Gastrointestinal parasites of Angora goats in Lesotho: prevalence and control methods

By

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Thesis

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Gastrointestinal parasites of Angora goats in Lesotho: prevalence and control methods

Summary

This research project composed of two approaches: the first approach involved a survey in which focus group discussion and individual interviews were conducted in lowlands, foothills and mountains. This part was aimed at assessing control measures for gastrointestinal parasites. Goat owners consisted of male (78.40%) and female (21.60%) farmers in all the agro-ecological zones of Lesotho with the average age of 45.11±12.53 in lowlands, 46.98±14.85 in foothills and 43.81±13.32 in the mountains. Majority of farmers in lowlands (66.70%), foothills (57.30%) and mountains (40.70%) had primary education and most of them have experience of more than 20 years in goat farming. Goat owners were aware of intestinal parasites but none of them was aware of coccidia. Goats were believed to get infection from rangelands. Gastrointestinal parasites (GIPs) were known to cause enormous effects and young goats were the most susceptible age group that mostly die of GIPs - 63.00%, 74.10% and 85.2% of farmers in the lowlands, foothills and mountains respectively. Higher rates of infections were noticed in summer months and farmers used several anthelmintics and traditional medicines to control GIPs when animals exhibited clinical signs. Majority of farmers (59.30% in lowlands, 44.50% in foothills and 66.70% in the mountains) kept their flocks in open kraals which were not regularly cleaned. Rangelands were communally used and the grazing management practices were used.

The second approach focused on the effect of agro-ecological zones, age, sex and infection trends over a six month period on the prevalence and faecal egg/oocyst loads of gastrointestinal parasites. The lowlands and foothills of Maseru and Quthing districts were observed to have got higher prevalence and egg loads of nematode while coccidia were more prevalent with higher oocyst loads in the mountains. Young goats and adults had similar prevalence and egg loads of nematode infection ($p>0.05$) but juveniles had significantly higher coccidia prevalence and oocyst loads. Males and females had similar prevalence and egg/oocyst loads of both nematode and coccidia ($p>0.05$). Nematodes were more prevalent in July and September in Maseru and Quthing districts respectively but coccidia were more prevalent in July in both districts. The faecal egg count (FEC) for nematodes was high in October and December in Maseru and Quthing districts respectively with while in July high coccidia oocysts were found

Declaration

I, **Morai Johannes Moiloa** hereby declare that the work on which this thesis is based is my original work and that neither the whole work nor any part of it has previously been submitted for another degree at this or any other University. Information from other sources has been cited and acknowledged by means of references. I therefore authorize the National University of Lesotho to supply copies of this dissertation to libraries and individuals upon request.

Signature: é é é é é é é é é é é é é ..**Date:** ....é é é é é é é é é é é é é

Dedication

The dissertation is dedicated to my grandmother, my mother, my sisters, my wife; óMamolete Evodia Moiloa and my son; Molete Moiloa for their life time support and unconditional love. I hope I have made all of you proud.

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This study was made possible through the help and patience of numerous people. I would like to thank all those who made all the contributions towards the completion of this study. The Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) is acknowledged for funding this study through Grant number: RU 2015 GRG-109. The government officers from the Department of Field Services in the Ministry of Agriculture and Food Security, Lesotho Wool and Mohair Growers Association are also acknowledged for assisting in starting up this study. Special thanks are owed to the farmers who gave me information about their goats and allowed me to use their animals for this study.

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On personal note, I wish to express my gratitude and appreciation to my family especially my wife for her understanding and moral support during this study, and for being satisfied with less time and attention than deserved and taking care of our son.

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GIP	Gastrointestinal parasite
FEC	Faecal egg count
EPG	Egg per gram
FOC	Faecal oocyst count
OPG	Oocyst per gram

CHAPTER 1

1.0 INTRODUCTION

1.1 Background

Lesotho is a temperate region found in the southern part of Africa particularly within the Republic of South Africa. It is a Kingdom, roughly with land surface area of 30,055 km^2 (3 million hectares), of which about 60% are rangelands (MFLR, 2014) and constitutes four agro-ecological zones namely lowlands, foothills, senqu river valley and the mountains. This kingdom is characterised by varying temperatures which can go as cold as -12^{0}C to as warm as +35^{0}C with the average rainfall of 753mm of which 80% falls in the warmer months (Mafisa, 1993).

Within the Lesotho agro-ecological zones are sparsely populated areas with villages in areas used to be exclusively range and arable lands. It is in these areas where resource poor goat farmers are located among other livestock owners with unequal distribution of livestock species. The majority of goats are owned by smallholder farmers in mixed crop-livestock system under the land tenure system where land is vested in the Basotho nation but held in trust by the state (Mahashe *et al*., 2016). The administration of land is responsibly charged over the local authorities (Councils) on behalf of the state. Angora goats (Figure 1) have been a part of Lesothoøs human and physical landscape since 1900 years. The population of goats reached one million in 1986 and became economically important to the extent that it is depicted on the national currency (Wilson, 1991).


Figure 1: Angora goats of Lesotho

Small stock rearing is a traditional profession of Basotho farmers which plays an integral part in the day- to- day living of economically deprived regions and remote areas. According to Nwosu *et al*. (2007), goat ownership in some instances may be the only attainable wealth of a rural household attached to socio-economic importance. In Lesotho, goats are the white mining of Basotho farmers through provision of cash either from the sale of mohair or the animal themselves. Goats provide meat, manure, serve as social security and are often used for cultural ceremonies (Hunter, 1987). Lesotho exports mohair and is the second worldôs largest producer after South Africa as it produces 14% of the mohair produced globally (Mokhethi *et al*., 2015) and mohair sales during the 2012/2013 season reached R29 million (USD 2.9 million).

Goats are reared extensively around homestead grazing pastures for part of the year and spend the other part in cattle-posts (Annor-Frempong, 2008). Apparently this is because of seasonal changes (onset of winter), management practices (shearing, dipping) or minimizing the risk of theft. This indicates that most stock has inadequate rations (in terms of poor nutritive value of forage) during long periods of the year, since farmers also lack tradition of fodder husbandry or conserving fodder as silage or hay (Annor-Frempong, 2008) and because most stock spends more time around homestead pastures, thereby, depending entirely on natural pastures for their nutritional requirements and production needs. However, there are exceptional farmers (smaller herd size) who do not go to cattle-posts.

According to Mafisa (1993) and Annor-Frempong (2008), goatsô flock numbers gradually fell because of herd being affected by diseases, overgrazing, productivity losses primarily linked to high mortality rates, limited investment in livestock improvement caused by increasing rates of livestock theft and consequent high risks to investment. Moreover, Angora goat production is also constrained by diseases and parasitic diseases which together conversely affect mohair production per goat as the report from the Department of Livestock Services of the Ministry of Agriculture indicated a decline from 0.93 to 0.84kg of mohair per goat from 2009/2010 to 2014/2015.

According to the Bureau of Statistics (2013/2014), 15 075 goats out of 824 698 (goat population) died of diseases and cold; diarrhoea accounted for 5 999 while internal parasites resulted with 1 844 deaths. Parasitism has grown to become one of the great health issue and a serious threat to the livestock economy globally (Vercruysse and Claerebout, 2001). Gastrointestinal parasites (GIPs) include nematodes, trematodes, cestodes and protozoan coccidia (Bagley, 1997). Parasites are one of the major causes of economic and nutritional hardship in poor goat farming communities. Affected goats exhibit rough dull-coat, weakness, diarrhoea, tail rubbing, bottle jaw, loss of appetite, weight loss (Risso *et al*., 2015), high morbidity and mortality among kids (Negasi *et al*., 2012), enhance susceptibility to other diseases, low milk production, stunted growth and low fertility (Hale, 2006).

At the onset of GIP infections, host and environmental risk factors play a crucial role. Environmental factors include agro-ecological conditions, weather conditions and animal husbandry practices (Ratanapob *et al*., 2012) and all these largely determine the type, incidence and severity of various parasitic diseases (Badran *et al*., 2012). Host factors such as sex, age, body condition and physiological status (Badaso and Addis, 2015) and parasitic factors like species and intensity of worm population have an effect on the development of gastrointestinal parasitic infections (Tarig *et al*., 2010). According to Nwosu *et al*. (2007), the predisposing factors that aggravate animal infection by parasites may include localized contamination of watering areas, warm temperatures, poor management practice and inadequate health control measures (Akhtar *et al*., 2000).

Gastrointestinal nematode infections (GIN) are the main prevalent parasitic diseases affecting small ruminant productivity (Torres-Acosta and Hoste, 2008; Calvete *et al*., 2014) and some of the most common nematodes globally known to affect small ruminants include *Haemonchus spp*, *Trichostrongylus spp* and *Nematodirus* spp (Bishop and Morris, 2007). In addition to gastrointestinal nematodes, coccidiosis (especially *Eimeria* spp) has also been known to infect livestock with moderate to high pathogenic effects (Radfar *et al*., 2011). According to Andrew *et al*. (2010), animals can be treated for parasitic infections using anthelmintics and they can be introduced to a new pasture. Weaners can be grazed in newly seeded pastures or hay fields. Furthermore, resting of heavily infected pasture by ploughing, reseeding, haying or grazing with another species (cattle) can reduce parasite loads and level of pasture contamination.

Exposure of animals to low levels of parasites helps them maintain their immunity although in adult goats immunity does not develop strongly after being weaned. They therefore, remain a serious source of pasture contamination and are thus at risk of developing anthelmintic resistance more quickly than sheep. They also rapidly metabolize anthelmintics more than sheep do, hence they require higher doses of anthelmintics (Andrew *et al*., 2010). Condensed tannin (CT) plants (Birdôs Foot trefoil (*Lotus corniculatus*) and Sulla (*Hedysarum coronarium*) seeded in pastures variably reduce shedding of eggs by the animals (Andrew *et al*., 2010). The spores of nematophagus fungus (*Duddingtonia flagrans*) which grows naturally in faeces and produce hyphae that trap and kill free living forms of nematodes in the faecal pellets, if fed to animals daily in sufficient quantity can reach the faeces and become effective in disrupting the build-up of third stage larva (L_3) long enough to delay disease occurrence in that grazing season (Soder and Holden, 2005).

There is, however, lack of comprehensive and systematic surveillance of prevalence of gastrointestinal parasites and assessment of associated risk factors in Lesotho owing to the fact that farmers treat their animals based on history and traditional knowledge. Without comprehensive, systematic surveillance and risk factors assessment baseline information, it is difficult to make inferences and successful formulation and implementation of an efficient national strategic parasite control system. The objective of the current study is therefore to determine the prevalence of gastrointestinal parasites in goats and control measures that can be adopted.

1.2 Problem statement

Angora goat farmers are facing high kid mortality which is associated with GIPs despite dosing of the animals and this problem is threatening the sustainability of the goat industry. Gastrointestinal parasites are also linked to diarrhoea particularly in kids and is thought to be aggravated by low levels of education of farmers which is a crucial factor for farmers to decide when to dose and with how much dose per animal. Gastrointestinal parasites are also a problem affecting all ages of goats and is thought to have been exacerbated by the system of communal grazing, low levels of income per household to access anthelmintics and emergence of drug resistance. Lastly, the lack of strong ground research in parasitological investigations across Lesotho and the lack of documentation on the little that has been made make it difficult for farmers and stakeholders to develop a national strategic control programme for gastrointestinal parasites.

