males had a prevalence rate of 8.0% and 1.8% for *Fasciola* spp and *Dicrocoelium* spp respectively while females had a prevalence rate of 4.8% and 0.0% respectively. Young animals had 7.0% and 1.1% for *Fasciola* spp and *Dicrocoelium* spp respectively; while adults had 8.7% and 1.1% respectively. There was no significant difference ($p>0.05$) between species, sex and age of small ruminants on the prevalence of trematode eggs

Table 4.8: Prevalence of *Fasciola* and *Dicrocoelium* spp in small ruminants by species, sex and age in Dogarawa slaughter slab in Zaria, Nigeria.

		Parasites	
Category	**No. Examined**	**Number (%) prevalence**	
Species		*Fasciola* spp	*Dicrocoelium* spp
Goats	99	10(10.1)	2(2.0)
Sheep	64	3(4.7)	0(0)
Sex			
Male	113	9(8.0)	2(1.8)
Female	50	4(8.0)	0(0)
Age			
Young	71	5 (7.0)	1 (1.4)
Adult	92	8 (8.7)	1 (1.1)

(P> 0.05)

CHAPTER FIVE

DISCUSSION

This study was aimed at evaluating the current status of GIT (abomasum, small intestine and large intestine) helminth infections of small ruminants slaughtered in Dogarawa slaughter slab in Zaria, Northern Nigeria.

Monthly mean minimum and maximum temperature, mean relative humidity and total rainfall during the study period were recorded. The study area was tropical, humid and with average minimum temperature of 13.8°C in December and maximum of 37.1ºC in April. The mean relative humidity was highest (83.8%) in the month of August and lowest (18.0%) in the month of March and with total annual rainfall of about 1417.3mm. This result was higher than the result recorded by Agbogu *et al*. (2006) in Zaria, Northern Nigeria.

In the present study, adult *Haemonchus* burdens were high from May to October. When this finding is correlated with weather data, it is obvious that at this period of the year there was the highest rainfall and most suitable temperature coupled with high relative humidity. This result agreed with the reports of Ogunsusi and Eysker, (1979).

A point to note is that under the conditions existing in Zaria, Northern Nigeria, temperature is not a limiting factor to *Haemonchus* worm burdens since the monthly mean temperature ranged between 21.1^{o}C and 30.4^{o}C but lack of rainfall/moisture contributes to low worm burdens recorded during the dry season. Vlassoff et *al.* (2001) reported similar findings that for successful development of eggs and pre-infective stages into L_3 statge in faeces, they must survive a range of climatic conditions. Optimal development occurs between 15°C and 30°C, but development will take place at varying rates within the temperature range of 4°C to 35°C if moisture is present. Eggs of *Haemonchus*, *Trichostrongylus*, *Ostertagia* and *Chabertia* spp develop to L_3 statge most rapidly at the mean monthly air temperatures of 15°C - 24°C. These prevailing weather conditions especially rainfall and temperature favours the development and survival of parasitic helminth eggs to infective stages in the study area.

The result of the faecal examination during the study revealed an overall prevalence rate of helminths as 77.3% in the small ruminants examined at Dogarawa slaughter slab, Zaria. The study showed that 82% and 75% of sheep and goats respectively had infected with one or more helminth eggs. These findings are higher than the results of other surveys in sheep and goat carried out in North-eastern Nigeria (Nwosu *et al*., 2007). The reason for this result was due to higher humidity and rainfall recorded in Zaria than in North-eastern Nigeria. The prevalence however, agrees with previous reports from other geographical regions of Nigeria which ranged from 77 - 100% (Chiejina, 1986; Nwosu *et al*., 1996a, b, Okaiyeto *et al*., 2008; Jatau *et al.,* 2011).

The mean FEC were generally moderate in both sheep and goats. *Strongyloides* were recorded highest in sheep when compared to goats but there was no significant difference between them. This result is in contrast with that of Nwosu *et al.* (2007) where he recorded EPG of Strongyle eggs to be highest followed by *Strongyloides*. Strongyle egg types were second highest in sheep with significant difference ($p<0.05$). *Moniezia* and *Trichuris* were recorded in lowest faecal egg counts and there was no significant difference ($p> 0.05$) between the Species.

The high prevalence reported in this study could be as a result of the management system practised by most small ruminant owners especially during the rainy season when animals are confined to avoid damage to crops. Consequently, such animals are confined to small areas leading to high pasture contamination. These factors are compounded by the high humidity of the rainy season which allows for a high rate of development of infective larvae. The prevailing climatic conditions reported in the study area especially rainfall and temperature favours the development and survival of parasitic nematode eggs to infective stages. This might explain the high prevalence rate observed in this study. The result agreed with the report of Chiejina and Emehelu, (1984).

Considering species of small ruminants as a predisposing risk factor on overall prevalence of gastro-intestinal helminth eggs and adults, it was observed that sheep had higher prevalence rate than goats. This result agrees with those of Teklye (1991) and Tesfaheywet (2012) in Ethiopia, Waruiru *et al*. (2005) in Kenya, Nwosu *et al*. (2007) and Jatau *et al*. (2011) in Nigeria and Asif *et al*. (2008) in Pakistan. The

possible explanation of higher prevalence in sheep might be the fact that sheep usually graze very close to the soil which might be helpful in the acquisition of more infective larvae of helminths from the contaminated herbage. On the other hand, goats browse on shrubs and small trees where translation of infective larvae to such a height seems to be impossible. However, it is contrary to reports of Abebe and Esayasu (2001); Regassa *et al.* (2006); Keyyu *et al*. (2006), Raza *et al*. (2007) and Biu *et al*. (2009) who all reported higher prevalence rate in goats. Hawkins and Cole (1945) had reported immune antibodies in sheep enabled it to throw off its worm burden and also prevented further infection by immobilizing the larvae in the gastrointestinal mucosa.

The study revealed that sex of the animal did not show any significant difference in prevalence, even though the rate was higher in females. These findings were similar to the reports of Keyyu *et al*. (2003); Regassa *et al*. (2006) and Ghanem *et al*. (2009). This also agrees with the reports of Dagnachew *et al*. (2011) who reported a higher prevalence rate of helminth infection in females. This may be attributed to the immunosuppressive effect of reproductive hormones of the female animals especially during pregnancy and peri-parturient period (Soulsby, 1986 and Urquhart *et al.,* 1996). In contrast, Gualy *et al.* (2006) and Raza *et al.* (2007) documented higher prevalence of helminth infection in rams than in females.

Young small ruminants were more at risk of infection of egg and adult helminths than in adults. This could be related to the higher susceptibility of younger animals to infection. These findings are in agreement with reports of Melkamu (1991); Fritsche *et al*. (1993); Keyyu *et al.* (2003); Ng'ang'a *et al.* (2004); Githigia *et al.* (2005); Regassa *et al.* (2006); Dagnachew *et al*. (2011) and Welemehret *et al.* (2012). Age was

considered an important risk factor in GIT helminthosis (Raza *et al*., 2007). Several authors have documented that adult animals develop acquired immunity (Urquhart *et al.,* 1996; Taswar *et al.,* 2010) against heiminth infections as they mature due to repeated exposure (Dagnachew *et al*., 2011) and this will help expel the parasite before it becomes established in the GIT (Dunn, 1978; Shah-Fischer and Say, 1989).

In this study, an insignificantly ($p>0.05$) higher prevalence rate of infection was obtained during the wet season. Thus, the mean counts of Haemonchus and Trichostrongylus were significantly higher during the late rainy season. Also, EPG values peaked during this season. This may lend support to the general understanding that moisture, humidity and optimum temperature are bionomic factors that support the development of the infective stage of most parasites and these factors have been recorded in the study area. This result agrees with the findings of Hansen and Perry (1994); Urquhart *et al*. (1996) and Almalaik *et al*. (2008). This phenomeno is also true in sub-Saharan Africa, where Teklye (1991) observed higher prevalence rate of infection during rainy seasons.