1.3 STUDY OBJECTIVES

1.3.1 General objective

The general objective of this study is to determine the prevalence, faecal egg load and control of gastrointestinal parasites of Angora goats.

1.3.2 Specific objectives

- To assess the goat farmers demographic characteristics in relation to gastrointestinal parasites control.
- To assess goat farmers awareness on the prevalence of gastrointestinal parasites.
- To assess control measures of gastrointestinal parasites.
- To assess farmers animal management practices in relation to gastrointestinal parasites.
- To investigate the effect of agro-ecological zone on the prevalence and faecal egg loads of gastrointestinal parasites of Angora goats.

- To investigate the effect of age on the prevalence and faecal egg loads of gastrointestinal parasites of Angora goats.
- To investigate the effect of sex on the prevalence and faecal egg loads of gastrointestinal parasites of Angora goats.
- To assess the trend of gastrointestinal parasites infections on Angora goats over a period of six months.

1.4 Justification

Gastrointestinal parasites cause devastating health problems in animals for both levels of farmers (small and large) across the country because of high mortality of younger animals which inevitably threatens success, growth, productivity and the sustainability of the goat farming. Therefore, considering the economic importance of the goats in Lesotho, the current study was designed to establish and form baseline information for farmers, livestock attendants, extension officers, and other related stakeholders on the prevalence and control of gastrointestinal parasites. The findings of this study will also inform farmers and other relevant stakeholders on the proper management of goats and grazing tactics as the tools for controlling GIP.

1.5 The study hypotheses

- Farmersô demographic characteristics will result in similar gastrointestinal parasites control.
- Goat farmersô awareness on the prevalence of gastrointestinal parasites is similar across the agro-ecological zones.

- Farmers control measures against gastrointestinal parasites are similar across the agro-ecological zones.
- Animal management practices on the gastrointestinal parasites are similar across the agro-ecological zones.
- Agro-ecological zones will result in similar prevalence and faecal egg load of gastrointestinal parasites.
- Age of the goats will result in similar prevalence and faecal egg load of gastrointestinal parasites.
- Sex of the goat will result in similar prevalence and faecal egg load of gastrointestinal parasites.
- Month of the year will result in a similar trend of gastrointestinal parasites infection throughout the study.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 Introduction

In many developing countries, livestock production is characterized by fast change, influenced by rapid human population growth and increased demand for livestock products (Thornton, 2010). However, small ruminants production is constrained by infections and parasitic diseases coupled with inadequate management to perform up to their capacity (Owhoeli *et al*., 2014). Gastrointestinal parasitism has unique importance in small ruminants and is the most serious parasitological constraint of goat production worldwide contributed by single or mixed infections (Sharma *et al*., 2009).

Infection is via ingestion by the host and live either at the mucosal surface of the gastrointestinal tract or cross the mucosal barrier on their way to their predilection site (Mucahy *et al*., 2004). Most helminths prefer moist or humid areas with an optimum temperature for development and survival of eggs and larvae although different parasites vary in their ability to survive in extremes of temperature and humidity (Ashad *et al*., 2013). A climate that is too hot or dry can kill most larvae on the pasture. However, knowledge of the seasonal population trends, life cycle and the prevalence of larvae in small ruminants are key notes and elucidate for developing control programs (Menkir *et al*., 2006).

According to Stehman and Smith (2004), coccidia on one hand are host specific and kids are most susceptible usually at weaning but coccidiosis can be realized as early as two weeks of age and if kids survive clinical disease, compensatory weight gain occurs but survivors can be unthrifty and require additional time to match weights of uninfected animals of the same age. Adult goats are usually resistant to clinical disease (diarrhoea, dehydration, loss of weight) and normally shed low numbers of oocysts unless they are exposed to a new species, an overwhelming dose and stress agents such as weather or feed changes, lactation, or concurrent diseases. Clinical diseases are usually seen in 3 - 5 months old kids and starts two weeks after ingestion (Stehman and Smith, 2004). According to Harwood (2006), coccidiosis is the leader in the mortality of small ruminants under four months of age and coccidia are characterized by short life cycle which give them great opportunity of infectiveness to build-up in the environment and kid- rearing areas (Andrew *et al*., 2010).

Gastrointestinal cestodes (tapeworms) occurrence on the other hand depends on the availability of the intermediate host (herbage mite) which largely depends on higher humidity, temperature and soil type for development (Hansen and Perry 1994). The duration of the rainy season may affect the dynamics of the intermediate hosts (oribatid mites) and the prevalence of tapeworm, however, the mites, which are soil-inhabiting, feed on manure during the night and early morning hence higher chances of picking flatworm eggs (Hansen and Perry 1994). Tapeworms of goats belong to *Moniezia* spp and are generally believed not to cause significant disease in small stock. Nevertheless, a severe infection can be associated with diarrhoea, unthriftiness, and occasionally the volume of parasites in the gut is associated with intestinal blockage and may be a risk factor for the bacterium (*Clostridium perfringens* type D) infection (pulpy kidney, also called enterotoxaemia) (Andrew *et al*., 2010).

Presumably for snail- borne fluke, water logging areas in and around the pasture lands enhance the availability of intermediate hosts required for trematode (liver flukes) occurrence and the snail activity and abundance is actively influenced by temperature (>9.5^0C), rainfall and soil moisture (Relf *et al*., 2011) for the parasite to develop from egg to miracidium. Trematodes are recognized as the major important helminthic parasites of ruminants found in many parts of the world (Kantzoura *et al*., 2011) because of clinical diseases they cause (mortality, liver condemnation, reduced production of meat, milk, mohair and expenditures on anthelmintics) (Kleiman *et al*., 2007) which contribute more importantly to economic losses. Taylor (2012) showed that hatching of fluke eggs and multiplication of the intermediate host require high rainfall and temperatures (>10 °C). These conditions generally result in large number of cercariae development and release on wet pastures before encysting onto herbage (Khanjari *et al*., 2014).

2.2 Parasite life cycle, survival and development

Nematodes

Nematodes (roundworms) have direct life cycle in which eggs are passed out with animal faeces, hatch and develop to the infective stage (L_3) which is picked on the pasture by grazing animals. The development and growth of infective larvae to adult and laying of eggs occur within the host (Sissay, 2007). Survival and the disease caused by adult worms depend on factors such as suitability of the environment and management aspects of the herd, parasite species infecting the host, intensity of infection, host response against parasite, age of the host and host immunological status (Taylor *et al*., 2007; Roeber *et al*., 2013).

Cestodes

Infection by tapeworms requires an intermediate host (free-living forage mite) that ingests eggs shed by goats, then eggs hatch and larvae migrate to mite body cavity where they develop into cysticercoids (infective stage) which when mites are ingested by the host, develop into adults and cause pathogenic effects (Andrew *et al*., 2010). From the point of ingestion to egg production in goat, tapeworm takes approximately 6 to 7 weeks (Schoenian, 2008) and infection is usually worse in summer months however, cysticercoids can survive over-winter in mites (Andrew *et al*., 2010).

Trematodes

Liver flukes adults lay eggs in the bile ducts which are later shed in goat faeces (Susan, 2005). Liver flukes require intermediate host (amphibious snail) which prefer wet, low lying land or pastures. The eggs hatch into miracidium which penetrate the suitable snail within 3 hours of hatching then the miracidium divides and develops into many cercariae which are shed from the snail and attach themselves to grass blades where they encyst as metacercariae (Chowdhury *et al*., 1994; Talukder *et al*., 2010). Upon ingestion by small stock, metacercariae migrate through the intestinal wall to the liver. The young flukes wander through the liver for about 2 months before moving into the bile ducts (predilection site) where they mature to egg laying adults. The disease may be acute, sub-acute or chronic depending on the number of metacercariae ingested and the stage of the disease (Andrew *et al*., 2010).

Coccidia

According to Stehman and Smith (2004), unsporulated oocysts passed out with goat faeces, sporulate 2 - 5 days if conditions are optimal (i.e. oxygen and moisture present, and temperatures between 24°C and 32°C). Oocysts do not survive below -30 or above 40°C. However, oocysts and sporocysts can survive for more than a year in the optimal temperature range if not exposed to sunlight or extreme drying. Sporulated oocysts are ingested by host then the immature stages go through a complex series of replications and changes in the wall of the intestine which amplifies the infection and causes damage to the host intestine (Stehman and Smith, 2004).

2.3 Gastrointestinal parasites faecal eggs

Parasite eggs do not have uniform appearance throughout the faeces of the animals and during egg count there is no specific protocol for determining a particular cut-point of FEC which indicates treatment is necessary. However, the threshold of 500 to 800 eggs is often used by veterinarians in an attempt to develop a control program based on monitoring (Andrew *et al.*, 2010). Moreover, several factors have been considered when deciding what cut-point to use, such factors like pasture rotation which allows dosing and moving animals to other pasture allow animals not to carry parasites into a clean pasture (Coffey and Hale, 2012). Gastrointestinal parasite infections can be quantitatively monitored by the variation in the number of eggs present in fecal samples of livestock over all different seasons of the productive year (Mandal *et al.*, 2010) and the seasonal fluctuations in the number of GIP eggs or larvae are influenced by variations in temperature and moisture on the soil surface (Morgan and Van Dijk, 2012).

Several factors are known to determine the epidemiological patterns of associated parasite disease condition and these factors include host factors such as age, sex, grazing behavior of the host, immunological/ health status of the host and host response against the parasite (Badaso and Addis, 2015). Management/husbandry factors like poor housing systems, grazing systems, unreliable deworming programmes (Ratanapob *et al.*, 2012) also contribute to parasitism, anthelmintic resistance and complexity of eradicating internal parasites. The physiological statuses of animals like parturition, lactation stage and pasture contamination can also influence the prevalence of GIP in different areas (Armour, 1980).

2.4 Prevalence and faecal egg loads of gastrointestinal parasites by agro-ecological zone

The variation in the prevalence of parasites depends upon the differences in the agro-climatic conditions and availability of the susceptible host (Singh *et al*., 2017). Dagnachew *et al*. (2011) found differences in distribution of GIPs between highlands and lowlands agro-ecological zones where the highest prevalence of helminthiasis was in the lowlands for strongyles infection with the lowest in the mountain. Environmental factors such as agro-ecological zones, temperature and rainfall patterns are very important in the hatching of viable eggs and development of parasite (Ratanapob *et al*., 2012) and these factors also influence and incriminate high parasite infective stages (larvae, oocyst and intermediate hosts) and severity of the parasite. The interactions between host factors with parasite factors mainly determine the potential for disease to occur and the pattern/course of infection whereas the interaction between host-environment and parasite-environment influence disease transmission (Roeber *et al*., 2013).