The higher EPG of *Strongyloides* recorded during early rain may be due to previous infection carried over from the late dry season. Localised contamination of watering and feeding troughs may predispose the animals to infection by such parasites as *Strongyloides* species which actively penetrate the skin of the host to initiate an infection (Nwosu *et al.* (2007).

However, the recovery of O*esophagostomum* spp was higher in early dry and late dry seasons in goats. This finding is in contrast with that of Sissay (2007) who reported *Oesophagostomum* spp throughout the year. The discrepancy in recovery of

Oesophagostomum spp may be due to accumulation of larva stage of *Oesophagostomum* in GIT from the previous rainy season.

Also *Moniezia* and *Strongyloides* were recorded higher during early dry and early rainy season respectively. The findings on *Moniezia* agrees with some other report which recorded higher prevalence rate of *Moniezia* during early dry season (Pav-lasek *et al*., 1990; Sievers *et al*., 2002). While other reports reported different peaks (Kaur *et al*., 1995; Tilahun, 1996). This inconsistency may indicate variable determinants for *Moniezia* spp in the different study seen.

Total worm counts in the present study showed the overall prevalence rate of 80.7% in the small ruminants examined with 85% and 78.5% for sheep and goats respectively. This high prevalence rate was in accordance with the findings of Molalegne *et al*. (2011) in Ethiopia and that of Ajanusi and Chiezey (2005) in Nigeria. But, the prevalence was however higher than the findings of Nwosu *et al.* (2007) conducted in North-eastern Nigeria. At necropsy, *Haemonchus* spp, *Trichostrongylus* spp, *Oesophagostomum* spp, *Trichuris* spp and *Moniezia* spp were recoverd. These have been reported previously from small ruminants in some parts of Nigeria (Chiejina, 1986; Nwosu *et al.,* 1996b). This indicates wide distribution of the helminths in Nigeria and Africa.

The relative proportion of each of the five genera recovered in this study is similar to the reports of Fakae (1990b), and suggests that *Haemonchus* is the predominant helminth of small ruminants in the country. It has been suggested that *Haemonchus* can acquire resistance to environmental factors faster than other gastrointestinal nematodes, like *Trichostrongylus*, because of its high biotic potential (Torres-Acosta

et al., 2003). This probably accounted for its high prevalence and total worm burden in this study.

The helminth egg types recovered in this study were strongyle, *Moniezia*, *Strongyloides and Trichuris*. The result showed that Strongyle egg type was the most prevalent with prevalence rate of 71% and 62% in sheep and goat respectively. This result agrees with previous report from other geographical regions in Nigeria (Chiejina, 1986; Nwosu *et al.*, 1996a, b) and in Ethiopia (Tesfaheywet, 2012).

The prevalence of *Moniezia*, *Strongyloides* and *Trichuris* egg types in goats were 15, 8.2 and 6% respectively. The corresponding values in sheep were 15, 8 and 4% respectively. This result also concurs with that of Tesfaheywet (2012).

The study further revealed that sex of the animal did not show significant influence on the prevalence of the parasites and degree of EPG except for strongyle egg types. The absence of association between sexes is consistent with previous reports (Keyyu *et al.*, 2003; Regassa *et al.*, 2006; Ghanem *et al.*, 2009). The higher faecal egg counts (FEC) of Strongyle egg types recorded in females compared to males concurs with the result of Barger (1993) and Garcia *et al*. (2007). The temporary loss of acquired immunity against gastrointestinal nematodes near the period of parturition and during lactation in ewes have been fingered to be responsible (Barger, 1993).