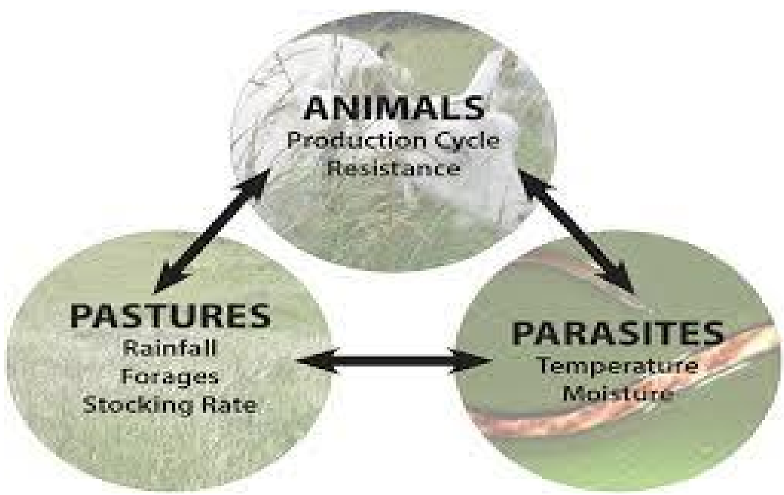

Figure 2: Parasites epidemiological triad

According to Odoi *et al*. (2007), the variations in agro-ecological zones can affect survival and development of infective larval stages of nematodes causing differences in the prevalence and egg loads of gastrointestinal parasites. Moreover, variations in the use of anthelmintics and grazing practices might also contribute to the differences in prevalence of gastrointestinal parasites (Getachew *et al*., 2017). According to Bagley (1997), GIPs are mostly severe in warm, humid climate and the prevalence is therefore related to the agro-climatic conditions like quantity and quality of pasture, physiological status of the animal together with pasture contamination. Kantzoura *et al*. (2012) reported that elevation of farm location was found to be a risk factor for helminths infections in small ruminants and farms located on high elevation had a higher prevalence of helminths infection, apparently, high elevations have favourable climatic conditions for the development of the free-living stages of the GI nematodes.

2.5 Prevalence and faecal egg loads of gastrointestinal parasite by age

Young goats during their first grazing season are susceptible to infection by GIP as normally would have not yet attained full natural immunity and the infective larvae, cysticercoids, metacercariae and infective oocysts on pasture infect naive kids when ingested (Andrew *et al*., 2010). The level of infective stages on pasture and the level of immunity in the young goats determine the level of disease seen in the animal, however, over the grazing season, the loads of GIP in the kids tend to increase and these animals become the major contributors to egg contamination on pasture (Hale, 2006). Adult animals on the other hand tend to have developed some level of immunity but they still get infected and contribute to pasture contamination (Andrew *et al*., 2010). Dams around kidding time usually have relaxed or compromised immunity known as periparturient relaxation of immunity (PPRI) which is associated with nutritional and parturition stresses. The phenomenon of periparturient egg rise has been found to give parasites opportunity to lay more eggs and serves to be the most important source of pasture contamination to new-borns (Andrew *et al*., 2010).

According to Getachew *et al*. (2017), the degree of nematode infection depends mainly upon the age of the host. The grazing animals under similar management have equal chances of exposure to the infective stage of the parasite. Waruiru *et al*. (2005) reported that GIT helminthes equally affect both ages of small ruminants. However, according to Zeryehun (2012), parasitic infection is high in younger animals and may be attributed to a weaker immunological response of young animals to infection while older animals recover from parasitic infection more quickly as the immunity of the host increases with age due to repeated exposure (Tariq *et al*., 2010 and Zeryehun, 2012). Dagnachew *et al*. (2011) on the other hand, documented that nematode infection is higher in adult and old animals than the younger. Furthermore, age has been considered as an influencing factor that has a significant influence on the prevalence of internal nematodes with young animals being more susceptible than adults. Tasawar *et al*. (2010) and Tariq *et al*. (2010) stated that older goats recover more quickly from parasitic infection and this is believed to be because of repeated exposure in adults which are immunized (Dagnachew *et al*., 2011).

Arafa and Fouad (2008) noted that nematode infections are more prevalent in adult animals than in young animals. In the case of coccidia, Stehman and Smith (1995) stated that kids are more susceptible to coccidiosis than adult goats because of immature immunity development while adults are believed to have developed immunity against coccidia. These findings are similar to that of Zvinorova *et al*. (2016) who reported higher egg loads of coccidia infestation in young goats and ascribed it to higher rainfall. Sharma *et al*. (2017) also reported that higher faecal oocyst count (FOC) in young goats than adult goats contributed by age-wise grouping of animals, management like frequency of treatment and body score. Gwaze *et al*. (2009) reported higher egg loads of coccidia infestation in both classes of goats (kids and adults).

On the other hand, Zeryehun (2012) reported that older animals recover from parasitic infection more quickly as the immunity of the host increases with age which could be the reason for lower faecal egg loads in adult goats. Furthermore, the lower FEC in adult goats can be due to the fact that adults have a tendency of expelling the ingested parasites and this is supported by Odoi *et al*. (2007).

2.6 Prevalence and faecal egg loads of gastrointestinal parasites by sex

Male goats are generally known to be more susceptible to gastrointestinal nematode infestation than females when taking sex as a determining factor for GIPs (Zvinorova *et al*., 2016) and this has been attributed to the genetic predisposition and differential susceptibility owing to hormonal control. Contrarily, Dagnachew *et al*. (2011) reported a higher prevalence of helminth infection in females which may be attributed to reproductive physiological stress during pregnancy and parturition which lower their resistance and also due to enhanced grazing during lactation.

However, many studies (Getachew *et al*., 2017; Fikru *et al*., 2006 and Negasi *et al*., 2012) reported sex of the goats as having no significant effect on gastrointestinal parasites prevalence mainly because of equal exposure of both sexes to the same contaminated grazing pasture and being from similar agro-ecological zone. Muluneh *et al*. (2014) also supported the fact that sex has not revealed significant influence on prevalence of gastrointestinal nematodes of goats, which explains the fact that males and females have the same exposure to infection particularly in contaminated communal pastures.

Odoi *et al*. (2007) and Zvinorova *et al*. (2016) found non-significant association between sex and helminthes degree of egg per gram (EPG). Similarly, Sharma *et al*. (2017) found no significant association between sexes with respect to variations in FEC. Zeryehun (2012) also found no significant difference between the degree of EPG and sex which was attributed to the individual host ability to detect or tolerate certain levels of infection without showing susceptibility. Gana *et al*. (2015) on the other hand, found females with higher mean FEC than males.

Furthermore, according to Sharma *et al*. (2017) male animals are generally susceptible to coccidia and also show higher prevalence than female goats. Moreover, the effect of sex on faecal oocyst count (quantum of infection) revealed statistical significance and male animals showed higher faecal oocyst count (FOC) when compared to females (Sharma *et al*., 2017). However, Rehman *et al*. (2011a) reported females with higher coccidia prevalence than males but Sharma *et al*. (2009) found no significant change in FOC between two sexes. On the other hand, according to Kheirandish *et al*. (2014), sex is not a determinant factor in the prevalence of coccidiosis.

2.7 Monthly prevalence and trends of gastrointestinal parasites

According to Khajuria *et al*. (2013) when comparing months for gastrointestinal helminths in small ruminants, the lowest egg per gram (EPG) was recorded during January and the highest during August with two peaks that occurred during August and May. As the temperature increases from March, the over-wintered larvae start moulting and become infective. The hypobiotic larvae in the final host during winter get released and develop faster in the animals with impaired immunity and further add to higher level of infection. Higher parasitic infections during the warm-rainy season than in the dry-cold season might be related to the availability of browse and a longer browsing time in the warm-rainy season by the host whereas sufficient moisture and temperature create favourable conditions allowing larval development, oocyst sporulation and survival of the infective larval stage (Pathak and Pal, 2008; Faizal and Rajapakse, 2001).

The seasonal occurrence of parasitic infection in small ruminants depicts higher infection of helminthes in rainy season which may be attributed to suitable molarity of salt present in soil, an important factor for ecdysis (Varadharajan and Vijayalakshmi, 2009). Low prevalence of GIP in winter season is associated to reduced grazing hours of the animals, which helps in reducing the chances of contact between host and parasites. Katoch *et al*. (2000) showed that climatic factors influence dispersion of larvae in the herbage which increase the chance of contact between host and larvae. Therefore, based on the seasonality of development and survival of L_3 on pasture, the timing of strategic anthelmintic use can be determined and integrated into control programmes and this is strongly dependent upon climate, climatic data from each study site or from local meteorological stations are required (FAO, 2014).

In the study of Kheirandish *et al*. (2014), there were no obvious seasonal patterns revealed in the faecal levels of coccidial oocysts (OPG) in goats, however, they were higher in winter season. Furthermore, Bakunzi *et al*. (2010) observed higher oocyst counts during the months of January to March, peaking in March, because those months are associated with heavy rains and higher temperatures that provide a proper environment for oocyst sporulation. Sharma *et al*. (2017) also reported higher faecal oocyst count in summer (March-June) and rainy season (July-October) which supported the findings of Bakunzi *et al*. (2010).

2.8 Refugia

According to Andrew *et al*. (2010), a higher proportion of the total parasite load on a small stock farm is on the pasture (80%) compared to the parasite load in the animal (20%) and this is important to understand how anthelmintic resistance develops on a farm. Deworming can be done and only resistant worms are left in the animal, but the refugia remain source of susceptible parasites. Moreover, when fewer numbers of animals receive treatment, the refugia population remains large (Hale, 2006). A high level of refugia (an area where special environmental circumstances have enabled a species or a community of species to survive after extinction in the surrounding area) may be a primary factor in small stock developing clinical parasitism and perhaps even dying of its effects (Andrew *et al*., 2010).

Refugia or worms that are not treated may apply to the free-living stages of GIP on pasture (L_1, L_2 and L_3 stages of larvae), worms and their consequent eggs in animals that were not treated, as well as eggs that were on the pasture at the time of deworming and thus not exposed to the dewormer (Hale, 2006).

2.9 Conventional methods of gastrointestinal parasites control

Parasites control traditionally have been based upon anthelmintic treatment, grazing management or both (Costa *et al*., 2006) with regular movement of animals to pastures free of parasiteọs larvae (rested for period of 9-12 months hence creating a relatively parasite-free pastures) (Terrill and Miller, 2005). Van Wyk (2001) indicated that the situation of seeding new pastures with only resistant worms is exacerbated by common practice of deworming animals and immediately moving them to clean pastures as only resistant worms will be left in the animal.

Grazing management schemes in light of Craig (2006), Prichard (1990), Saratsis *et al*. (2011) and Tharmsborg *et al*. (1996) are often impractical because of expenses caused by hardness of infective larvae on pasture, unanticipated factors like farm size, stocking rate and age of the animal while the evolution of anthelmintic resistance in parasite population threatens the success of drug treatment programs. According to FAO (2014), overstocking do not only contribute to pasture degradation and soil erosion but also forces the animal to graze closer to faecal material which inevitably increases the uptake of infective larvae. Therefore, proper stocking rates, improved grazing management and introduction of safe pasture concept can reduce parasite burden and use of anthelmintics thereby minimizing risk of anthelmintic resistance development. Furthermore, ungrazed pastures for prolonged period and those previously grazed by other species (cattle) before introducing small ruminants are parasitologically safe hence young stock can be dewormed at the onset of rains and placed on safe pastures entirely separated from the older animals FAO (2014).

The strategies such as incorporating anthelmintics into medicated salt-molasses blocks and prepared mineral mixes can be used to achieve prolonged protection of grazing livestock but to maximize effectiveness of treatments, increasing anthelmintic efficacy, while reducing rate of anthelmintic resistance development host physiology and parasiteœs biology are useful during development of such strategies (FAO, 2014). Moreover, increasing the duration of contact time between the parasite and the drug by restricting feed intake for 24 hours prior to treatment to reduce the rate of digesta flow down the gastrointestinal tract or by administering two doses within a short time frame can increase anthelmintic efficacy (Hennessy, 1994). Non-chemical method like copper oxide wire particles (COWP) effectively reduces *H. contortus* infection and 82% reduction in FEC in goats given four grams of COWP boluses in a grazing trail was reported by Kallu *et al*. (2005) and Chartier *et al*. (2000).

Heath and Harris (1991) showed that preventive strategies for controlling internal parasites can either be by strategic or suppressive deworming. Continual administration of anthelmintics exposes the GIP population to the drug, increasing greatly selection for anthelmintic resistance which is thought to be brought by the common practice of communal grazing system, improper dosing strategies, evolving of new resistant strains of parasites and the fact that small-scale subsistence farmers use anthelmintic treatment whenever they suspect GIP in their animals (Kaplan, 2004; Waller *et al*.. 2004 and Coles, 2005). Therefore, smart drenching can be used to enhance or preserve the effectiveness of anthelmintics (Hale, 2006).

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CHAPTER 3

Control measures for gastrointestinal parasites of Angora goats in communal farming of Lesotho

Abstract

A survey was conducted to assess farmersô awareness and control measures on the prevalence of gastrointestinal parasites in Angora goats in Maseru and Quthing districts. A total of two hundred and sixteen (216) farmers were interviewed in which 15 farmers participated in nine focus group discussions and 81 in the individual interviews. The majority were male farmers and most of them (66.70% in lowlands, 57.30% in foothills and 40.70% in mountains) had primary education. Majority of the farmers (48.20% in lowlands, 27.80% in the foothills and 33.40% in the mountains) had been farming with goats for more than 20 years. Farmers were aware of different GIPs and tapeworms were the most common as shown by 22.2% in the lowlands, 29.60% in the foothills and 33.30% in the mountains. Gastrointestinal parasites were known to cause significant losses and ill-health to goats and majority of farmers (63.00% in lowlands, 74.10% in the foothills and 85.20% in the mountains) reported kids being the most vulnerable group. Higher GIP infestation was commonly observed in summer months. Farmers controlled GIP with both commercial anthelmintics and traditional medicine with applications done upon the exhibition of clinical signs. Angora goats are kept in non-roofed kraals for most of the seasons and 59.30%, 61.20% and 100.00% of farmers in lowlands, foothills and mountains respectively cleaned their kraals when necessary. Communal grazing was linked with GIP transmission between and within flocks. Therefore, GIPs in goats were found to be a major problem hence a need for intervention.

Key words:

Gastrointestinal parasites control, Angora goats, agro-ecological zone

3.1 INTRODUCTION

The pride and wealth of Basotho are rooted and reflected in the rearing and ownership of livestock which depends entirely on communal rangelands for their nutritional requirements. However, these natural pastures show extremely low protein values especially during winter months when there are low temperatures that do not sustain plant growth (Lenono and Odenya, 2009) and unfortunately, this is the time when Angora goats are pregnant. As a result, immune system of these goats is compromised for opportunistic diseases, thus they give birth to lighter kids that are most vulnerable because of limiting nutrients provided to the growing foetus (Lenono and Odenya, 2009).

Gastrointestinal parasites remain a major threat affecting goat health and production (Hoste *et al*., 2010). Generally gastrointestinal parasites are associated with economic losses, lowered productivity, reduced animal performance (Badran *et al*., 2012), morbidity and mortality (Negasi *et al.*, 2012). According to Kantzoura *et al*. (2012), a large part of the variation in the performance of livestock production is caused by the quality of the management-stock people team, therefore, the low education level of farmers may be associated with a low degree of stock-manship and a higher number of at-risk activities, such as the careless manipulation of offal, carcass, faeces, water or feed in the farm, which favour the transmission of certain parasites. Odoi *et al*. (2007) therefore regarded educational level of farmer as an important risk factor of gastrointestinal helminth infections.

The principle of a parasite control strategy is to keep the challenge to livestock at a minimum rate through controlling the density of livestock (stocking rate) as overstocking forces the animals to graze closer to the ground and faecal material and this may result in the consumption of a higher number of infective stages of parasites (Hansen and Perry, 1994).

Furthermore, grazing management techniques can be used to minimize the uptake of infective stages of parasites and to create safe pastures (Terrill and Miller, 2005). According to Hansen and Perry (1994), the strategy of separating age groups in the more intensive production systems is known to reduce the worm burden to young animals and the effects of GIPs can also be reduced by assuring adequate planed of nutrition or practising periodic deworming or strategic deworming when conditions are most favourable for development of infective stages on the pasture. According to Costa *et al*. (2006), the control of GIPs relies on the grazing management, anthelmintic treatment or both.

Gastrointestinal parasites are a serious problem facing resource poor goat farmers in the country. Therefore, the purpose of this study is to assess farmersô awareness on the prevalence of gastrointestinal parasites and control methods that can be adopted

3.2 MATERIALS AND METHODS

3.2.1 Study site

An interview schedule was used in two districts of Lesotho (Maseru and Quthing), covering the lowlands, foothills and mountains agro-ecological zones. Three villages under one wool shed in each agro-ecological zone were randomly chosen and the meeting points were held at the woolsheds.

3.2.2 Selection of farmers per agro-ecological zone

In order to achieve the objectives of this study a cross sectional study design was employed using simple random sampling procedure in which two hundred and sixteen (216) farmers were randomly selected to participate. Farmers were selected in collaboration with government officials from the Department of Field Services in the Ministry of Agriculture and Food Security as well as Lesotho Wool and Mohair Growers Association and the officials also facilitated the formation of a technical group that helped with the management of the process and identification of demographically representative group of farmers. The ILRIôs Feed Assessment Tool (FEAST) guide (ILRI, 2015) was adopted for sampling where 15 farmers formed nine focus group discussions and nine from each focus group participated in individual interviews. The FEAST method involved a set of forms and procedures designed to help a facilitator sample and collect data related to local conditions and agricultural practices.

In selecting farmers to participate in an interview, farmers were asked to organize themselves into three categories: small holders category (i.e., those whose herd consists of less than 20 goats); medium holders (i.e., those whose herd consists of between 21 and 50 goats); and large holders (i.e., those whose herd consists of >50 goats). Farmers from each category selected three members to participate in the one-on-one interview.

3.2.3 Data analysis

The set of information obtained from each groupôs interviews was entered into Microsoft Excel 2010 and transferred to statistical package (SPSS version 16) for analysis. Individual interview data were coded into appropriate variables and assigned numerical values then descriptive statistical tools were used to describe the data and percentages were also used to measure the response from the interviewees.

3.3 RESULTS AND DISCUSSIONS

3.3.1 Demographic characteristics of farmers

Table 1 summarises the profile of interviewed farmers in the study area. Goat farming in the study area consisted approximately of male farmers than female farmers in all the agro-ecological zones (Table1). The farming households in the study area appeared to be that of a mix of ages from less than 30 years to above 60 years old with the mean age of 45.11±12.53, 46.98±14.85 and 43.81±13.32 in the lowlands, foothills and mountains respectively.

Table 1: Farmers profiles in the lowlands, foothills and mountains of Lesotho

Category	Lowlands (%)	Foothills (%)	Mountains (%)
	Gender		
Male	70.40	83.30	81.50
Female	29.60	16.70	18.50
	Age (years)		
Less than 30	7.40	14.80	18.50
31-40	33.30	20.20	25.90
41-50	14.80	21.40	18.50
51-60	33.30	20.40	29.60
More than 60	11.20	20.50	7.50
	Educational level		
No formal education	11.10	0.00	37.00
Primary	66.70	57.30	40.70
Secondary	14.80	13.00	7.50
High School	3.70	3.70	14.80
Tertiary	3.70	26.00	0.00
	Experience in goat farming		
1-5 years	14.80	24.20	14.80
6-10 years	7.40	24.00	18.50
11-20 years	29.60	24.00	33.30
More than 20 years	48.20	27.80	33.40

The results showed that most of the goat farmers have a relatively little formal schooling, but with a relatively good understanding of farming principles as shown by 66.70%, 57.30% and

40.70% of farmers who had gone to school for seven years or less in the lowlands, foothills and mountains respectively (Table 1). Most of the goat owners in the lowlands (48.20%), foothills (24.20%) and mountains (33.40%) respectively have an experience of more than 20 years in goat farming.

A noticeable inequality observed between female and male farmers with male goat farmers making a larger proportion than that of their female counterparts could be traced back and linked to traditional norms and customs that males were the ones responsible for possession and management of animals while women were known to take care of the domestic works in the household. Farmersô level of education was not a big issue because they get pieces of advice on GIPs amongst themselves together with indigenous knowledge they already have. Moreover, those that have been farming with goats for more than 10 years suggest that they are equipped with strategies to employ on gastrointestinal parasites control possibly because of exposure and repeated challenge of GIP in their flocks.

The present findings are similar to those of Adams and Ohene-Yankyera (2014) and Baah *et al*. (2012) who reported that male farmers dominated the goat industry. Similarly, Sebei (2005) had reported higher male numbers (11) than females (9) in goat farming in North West province of South Africa. Mahanjana and Cronje (2000) reported similar results of higher ratio of males to females. However, the findings of Oladele and Monkhei (2008) showed women being most prominent in goat ownership in Botswana.

Adams and Ohene-Yankyera (2014) reported 46 to 48 years as the mean age of farmers in different areas and this is in agreement with the findings of this present study. Similar results of majority of farmers who received education or went to school for five years or less were reported by (Mahanjana and Cronje, 2000) while Adams and Ohene-Yankyera (2014) reported majority of farmers as being illiterate or non-scholars. Baah *et al*. (2012) reported that majority of farmers acquired formal education up to high school.

Furthermore, the results obtained in this present study are in agreement with the findings of Mahanjana and Cronje (2000) who noted that majority of goat farmers had an experience of more than 20 years in the industry and this was attributed to retrenchments in the mining industry and a decline in the national economy which might have caused an influx to rural areas of older men who are less likely to be employed as migrant workers. Mhoma *et al*. (2011) reported that goat keeping creates employment opportunities at household level and increases income especially for vulnerable groups of people.

3.3.2 Farmers' awareness of the prevalence of gastrointestinal parasites

Goat owners are aware of GIPs and indicated ñ*milk parasites*ò (described as thick, white and segmented) as the obvious parasites in young goats. This was supported by 22.20%, 29.60% and 33.30% of the farmers in lowlands, foothills and mountains respectively. However, majority of farmers are aware of more than one parasite (nematodes, tapeworms and liver flukes) but none of them mentioned coccidia (Figure 3).

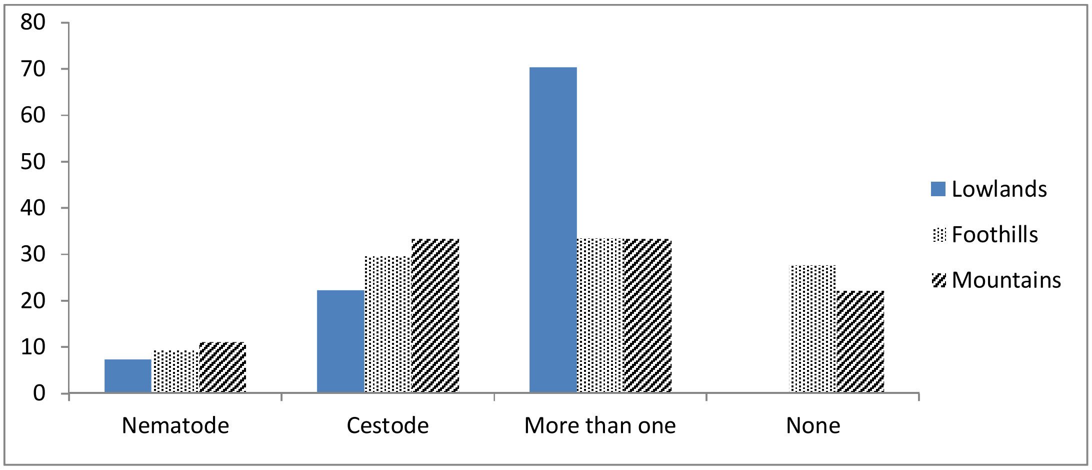

Figure 3: Names of parasites known by farmers in the lowlands, foothills and mountains of Lesotho

With the description of ómilk parasitesô by the farmers their awareness of GIP suggests that acceptance and adoption of new techniques on GIPs control will not pose any problem. However, farmers still require some knowledge about coccidia.