The proportion of inhibited larvae increased during the dry season and decreased as the early rains approached. Our findings are similar to other epidemiological studies (Eysker and Kooyman (1993); Chienjina *et al*. (1988) in Nigeria; Allonby and

Urquhart (1975); Gatongi *et al*. (1998) in Kenya; Pandey *et al*. (1994) in Zimbabwe; Vercruysse (1985) in Senegal; and Menkir *et al*. (2007) in Ethiopia) on nematode parasites of small ruminants in semi-arid regions of the African continent, where inhibition of *H. contortus* is a feature during this period of the year. This result illustrates the remarkable adaptability and biological plasticity of *H. contortus* which when compared with other major nematode parasites of small ruminants, is not known for hardness of the free-living stages on pasture (Donald, 1968; Donald and Waller, 1973). In the temperate regions of the world, seasonal inhibition of larval development is a feature of a number of nematode parasites species (e.g *Teladorsagia/Ostertagia* spp., *H. contortus* and to some extent with *Nematodirus* spp.), with the onset of cold weather conditions of autumn/winter (Eysker, 1997).

The higher number of inhibited larvae recorded in this study during the late dry season without recording any inhibited larvae during the early rain season contradict the report of Ogunsusi and Eysker (1979) who reported inhibited larvae throughout the rainy season in the same Zaria, Northern Nigeria. The reasons for this might be due to factors such as the use of tracer animals and immunological response of the animals.

There was an increase in the number of inhibited larvae in this study during the late rainy season (September and October). This agreed with the results of Ogunsusi and Eysker (1979) who reported greatest numbers of inhibited larvae of *H. contortus* during the long rainy seasons in the same Zaria Nigeria. Tembely *et al*. (1997) also reported increase in the number of inhibited larvae during the long rainy season in cool tropical environment. The increase in the number of inhibited larvae in this study may be due to the host immune responses which inhibit the normal development of the

parasitic phase of the life cycle and an overcrowding effect whereby the presence of adult worms cause the "feedback" inhibition of incoming infective larvae which go into arrest until the adult worm population decreases in number or is eliminated (Michel, 1976; Armour, 1980; Armour, 1982; Gibbs, 1986).

This study demonstrated a significantly ($p < 0.0001$) positive correlation between EPG and worm burden but a significantly ($p < 0.0001$) negative correlation between worm burden and PCV and as well as EPG and PCV. This means that as EPG and worm burdens increased, the PCV decreased and vice versa. This result agreed with the result of Ajanusi and Chiezey, (2005); Menkir *et al. (*2007) and Okaiyeto *et al*. (2008). The negative correlation of adult worms and PCV is likely due to the blood sucking effects of the adult *H. contortus* worms in which each worm can sucks 0.05 ml daily (Martin and Ross 1934 and Urquhart *et al.*, 2000). Similar results have been reported in other countries where *H. contortus* is the major problem of sheep and goats production (Miller *et al.,* 1998; Vatta *et al*., 2001; Kaptan *et al*., 2004). Infection with *Haemonchus* spp may cause severe anaemia and hypoproteinemia, leading to depression, loss of condition, reduced productivity and eventually death (Al-Shaibani *et al.,* 2009). The disease tends to be more severe in the young kids and lambs and particularly in lactating females where their immune status is compromised (Menkir *et al*., 2007).

The results of bile examination in sheep and goats showed the presence of *Fasciola* spp and *Dicrocoelium* spp. The prevalence rate of *Fasciola* spp in goats in this study agreed with the result of Osakwe and Anyigor (2007), but lower than the result of Olupinyo and Ajanusi (2005) in Zaria. The prevalence of *Fasciola* spp and

Dicrocoelium spp in goats is higher than that of sheep. This finding contradicts the reports of Olupinyo and Ajanusi (2005) in Zaria. The reasons for these discrepancies are not known but may be related to areas where the animals were raised.

The prevalence of *Fasciola* spp in small ruminants was comparatively higher than the prevalence of *Dicrocoelium* spp infection which is in accordance with the result of Olupinyo and Ajanusi (2005) in Zaria. This can be attributed to the higher abundance of the intermediate hosts for *Fasciola* spp in the environment, unlike the *Dicrocoelium* spp which utilizes both the land snail and ants.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

This study established the overall prevalence rate of helminth infection through necropsy and faecal examinations to be 80.7% and 77.3% respectively in small ruminants. The helminth genera recovered at necropsy were *Haemonchus* spp, *Trichostrongylus* spp, *Oesophagostomum*, *Moniezia* and *Trichuris* spp. in sheep and goats. Of these helminths, *Haemonchus* was recorded higher in both prevalence (85%)

and intensity (145.6±48.99) worm burden than other genera encountered during the study.

High levels of prevalence, intensity and abundance of *Haemonchus* was generally observed during late rainy season. This confirmed that the weather conditions of the wet seasons were generally favourable for the development, survival and transmission of the free-living stages of *Haemonchus* spp.

Inhibited Larvae of *Haemonchus* spp were recovered during early dry, late dry and late rain with overall contribution of 1.1% to total worm burden of *Haemonchus* spp. This showed the remarkable adaptability and biological plascity of *Haemonchus* spp when compared to other nematodes.

Faecal examination revealed the presence of strongyle, *Moniezia, Strongyloides* and *Trichuris* egg types with prevalence rates of 62, 15, 8.2 and 6% respectively in goats and 71, 15, 8 and 4% respectively in sheep. Only Strongyle egg types in both species of small ruminants showed seasonal variation which was higher during the late rainy season. The study demonstrated a significantly ($p<0.0001$) positive correlation between worm burden and EPG; but a significantly ($p<0.0001$) negative correlation between worm burden and PCV; as well as EPG and PCV.

This study has therefore confirmed that helminthosis, especially haemonchosis is a threat to small ruminants in the study area. Based on the observation that season was the most important factor affecting prevalence, this study has highlighted the urgent need for the development of epidemiologically-based control strategies for control of helminth parasites of small ruminants in this area.

6.2 Recommendations

Based on the above conclusion, I recommend the following:

- Strategic deworming of animals, when conditions are most favourable for larval development on the pasture, using broad spectrum anthelmintics since polyparasitism is a common problem.
- Education and awareness creation for farmers with regards to the epidemiology of parasitic diseases. They should be taught the best parasite control strategy and management practises through extension.
- Provision of animal health extension services, which includes regular monitoring of faecal egg output of selected animals, assessment of anaemia using the FAMACHA chart, and treatment of animals based on the outcome of these analyses.

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APPENDICES

Appendix 2.1: A simple key for identifying common gastro intestinal parasites of sheep and goats (http://www.fao.org/Wairdocs/ILRI/x5492E/x5492e06.htm)

Organ location	Head region	Characteristics of Parasite		
		Anterior end	Mature size	Genus
Abomasum	No cephalic	Cervical papilla	Large	*Haemonchus*

	swelling	present	Medium	*Ostertagia*
		Prominent excretory pore	Small	*Trichostrongylus*
		Very long oesophagus	Medium	*Strongyloides*. Also present in small intestine
Small intestines	Cephalic swelling with striations		Small, coiled	*Cooperia*
			Medium, tangled	*Nematodirus*
	Distinct buccal cavity with teeth	Head bent dorsally	Large, stout	*Bunostomum*
	Tapeworms Long, flat, segmented	Scolex with suckers	Large, 2 genital pores/seg.	*Moniezia*
			Small, indistinct segments	*Avitellina*
Caecum and large intestines	Small, indistinct	Very long thin neck	Large, whip-like	*Trichuris*
	Leaf crowns present	Cervical papillae level with oesophagus	Large, stout	*Oesophagostomum columbianum*
		Cervical papillae behind oesophagus	Large, stout	*Oes. venulosum*

Appendix 3.1: Goats and sheep tethered in Dogarawa slaughter slab in Zaria, Nigeria.

Appendix 4.1: Monthly mean maximum and minimum temperature, humidity and rainfall in the study area during 2011- 2012.

Month	Minimum Temperature (^{o}C)	Maximum Temperature (^{o}C)	Temperature mean(^{o}C)	Mean Relative Humidity (%)	Total rainfall(mm)
November	15.7	32.2	24.1	34.9	0.0
December	13.8	29.3	21.6	31.8	0.0
January	14.0	30.1	22.1	27.6	0.0
February	19.6	34.4	27.0	21.7	0.0
March	20.1	34.8	27.5	18.0	0.0
April	23.7	37.1	30.4	51.1	16.7
May	21.8	32.7	27.3	69.5	270
June	20.9	30.6	25.8	76.1	143.7
July	28.9	28.9	24.8	82.8	282
August	20.2	28.0	24.1	83.8	396.1
September	20.4	29.4	24.9	80.1	224.1
October	20.9	32.2	26.6	71.0	84.7

Appendix 4.2: Mean worm counts of adult helminths recovered from goats and sheep slaughtered at the Dogarawa slaughter slab in Zaria, Nigeria.