<u>Effect of gastrointestinal parasites on goats</u>

The respondents felt gastrointestinal parasites of goats as the main constraint of goats causing diarrhoea, water under the jaw, lack of appetite, weak, poor growth, rough hair coat, lagging behind others and high deaths of kids. Majority of farmers (48.10% in lowlands, 35.15% in foothills and 40.70% in mountains) felt that diarrhoea was responsible for the death of between 1-5 goats.

The present findings in this study are similar to those of Nasrullah *et al*. (2014) who reported gastrointestinal parasites as the biggest threat and a limitation to the productivity of small ruminant production. Similarly, Metzger (2014) explained that pathogenic effects caused by internal parasites include rough dull-coat, weakness, diarrhoea, tail rubbing, bottle jaw, loss of appetite, weight loss, high morbidity and mortality among kids, abdominal pain, anaemia, weakness, weight loss, dehydration and kid death.

Age susceptibility

The larger proportion of farmers reported that kids are the most susceptible age group mostly affected by gastrointestinal parasites (Figure 4).

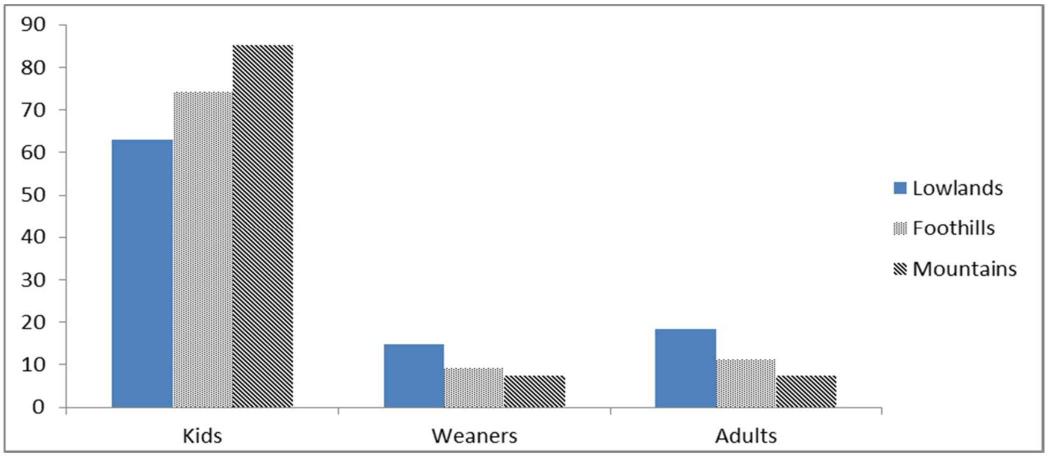

Figure 4: Effect of age on the susceptibility of goats to gastrointestinal parasites

The higher mortality in kids as reported by farmers in their first grazing season is believed to be due to delicacy and low levels of immunity against GIP infections and their detrimental effects. Moreover, this indicates a threat to the growth of the industry which affects negatively resource poor farmers financially in terms of treatment and losses from deaths of kids. However, weaners and adult goatsô susceptibility to GIPs were believed to be lower because of acquired immunity when aging.

The findings of the present study are in agreement with the report of Sebei (2005) who stated that goat kids are the most fragile and perishable component of a goat flock and high mortality among kids and slow growth among those that survive are the major constraints to production. Andrew *et al.* (2010) also reported that kids tend to have low natural immunity and the infective stages of parasites on pasture serve to infect most of naive kids. Similarly, Blackie (2014) stated that kids are known to be more vulnerable compared to adults and worm burdens decrease with increasing age.

Blackie (2014) further argued that lower prevalence of GIPs in adults has been attributed to immunological maturity as the animals grow and the increase in acquired resistance due to repeated exposure to parasites. Ficarreli (1995) mentioned that goat keepers loose more than 30% of their young stock every year, particularly during the rainy seasons and that high mortality rate is the major constraint limiting the productivity of local flocks and significantly reduces farmersô benefits.

Seasonal prevalence of gastrointestinal parasites

Farmers from the focus groups noted that infections start in spring months and increases as the season advances with higher infections in summer months and subside in autumn while winter months were associated with low infestation. This was reflected by majority of farmers in the lowlands (92.60%), foothills (87.00%) and mountains (100.00%) that higher GIP infections were observed in summer as compared to other seasons of the year (Table 2). This could possibly be linked to prevailing climatic conditions that favour parasite development.

Table 2: Farmers perceptions on the seasonal level of gastrointestinal parasite infection

Farmers perceptions	Lowlands (%)	Foothills (%)	Mountains (%)
		Summer	
High	92.60	87.00	100.00
moderate	7.40	13.00	0.00
Low	0.00	0.00	0.00
		Autumn	
High	11.10	7.40	40.70
moderate	63.00	83.30	59.30
Low	25.90	9.30	0.00
		Winter	
High	3.70	1.90	0.00
moderate	3.70	7.40	48.10
Low	92.60	90.70	51.90
		Spring	
High	14.80	20.40	7.40
moderate	55.60	29.60	48.20
Low	29.60	50.00	44.40

The present findings in this present study are similar to the report of Sanhokwe *et al*. (2016) who found higher prevalence of parasites in summer. Margan and Van Dijk (2012) furthermore argued that seasonal fluctuations in the number of GIP eggs or larvae are influenced by variations in temperature and moisture on the soil surface. Katoch *et al*. (2000) also indicated low prevalence of GIP in winter season which was associated with reduced grazing hours of the animals, which helps in reducing the chances of contact between the host and parasites.

Ratanapob *et al*. (2012) found out that several risk factors such as animal husbandry practices and weather conditions play crucial roles in the onset and severity of GIP infections. Relf *et al*. (2011) also noted the importance of warm temperature, optimum moisture and poor hygiene as predisposing factors to GIP infections. Velusamy *et al*. (2015) and Pathak and Pal (2008) found that parasitic infection is high in rainy seasons and low in winter season.

3.3.3 Control of gastrointestinal parasites

In the study area, parasites control relied entirely on commercial anthelmintics and traditional medicines. This tradition of GIPs control is similar to the findings of Hansen and Perry (1994) who reported that parasite control can be achieved by practice of periodic deworming or strategic deworming. Similarly, Terrill and Miller (2005) reported that parasites control traditionally have been based upon anthelmintic treatment and grazing management involving regular movement of animals to pastures free of parasite larvae. However, random dosing has not being effective in this communal system because farmers have indicated that they frequently and differently dosed their animals and that their animals did not always recover from suspected infections.

<u>Anthelmintics commonly used by farmers</u>

The most commonly used anthelmintics include lintex, ivermectin, valbantel and albendazole. Lintex was the most common drug used in the lowlands (37.00%) while farmers in the foothills (46.30%) normally use fenbendazole and levamisole but 44.50% in the mountains could not remember or provide the names of the anthelmintics they normally use.

Farmers seemed inclined to buy anthelmintics in the commercial stores. However, most of the farmers in the mountains would take a piece of a paper from the drug bottle or take the bottle with them to the store. The fact that these farmers could not provide the anthelmintic names could possibly be related to their low educational level. The results of the current study are not consistent with the findings by Domke *et al*. (2011) who reported benzimidazole and macrocyclic lactones as the most common anthelmintic class used.

Traditional medicine

The results of the present study revealed that 55.6%, 50.00% and 63.00% of farmers in the lowlands, foothills and mountains respectively used traditional medicine to treat their animals against parasites when necessary. This suggests that most farmers have faith in traditional medicine and use many of them to prevent diseases and improve the overall health of their animals. This is done provided herbs used are locally available without any cost or minimum cost, easily prepared and administered to the animals.

Similarly, Sanhokwe *et al*. (2016) reported that while commercial drugs are mostly used to control parasites, they are expensive and are out of reach for many resource-poor farmers. Therefore, this has led farmers to resort to alternative measures that include the use of medicinal plants to treat and control livestock parasites. Sanhokwe *et al*. (2016) further argued that, the knowledge on the use of ethno-veterinary medicine is passed on orally and is cheaper to use. Tabuti *et al*. (2003) and Njoroge and Bussmann (2006) also stated that ethno veterinary medicine is gaining popularity in developing countries because it is readily accessible, easy to prepare and administer and available at little or no cost to the farmers. Erasto (2003) reported that natural products are safe to use and are harmonious with the biological system. Shalaby (2013) also reiterated the use of botanical anthelmintics such as *Allium sativum (purple garlic)* that has been reported to be important in the reduction of helminths.

Frequency of anthelmintics use

Most of the respondents used anthelmintic treatments when necessary targeting all the animals in the flock followed by those that used anthelmintic treatments four times a year (Table 3).

Table 3: Number of times farmers uses anthelmintics in a year in each agro-ecological zone of Lesotho

Frequency	**Lowland (%)**	**Foothill (%)**	**Mountain (%)**
Once a year	26.00	9.30	7.40
Twice a year	3.70	22.20	3.70
Four times a year	33.30	33.40	29.60
When necessary	37.00	35.20	59.30

Deworming which has been practised without any investigations was the only way for GIP treatment and control with farmers who frequently dosed their animals with the reason that some animals could not effectively recover from suspected infection and because some parasites have possibly developed genes that are resistant to drugs. Most of the farmers used anthelmintics when necessary (Table 3) suggesting that farmerôs used anthelmintics as symptoms appeared, therefore, animals are invariably exposed to GIP infections all year round. However, those farmers that dose four times a year have a strategy of dosing at least once in a season to avoid re-infection from communal pastures.

In line with the results of this study, Shalaby (2013) reported that frequency of anthelmintic treatments may result in the development of anthelmintic resistance and that there is evidence that resistance develops more rapidly in regions where animals are dewormed regularly. Similarly, a high treatment frequency is considered as a major risk factor for the development of anthelmintic resistance (Hong *et al*., 1996). Andrew *et al*. (2010) also found out that goats are at particular risk as anthelmintic resistance tend to develop more quickly with this species because many anthelmintics are metabolized more quickly in goats, therefore, increases the risk of frequent dosing. Domke *et al*. (2011) reported that the treatment was not based on clinical signs or laboratory examinations. However, Zanzani *et al*. (2014) who reported that annual treatments of goats against helminths were usually done without any parasitological analyses and were only performed on particular occasions and farmers declared that they did not regularly treat their goats every year.

<u>Cost of gastrointestinal parasites treatment</u>

On the average, 61.20% and 70.40% of farmers in the foothills and mountains respectively incurred heavy cost related to the treatment of GIPs in their goats, with amounts of money exceeding M1500.00 ($113.53US) per year per farmer while 40.70% of farmers in the lowlands spend between M600 and M1000 ($45.41 US and $75.69 US) per year per farmer.