Helminths spp	**Mean worm count**	**Mean worm count**
	Mean±SEM(range)	Mean±SEM(range)
	Goats (n=200)	**Sheep (n=100**)
Haemonchus spp	60.83±5.88[a] (1-420)	145.6±48.99[b] (1-4100)
Trichostrongylus spp	29.56±8.96 (1-300)	16.61±3.68 (1-85)
Oesophagostomum spp	16.41±7.29 (1-176)	22.38±8.14 (2-110)
Trichuris spp	9.42±2.03 (1-112)	9.59±1.78(1- 35)
Moniezia sp	8.02±3.28 (1- 33)	13.54±3.28(2-80)

Means with different superscripts within the same row are statistically significant

Appendix 4.3: Mean counts of adult helminths recovered from small ruminants by sex and age slaughtered in Dogarawa slaughter Slab in Zaria, Nigeria.

Helminths spp	Mean worm counts	Mean worm counts
	Mean±SEM (range)	Mean±SEM(range)
By sex	**Male (n=225)**	**Female (n=75)**
Haemonchus spp	63.14±6.47[a] (1-500)	166.4±63.19[b] (1- 4100)
Trichostrongylus spp	19.46±5.50 1-300)	20.62±6.13 (1-115)
Oesophagostomum spp	21.68±10.18 1-276)	18.60±10.39(1-108)
Trichuris spp	8.88±1.96(1-112)	9.90±2.00 (1-29)
Moniezia spp	10.02±1.90 (1-80)	11.47±2.0 (2-30)
By age	**Young(n=140) (>2years)**	**Adults (n=160) (< 2 years)**
Haemonchus spp	79.13±9.16 1-500)	102.6±32.16 (1-4100)
Trichostrongylus spp	26.45±7.41 (1-177)	26.83±7.90 (1-300)
Oesophagostomum spp	11.62±5.05 (1- 108)	30.68±14.82 (1-276)
Trichuris spp	11.80±3.55 (1-112)	5.92±1.01 (1-49)
Moniezia sp	10.13±2.82 (1-80)	10.06±1.43 (1-30)

Mean with different superscripts within the same row are statistical significant.

Appendix 4.4: Mean egg counts per gram of faeces of small ruminants by species, sex and age in Dogarawa slaughter slab in Zaria, Nigeria.

Helminth eggs	**EPG**	**EPG**
	Mean±SEM (range)	Mean±SEM (range)
Species	Goats(200)	Sheep(100)
Strongyle	1301±189.9[a](20-12080)	2966±435.7[b](20-13320)
Strongyloides	2630±138.8(20-5000)	4208±343.1(20-28000)
Trichuris	138.8±30.39(60-360)	90.00±23.80(60-160)
Moniezia	124.7±442.8(20-10000)	718.0±244.3(40-2800)
Sex	Male(225)	Female(75)
Strongyle	1537±224.6[a](40-12080)	2771±428.3[b](60-11400)
Strongyloides	2468±1329(20-28000)	444.0±121.1(20-720)
Trichuris	131.1±24.99(60-360)	60.00±00(60)
Moniezia	1106±374.9(20-10000)	867.8±360.5(80-2800)
Age	Young(140)	Adult(160)
Strongyle	1797±300.9(20-13320)	1898±270.3(40-11400)
Strongyloides	958.2±475.8(20-4200)	3012±2121(40-28000)
Trichuris	190.0±46.98(60-500)	53.20±12.42(60-80)
Moniezia	1456±558.3(20-10000)	981.4±391.9(20-8000)

Mean with different superscripts within the same row are statistical significant

Appendix 4.5: Seasonal variation of the mean worm counts of adult worms recovered from goats slaughtered in Dogarawa slaughter slab in Zaria, Nigeria.