With respect to money spent on anthelmintics, the results of the current study are supported by the report of Bukhari and Sanyal (2011) who indicated that farmers are expected to spend their own money to get their animals dewormed. However, Bamaiyi (2011) reported that in order to address the problem, relevant government authorities and funding agencies can successfully help in the implementation of strategic deworming programme against gastrointestinal parasites. Lanusse and Prichard (1993) reported that the high cost of treatment against helminth parasites in ruminants alone worldwide is estimated at $1.7 billion annually.

3.3.4 Animal management practices

<u>Housing management</u>

Angora goats are kept under numerous housing structures (Annex 1) during the night and taken for grazing in communal rangelands during the day. Most of the farmers keep their flocks in open kraals and a sizable number keep their flocks indoors during harsh weather conditions and in kraals during warmer times. It was observed that 29.60%, 29.60% and 22.20% of respondents in the lowlands, foothills and mountains respectively keep their animals under roofs year round (Figure 5).

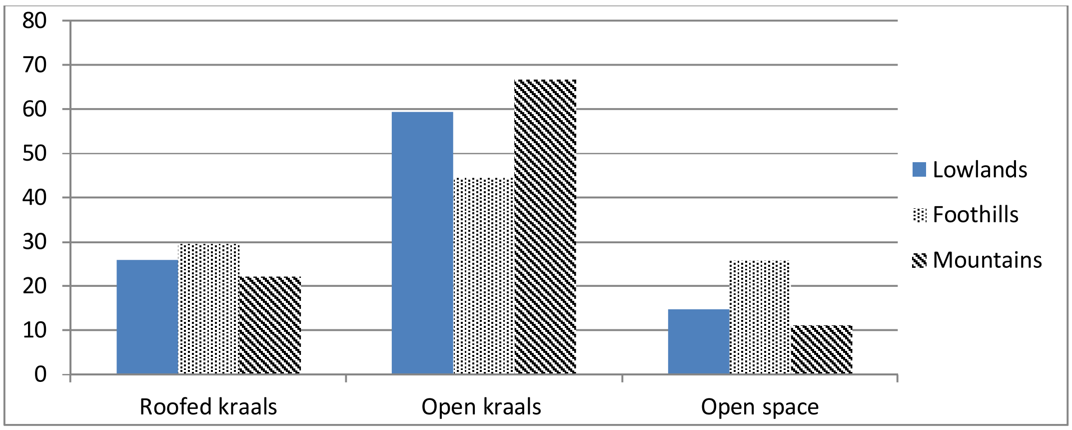

Figure 5: Housing structures as management indicator for goat farming

Although farmers have numerous systems of enclosure for keeping their goats, 59.30%, 61.20% and 100.00% in the lowlands, foothills and mountains respectively, do not regularly clean their animal enclosures but clean only when necessary, such as when it is muddy or when digging blocks to dry them for firewood especially in winter season.

The fact that kraals are not regularly cleaned can possibly encourage parasites build up and endanger susceptible animals to GIPs. The findings of this study are related to the statement of Hansen and Perry (1994) that poor sanitation and ventilation most commonly occurring when animals are closely confined predispose them to picking infective stages of parasites. Similarly, Sebei (2005) pointed that poor and unhygienic housing cause loss in goat production as it is in the dungs of animals that parasites survive and later on infect young animals. Furthermore, Zainalabidin *et al*. (2015) and Odoi *et al*. (2007) also noted that poor sanitation exacerbates GIP infections in small ruminants.

Grazing management

The respondents indicated that a minimum of two villages with all types of livestock share a given area for grazing and goats were believed to get infection from contaminated rangelands and dirty watering areas. However, the rangelands are rotated and rested four to six months as range management strategies though the farmers indicated that the rangelands are in poor condition because of extreme droughts and encroachment of bush and therefore, their animals are grazing close to the ground. Most of the respondents in the lowlands, foothills and mountains allow their animals start grazing between 06:00 and 09:00 am and are taken into kraals around 18:00 pm.

All the farmers in the lowlands and mountains and 85.2% of farmers in the foothills plough fodder for supplementary feeding and provide both roughage (crushed grain stalks) and concentrates (crushed grains and sunflower seeds) particularly for gestating does and bucks. However, they have the feeling that supplementation is much better than grazing although is much difficult to maintain throughout the year because of large flock sizes.

The communally used rangelands were linked with transmission of GIPs because dewormed flocks graze on the same area with those not dewormed from other households posing a major challenge in the use of grazing management as a control strategy against GIPs.

In line with the results of the present study, Mamabolo and Webb (2005) and Ershaduzzaman *et al*. (2007) have also noted that rearing goats in communal areas is characterised by poor management and low productivity resulting in high kid mortality and lack of good animal husbandry practices due to lack of veterinary advice in communal areas. Similarly, Hale (2006) reported that when fewer numbers of animals receive treatment, the refugia population remains large and a high level of refugia may be a primary factor in small stock developing clinical parasitism and perhaps even dying of its effects (Andrew *et al*., 2010).

The findings in this survey that management practice of rotational grazing and resting grazing areas play significant role in controlling GIPs. Hansen and Perry (1994) also noted that assuring adequate plane nutrition can reduce effects of GIPs. Coffey and Hale (2012) reported on the benefit of resting pastures as a conventional strategy to control GIPs. Similarly, Andrew *et al*. (2010) pointed that grazing management schemes help in reducing parasite loads in the host and level of pasture contamination. Andrew *et al*. (2010) also illustrated the importance of supplementation especially with protein (soya bean meal) to improve immunity that can confer resistance to many GIPs. However, the control of GIP relies on the grazing management, anthelmintic treatment or both (Costa *et al*. 2006).

3.4 CONCLUSION

Gastrointestinal parasites are a major problem causing the deaths of several young goats. Farmers are aware of nematodes, liverflukes and tapeworms but none of them was aware of coccidia. Higher parasitic infestations were seen in summer and farmers use both commercial anthelmintics and traditional medicines to control GIPs once they see convincing symptoms. Goatsô kraals were not regularly cleaned. The transmission of GIPs was associated with communal grazing.

3.5 RECOMMENDATIONS

Based on the results of this study, it is recommended that:

- Farmers should be empowered with the knowledge on GIP biology and how they behave in different times of the year to facilitate the reduction of gastrointestinal parasites prevalence. This will assist them in understanding why dosing schedule provided by relevant Animal Health expects should be followed.
- Focus should be more on young goats with respect to control and treatment of GIPs.
- Farmers should be advised on proper grazing, housing management and sanitation of goats.
- Farmers need to be assisted to form cooperatives to facilitate buying anthelmintics at affordable costs.

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CHAPTER 4

Prevalence and loads of gastrointestinal parasites of Angora goats in Maseru and Quthing districts

Abstract

Considering the importance of gastrointestinal parasites infection and their implications on goatsô well-being and householdsô security, this study was carried to determine the prevalence and egg/oocyst loads of gastrointestinal parasites of Angora goats in two districts (Maseru and Quthing) of Lesotho. A total of 1795 faecal samples were collected from the rectum of goats for 6 months. Binary logistic regression was used to ascertain the effect of agro-ecological zone, age and sex on gastrointestinal parasites. Negative binomial regression and Poisson regression were used to test how faecal egg count is associated with agro-ecological zone, age and sex. The prevalence and faecal egg loads of nematodes were higher in the lowlands and foothills in Maseru and Quthing districts respectively while coccidia prevalence and oocyst loads were higher in the mountains. Age was not significantly ($p>0.05$) associated with nematode prevalence and egg loads but juveniles were significantly ($p<0.05$) having higher coccidia prevalence and oocyst loads than adults. Sex had no effect on the prevalence and egg/oocyst loads of nematode and coccidia ($P>0.05$). The higher prevalence of nematodes was obtained in July with the lowest in December in Maseru but in Quthing, the highest was in September and lowest in October. Coccidia prevalence was high in July in both districts. The nematodes FEC were higher in October and December in Maseru and Quthing respectively while the animals were heavily loaded with coccidia in July. Therefore, it is important to factor in agro-ecological zone, age and month of the year when designing the integrated GIP control programme of Angora goats in Lesotho.

Key words:

Gastrointestinal parasites, prevalence, faecal egg load, agro-ecology, goats age and sex

4.1 INTRODUCTION

Lesotho Angora goats are early domesticated dual purpose animals reared by smallholder farmers primarily for mohair production (Mafisa, 1993). Angora goats are also producing meat mainly for home consumption. However, Angora goat farming is constrained by diseases and parasitic diseases (Ademosun, 1994).

Gastrointestinal parasitic diseases in Angora goats constitute a global health burden in most developing countries mainly because of faecal contamination of grazing land and water (Pathak, 2011). According to Yusof and Muhammad (2016), gastrointestinal parasites (GIP) remain one of the main constraints in goat production as they can cause several subclinical effects such as hypoproteinemia, growth depression, loss of appetite and digestive inefficiency (Yusof and Muhammad, 2016). Gastrointestinal parasites reduce voluntary feed intake and efficiency of feed utilization and are major contributors to reduced goat products (meat, milk and mohair) as noted by Coop and Holmes (1996). Gastrointestinal nematodiasis, referring mainly to haemonchosis (*H. contortus*) is classified as one of the most prevalent nematode responsible for morbidity and mortality in small ruminants (Nor-Azlina *et al*., 2011).

Coccidiosis on the other hand is another important small ruminant parasitic infection that prevails widely in many parts of the world either clinically or sub-clinically (Yusof and Muhammad, 2016). Coccidial parasites of the genus *Eimeria* contributes highly to enteric diseases especially in young or stressed goats under poor farm management and this leads to high mortality in goat kids (Ratanapob *et al*., 2012). Furthermore, coccidiosis in goats is manifested by clinical diseases (diarrhoea) and sub-clinical disease (poor weight gain) and these conditions have a great economic importance to smallholder farmers and livestock productions especially if goats are kept in large numbers under numerous management systems (Abo-shehada and Abo-Farieha, 2003 and Faizal and Rajapakse, 2001).

Andrew *et al.* (2010) denoted that, gastrointestinal cestodes on the other hand are generally believed not to cause significant diseases to small ruminant. However, ingestion of high number of intermediate host harbouring infective stages of cestodes can lead to production of many parasites associated with intestinal blockage or predispose the animal to bacterial (Clostridium *perfringens*) infection. Trematodes prevalence mainly depends on the availability of the intermediate snail host whose activity and abundance depend on temperature and soil moisture content (Relf *et al*., 2011). Trematodes because of their association with clinical diseases in small ruminants are seen as another important group of helminths that cause direct damage (Kantzoura *et al*., 2011).

Environmental factors and vector abundance have been incriminated in the existence and distribution of most parasitic diseases (Adejinmi *et al*., 2015). Moreover, nematodes and coccidial infections among goats are closely associated with several factors such as poor farm management, ingestion of contaminated food and water, nutritional deficiencies, age of the goat and climate factor (Gwaze *et al*., 2009). According to Getachew *et al.* (2017), the intensity of parasite infection depends mainly upon the age of the host, the breed, the parasite species involved, and the epidemiological patterns which include husbandry practices and physiological status of the animals. More importantly, environmental conditions such as temperature, rainfall and humidity are major factors that affect development of eggs, free living stages of the parasites and oocysts (Fikru *et al*., 2006 and Menkir *et al*., 2006).