Adult helminths	**Season**			
Genera	Early dry (ED)	Late dry (LD)	Early rain (ER)	Late rain (LR)
Haemonchus spp	45.53± 8.54[a]	36.71± 7.73[a]	51.00±8.68[a]	103.3 ± 15.69[b]
Trichostrongylus spp	24.00± 16.00[a]	12.00 ± 3.31[a]	18.86 ±5.37[a]	76.00 ± 35.69[b]
Oesophagostomum spp	25.27± 15.22	16.11 ± 11.60	3.50 ± 1.50	2.60 ± 0.60
Trichuris spp	9.08 ± 4.33	14.21 ± 4.86	6.79 ± 2.12	3.57 ± 0.84
Moniezia spp	6.75 ± 2.68	3.33 ± 0.88	5.56 ± 2.00	10.83 ± 2.39

Superscripts with different alphabet in the same rows are statistically significant

Appendix 4.6: Seasonal variation of the mean worm counts of adult worms recovered from sheep slaughtered in Dogarawa slaughter slab in Zaria, Nigeria.

Adult Helminths Genera	**Season**			
	Early dry (ED)	Late dry (LD)	Early rain (ER)	Late rain (LR)
Haemonchus spp	33.62± 10.45[a]	22.47 ± 6.61[a]	86.65± 33.36a	265.3±105.9[b]
Trichostrongylus spp	9.00± 8.00	14.33 ± 4.96	8.67 ± 4.36	22.57 ± 7.05
Oesophagostomum spp	6.00± 4.00	20.50 ± 8.73	9.00 ± 0.0	31.33 ± 16.5
Trichuris spp	9.00 ± 3.49	14.29± 4.85	10.50 ± 3.85	6.00 ± 1.96
Moniezia spp	22.71 ± 9.83	8.00 ± 2.00	6.00± 2.08	11.00 ± 2.67

Superscripts with different alphabet in the same rows are statistically significant

Appendix 4.7: Seasonal variation of egg counts per gram of faeces recovered from goats in Dogarawa slaughter slab in Zaria, Nigeria.

	Season			
Egg type	**ED**	**LD**	**ER**	**LR**
Strongyles	660.8 ± 160.2[a]	197.6 ± 4.86[a]	650.3±152.2[a]	2944±470.0[b]
Moniezia	1991.0± 1065	433.3 ± 40.55	565.0 ± 318.3	995.0 ± 507.3
Strongyloides	293.3 ± 104.8	300.0 ± 0.0	1828 ± 946.6	851.7 ± 446.5
Trichuris	230.0 ± 130.0	137.2 ± 51.15	93.20 ± 31.78	0.0± 0.0

Superscripts with different alphabet in the same rows are statistically significant

Keys:

ED – Early Dry (November, December and January).

LD – Late Dry (February, March and April).

ER – Early Rain (May, June and July).

LR – Late Rain (August, September and October).

Appendix 4.8: Seasonal variation of egg counts per gram of faeces recovered from Sheep in Dogarawa slaughter slab in Zaria, Nigeria.

	Season			
Egg type	**ED**	**LD**	**ER**	**LR**
Strongyles	404.4 ± 116.6[a]	215.4 ± 47.62[a]	669.3 ± 161.1[a]	5709 ± 629.3[b]
Moniezia	442.0 ± 163.4	700.0 ±0.0	0.0± 0.0	745.0± 427.2
Strongyloides	0.0± 0.0	0.0 ± 0.0	520.0 ± 0.0	4734 ± 391.5
Trichuris	60.0 ± 0.0	120.0 ± 40.0	0.0 ± 0.0	60.0 ± 0.0

Superscripts with different alphabet in the same rows are statistically significant

Keys:

ED – Early Dry (November, December and January).

LD – Late Dry (February, March and April).

ER – Early Rain (May, June and July).

LR – Late Rain (August, September and October).