Odoi *et al*. (2007) on the other hand, broadly classified major risk factors as parasite factors (including epidemiology of the different species), host factors (genetic resistance, age, sex and physiological status of the animal) and environmental factors (climate, nutrition, stocking density and management). Asif *et al*. (2008) reported that male animals are generally known to be more susceptible to gastrointestinal parasite infestation than females because of the production of androgen hormone which lowers immune response in males. Equally important, Odoi *et al*. (2007) reported that infestation of parasites varies by host age group and the higher infestation of suckling than young and adult animals may be attributed to a weaker immunological response of young animals. Older animals on the other hand recover from parasitic infection more quickly as the immunity of the host increases with age mainly because of repeated exposure (Tariq *et al*., 2010; Zeryehun, 2012 and Dagnachew *et al*., 2011).

According to Mandal *et al*. (2010), gastrointestinal parasite infection in animals can be quantitatively monitored by the variation in the number of eggs present in faecal samples of livestock over all different seasons of the productive year. Chattopadhyay and Bandyopadhyay (2013) pointed out that the aim of any parasite control program must ensure that parasite populations do not exceed threshold levels such that eventual productivity rates are consistently compatible with expected levels of economic production.

There is currently no published information on the burden of GIPs and concurrent GIP infections in goats kept under smallholder farms in Lesotho, where these animals are important assets to the remote area farmers. Therefore, this study was undertaken to investigate the prevalence, faecal egg load and control of GIPs of Angora goats in Maseru and Quthing districts.

4.2 MATERIALS AND METHODS

4.2.1 Study site

The faecal sample collection was undertaken in each of three agro-ecological zones of Maseru and Quthing districts. In each agro-ecological zone, three villages were randomly selected. In Maseru district, faecal samples were collected from the respective kraals in the lowlands and villages were Mahloenyeng, Ha-Panya and Morija. In the foothills, sampled villages were Ha-Lebamang, Ha-Chele and Thabana Limmele. Villages where samples were collected in the mountain were Semonkong town, Ha-Konyanatsôoana and Ha-Leloko. On the other hand in Quthing district, faecal samples were collected from respective kraals in the lowlands and villages were Moyeni, Mabitseng and Ha-liqa. In the foothills, villages selected were Namolong, Phokeng and Mapekeng. In the mountains the villages selected were Ha-Mohlakoana, Lebelonyane and Matamong.

4.2.2 Faecal sample collection

The experimental animals used were tagged where sex and age of each animal were recorded. Faecal samples were collected for six months from July to December 2016 from the same goats. An average of 5g of faecal samples was collected directly from the rectum of randomly selected animals using sterile disposable plastic gloves. Samples were then placed in a srewcapped plastic bottle. The samples were clearly marked for identification, kept in a cooler box with dry ice packs and transported on the same day of collection to the National University of Lesotho laboratory for examination. In the laboratory, faecal samples were refrigerated at 4 ^{0}C and processed within 48 hours.

Figure 6: Collection of faecal samples from the rectum Angora goats

4.2.3 Examination of faecal samples

Samples were crushed thoroughly and 2g of each crushed faecal sample were mixed with 58ml of NaCl solution (floatation fluid) and blended. After obtaining homogenous mixture, it was sieved into a beaker. Few drops of amyl alcohol (3-6) were added to treat bubbles in the mixture. The disposable pipettes were used to draw few millilitres and used to fill the two chambers of the McMaster slides which were viewed under the microscope (×10 and ×40 objectives) as recommended by Dryden *et al*. (2005). Identification of parasite eggs was based on morphological characteristics. Floating parasite eggs were then counted by using laboratory cell counter and each number was multiplied by a factor 100 to give an approximate number of eggs/gram of faeces.

4.2.4 Data analysis

Data collected from individual animals and parasitological examination results were entered into Microsoft excel spread sheet. The prevalence of each parasite species was calculated as a percentage of number of faecal samples infected in the total number of samples examined ($P = d / n * 100$). Binary logistic regression within generalised estimating equations was used to ascertain the effects of age, sex and agro-ecological zone on the likelihood that the goats have gastrointestinal parasite infection. Odds ratios were used in assessing the strength of the association.

The model is as follows:

$$Y_{ijk} = ɓ_0 + A_i + B_j + C_k + ɭ_{ijk}$$

Where Y_{ijk} = dependent variable (parasite egg count), $ɓ_0$ is regression parameter. A_i, B_j and C_k are independent variables (Age, Sex and Agro-ecological zone of the goat respectively) then $ɭ_{ijk}$ = error term.

Generalized estimating equations were used to analyse the faecal egg counts (FEC) where for each observation negative binomial regression (for nematode FEC) and Poison regression (for coccidia FEC) were adopted in the analysis. Factors such as agro-ecological zone, age groups and sex of the goats were tested for significance in the parts of the models. The model used is as follows:

$$Y_{ijk} = ɓ_0 + A_i + B_j + C_k + ɭ_{ijk}$$

Where; Y_{ijk} = Individual gastrointestinal parasites egg species count, $ɓ_0$ = regression parameter, A_i = Effect of age, B_j= Effect of sex, C_k = Effect of agro-ecological zone and $ɭ_{ijk}$ = Random residual error.

The Exp (B)/IRR were expressed in percentages where difference between 1 and the value of Exp (B) was multiplied by 100. All analyses were performed using SPSS software for Windows version 16.0. In all analyses, confidence level was held at 95% and P value of 0.05 was set as the level of significance.

4.3 RESULTS AND DISCUSSION

4.3.1 Overall prevalence of gastrointestinal parasites

A total of 1795 faecal samples from Angora goats were processed and examined for gastrointestinal nematodes eggs, coccidia oocysts, cestodes eggs and trematodes eggs over six months (Annex 2 and 3). The overall prevalence in the Maseru district was 709 (78.69%) of the 901 total faecal samples examined for nematodes, 469 (52.05%) of the 901 total faecal samples examined for coccidia and 2 (0.22%) of 901 total faecal samples examined for cestodes. No sample was positive for trematodes in Maseru. For Quthing district, a total of 663 (74.16%) of the 894 faecal samples examined were positive for nematodes while 323 (36.13%) of 894 examined samples had coccidia. Only 7 (0.78%) of 894 faecal samples examined were positive for cestodes while samples positive for trematodes accounted 2 (0.22%) of 894 samples examined.

The prevalence rate of intestinal parasites observed in this study may be attributed to poor herd and communal range management, variations in the anthelmintic use, agro-ecological zones with favourable climatic conditions for egg hatching, survival and development of parasites. Thus the present findings are similar to the findings of Nwoke *et al.* (2015) who reported 73.8% prevalence of nematodes in slaughtered goats. Moti (2008) reported similar results of overall prevalence of nematodes in small ruminants. According to Velusamy *et al.*

(2015), prevailing climatic conditions especially rainfall and temperature which favour development and survival of parasitic nematode eggs and infective stages can be responsible for high infection rate.

These results obtained in this present study are in agreement with the findings of Yusof and Muhammad (2016) who reported that coccidiosis is a parasite that prevails widely in many parts of the world either clinically or sub-clinically. According to Harwood (2006) coccidia are characterized by quick short life cycle which quantify give them opportunity of infectiveness to build-up in the environment and kid rearing areas (Andrew *et al*., 2010). Sharma *et al*. (2017) found coccidia prevalence of 86.71% which indicated the seriousness of the problem and advocated the need for its proper management.

On the other hand, while the prevalence of cestodes and trematodes in this study were smaller than 1% this can however be attributed to unavailability and variability of favourable habitats of their intermediate host. Moreover, lower prevalence of trematodes can be attributed to the limitations of the floatation method normally used to recover nematode eggs as opposed to sedimentation method which is appropriate to recover trematode eggs because these eggs are relatively large and heavier than nematode eggs but this technique is generally done when such infections are suspected and is not done routinely (Hansen and Perry, 1994).

These results in this present study are similar to the findings of Nwoke *et al*. (2015) who reported that cestodes and trematodes were not common in their own study and if they were present, they occurred in mild form which might not have been harmful to the host as a single infection. However, Dagnachew *et al*. (2011) found 6.99% of liver fluke in small ruminants.

4.3.2 Prevalence of gastrointestinal parasites by agro-ecological zones

In Maseru district, the lowlands had higher prevalence of nematode infestation followed by the mountains then the foothills (Table 4 and Annex 4). The results also showed that the odd of having nematode infection from lowlands to foothills significantly ($p<0.05$) increased by 5.65 times while from lowlands to mountains increased by 4.53 times. The change from the mountains to the foothills revealed that the odd of exhibiting nematode egg was 1.25 times greater and was not statistically significant ($p>0.05$).

In Quthing district, the foothills had high nematode infestation followed by the mountains and lastly the lowlands (Table 4 and Annex 4). These results showed that, from foothills to lowlands and from foothills to mountains the chances of having nematode faecal eggs significantly ($p<0.05$) decreased by 0.34 and 0.16 times. The chances of having nematodes from the mountains to the foothills significantly ($p<0.05$) decreased by 0.48 times.

Table 4: Prevalence of nematode and coccidia by agro-ecological zone

Maseru				**Quthing**			
Agro-ecological zone	**No. Samples Examined**	**Prevalence (%)**	**Exp (B)**	**Agro-ecological zone**	**No. Samples Examined**	**Prevalence (%)**	**Exp (B)**
			Nematode				
Mountains	264	73.90 [b]	4.53	Mountains	284	78.50 [c]	0.34
Foothills	313	68.40 [b]	5.65	Lowlands	300	55.70 [b]	0.16
Lowlands	324	92.60 [a]	1	Foothills	310	88.10 [a]	1
			Coccidia				
Mountains	264	61.00 [c]	0.71	Mountains	284	52.10 [b]	0.42
Foothills	313	43.10 [b]	1.47	Lowlands	300	30.70 [a]	1.28
Lowlands	324	53.40 [a]	1	Foothills	310	26.80 [a]	1

Different superscripts within the column are significantly different ($p<0.05$), No. refer to number, Exp (B) refer to exponentiated beta.

The prevalence of coccidia infestation in both districts (Maseru and Quthing) had a similar pattern with higher prevalence in the mountains followed by the lowlands and then the foothills (Table 4 and Annex 4). In Maseru district, the results revealed that, the odds of goats having coccidia eggs increased by 1.47 times from the lowlands to the foothills but a change from the lowlands to the mountains has 0.71 times lower odds of exhibiting coccidia eggs. A change from the mountains to the foothills significantly ($p<0.05$) increased the likelihood of exhibiting coccidia eggs by 2.06 times.

In the case of coccidia in Quthing as illustrated in Table 4, the odds of goats having coccidia eggs increased insignificantly ($p>0.05$) by 1.28 times from foothills to lowlands while the odds of exhibiting coccidia eggs decreased by 0.42 times from the foothills to the mountains ($p<0.05$). The change from the mountains to the foothills revealed that the odds of having coccidia egg was lower ($p<0.05$) by 3.09 times.

In the lowlands of the Maseru district, the obtained results were expected because it is assumed to be warmer than the other agro-ecological zones while in Quthing the results could be explained by the fact that the lowlands are nested within the Senqu river valley. Therefore, because of the river, temperatures might have been the factor for unfavourable climate for parasite development. Apart from that, Quthing lowland at the time of carrying out this survey had droughts which negatively affected the moisture content and optimal temperatures required by parasites to develop. In Quthing, the higher prevalence of nematodes in the foothills compared to the lowlands could be traced to the fact that this zone geographically is a little outside the valley hence it is warmer and conducive for parasites development. Furthermore, trans-humance which occurs in warmer months after emergence of grain crops and communal grazing are thought to have increased parasitic infection and cross parasite contamination in the mountains of both districts.

Thus the present findings are similar to the report of Aga *et al*. (2013) who noted that variation of prevalence of helminths in agro-ecological zones might be influenced largely by variation in geographic and climatic conditions. Zeryehun (2012) also found that agro-ecology is an important factor in determining levels of infection for species of parasite and the differences were attributed to variations in climate. According to Jacquiet *et al*. (1992), climatic factors such as sunlight, temperature, rainfall, humidity and soil moisture, influence the development of viable eggs of parasitic helminths within faecal pellets herbage.

The present results for Maseru district are similar to the findings of Dagnachew *et al*. (2011) who reported that lowlands had highest prevalence of helminths. Kantzoura *et al*. (2012) on the other hand found that elevation of farm location is a risk factor for gastrointestinal helminth infections in sheep and goats where farms located on high elevation had a higher prevalence of gastrointestinal helminth infections. These results are similar to the present findings especially in Quthing where foothills and mountains had higher prevalence than the lowlands.

4.3.3 Prevalence of gastrointestinal parasites by age

The prevalence of nematodes between age groups in both districts was almost equal with the difference of 3.10% and 3.60% in Maseru and Quthing respectively. However, in both districts (Maseru and Quthing) young goats were slightly more infected with nematodes than adults (Table 5 and Annex 5). For prevalence of coccidia in both districts (Maseru and Quthing) based on age groups, the results showed that young goats had higher prevalence of coccidia than adults with the difference of 10.70% and 6.90% for Maseru and Quthing districts respectively.

Table 5: Prevalence of nematodes and coccidia by goatsô age in Maseru and Quthing

Maseru				Quthing			
Goat Age	**No. Samples Examined**	**Prevalence (%)**	**Exp (B)**	**Goat Age**	**No. Samples Examined**	**Prevalence (%)**	**Exp (B)**
			Nematode				
Adult	488	77.30[a]	1.15	Adult	456	72.40[a]	0.98
Juvenile	413	80.40[a]	1	Juvenile	438	76.00[a]	1
			Coccidia				
Adult	488	46.70[b]	1.59	Adult	456	32.80[b]	1.42
Juvenile	413	58.40[a]	1	Juvenile	438	39.70[a]	1

Different superscripts within the column are significantly different ($p<0.05$), No. refer to number, Exp (B) refer to exponentiated beta

In Maseru district, a change from young goats to adults revealed that the odd of likelihood of goats having nematode eggs increased by 1.15 times and the difference in change was not significant ($p>0.05$). In terms of coccidia the odds increased by 1.59 times significantly ($p<0.05$) from juveniles (young goats) to adults.

In Quthing district, the results showed that the odd of goats exhibiting nematode eggs insignificantly ($p>0.05$) decreased by 0.98 times from young goats to adults. For coccidial infestation in Quthing district, a change from young goats to adults showed that the odds of likelihood of goats exhibiting coccidia egg increased by 1.42 times.

The findings in this current study, are in agreement with Zeryehun (2012) and Andrew *et al*. (2010), who reported that age seems to have significant influence on the prevalence of helminthiasis which can be related to younger animals being highly susceptible due to low natural immunity which have not been fully developed. Furthermore, Raza *et al*. (2007), considered age as an important risk factor in gastrointestinal helminthiasis and reported an increased prevalence in young animals.

On the other hand, Urquhart *et al*. (1996), Taswar *et al*. (2010) and Dagnachew *et al*. (2011) reported that adult goats and old animals develop acquired immunity against helminth infections as they get mature due to repeated exposure hence this is thought to reduce GIP establishment in the GIT. In another study, Dinka *et al*. (2010) and Gebeyehu *et al.* (2013) reported higher prevalence of GIP in adults than in young goats.

4.3.4 Prevalence of gastrointestinal parasites by goat's sex

Nematode prevalence between males and females in Maseru district was almost equal with the difference of 2.90% but males were virtually more infected than females while in Quthing district the males had higher prevalence of nematodes when compared to females as shown in Table 6. On the other hand, prevalence of coccidia in both districts was observed to be higher in males than females.

Table 6: Prevalence of nematode and coccidia by sex

Maseru				Quthing			
Sex	**No. Samples Examined**	**Prevalence (%)**	**Exp (B)**	**Sex**	**No. Samples Examined**	**Prevalence (%)**	**Exp (B)**
			Nematode				
Male	425	80.20[a]	0.88	Male	370	77.30[a]	0.74
Female	476	77.30[a]	1	Female	524	71.90[a]	1
			Coccidia				
Males	425	54.10[a]	0.86	Males	370	36.80[a]	1.04
Females	476	50.20[a]	1	Females	524	35.70[a]	1

Different superscripts within the column are significantly different ($p<0.05$), No. refer to number, Exp (B) refer to exponentiated beta

In Maseru district, the likelihood of having nematode infection decreased by 0.88 times from female to male goats (Table 3 and Annex 6). In the case of coccidial infestation a change from females to males was associated with a non-significant ($p>0.05$) reduction of 0.86 times.

In Quthing district, the results showed that the chance of goats exhibiting nematode eggs decreased by 0.74 times from females to males while the odds of goats having coccidial eggs insignificantly ($p>0.05$) increased by 1.04 times.

In view of the results of current study, there was no significant ($p>0.05$) difference between male and female goats in spite the males having higher prevalence of nematodes and coccidia. The difference in the prevalence rates could be attributed to the fact that many studies assume sex to be a determining factor influencing prevalence of parasitism (Maqsood *et al*., 1996). Urquhart *et al*. (1996) also noted that entire male animals are more susceptible than females to some helminth infections because of androgen activity. Dagnachew *et al*. (2017) also reported that males have higher prevalence than females for nematodes but showed no significant difference. Contrary to the findings in this present study, Dagnachew *et al*. (2011) found that females have relatively higher prevalence of parasites when compared with males despite being exposed to similar husbandry practices. The vulnerability of females to GIP can be traced to periods of pregnancy and periparturient which cause stress and reduced immunity (Urquhart *et al*., 1996).

4.3.5 Prevalence of gastrointestinal parasites by Months

The infection rates were higher during winter months and lower in warmer months in Maseru district. Figure 7 shows that monthly prevalence values in Maseru district ranged from

54.90% in December to 98.00% in July for nematodes infection whereas in Quthing, monthly prevalence values for nematodes infections were between 64.20% and 79.60% during the six months study period with the lowest value being in October and highest in September. In Maseru district, the monthly prevalence for coccidia ranged from 0.70% in November to 97.40% in July while in Quthing, coccidial prevalence ranged from 5.10% in November to 98.20% in July (Figure 8).

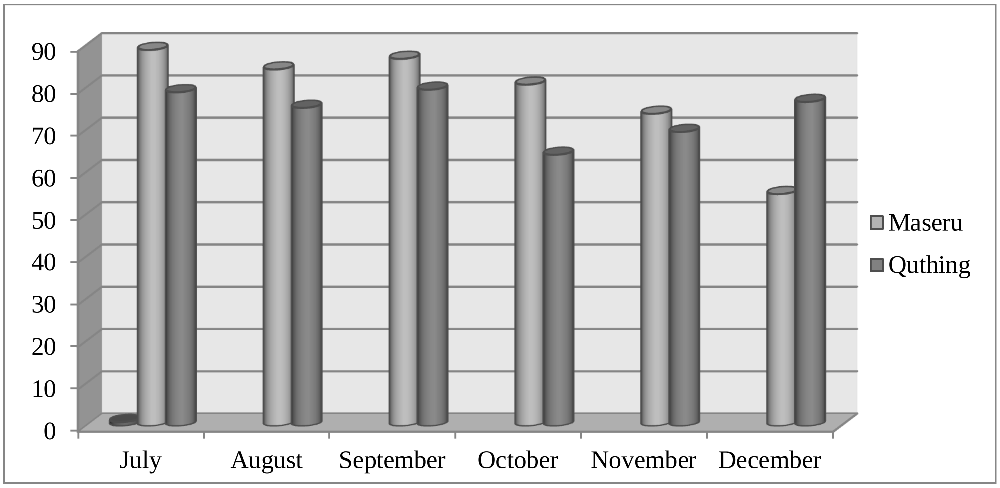

Figure 7: Monthly prevalence of gastrointestinal nematode of goats from two districts of Lesotho in 6 months period

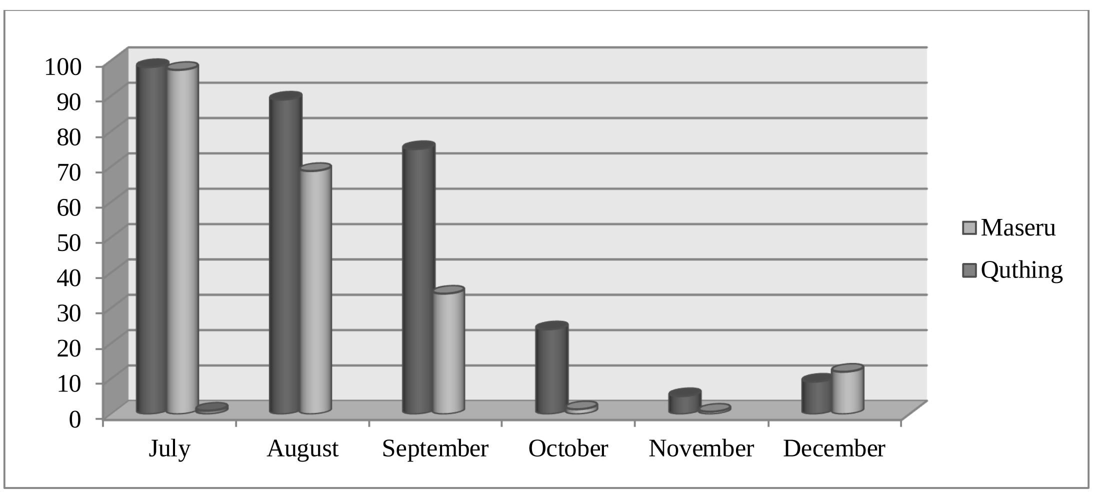

Figure 8: Monthly prevalence of gastrointestinal coccidia of goats from two districts of Lesotho in 6 months period

The results of the present study showed that the prevalence of nematodes and coccidia were high during colder months and lower in warmer months of the year. Among other things, higher prevalence of GIP in winter months could be attributed to the pregnancy period of does which could have affected their immunity (periparturient egg rise) coupled with parturition stress as goats were in gestation and kidding at this time of the year. These factors might have increased stress and provide chance to parasites to multiply. The high prevalence of coccidiosis in winter month could also be due to management system operated by farmers by confining animals in a small roofed pen to avoid death from cold. Consequently, such animals are overcrowded in those pens which are not regularly cleaned hence increasing the stocking density which might have exacerbated mixed and re-infection rate.

The present results are similar to the findings of Saha *et al*. (1996) who reported highest parasite prevalence in winter in goats from West Bengal. Singh *et al*. (2017) also reported that the highest prevalence of helminths was in Monsoon (July to October) followed by winter (November to February) and lowest summer (March to June). Katoch *et al*. (2000) noted that low prevalence of GIP in winter season is associated with reduced grazing hours of the animals which help in reducing chances of contact between host and parasites. However, the findings of Katoch *et al* (2000) is contrary to the situation in Lesotho where in winter, farmers take their animals for grazing in the early hours of the morning and bring them back home when sunset as to compensate the shortening of the day and nutritional stresses, therefore, there is high possibility and chance of contact between animals and parasites which can be the reason for the high parasitic infestation during this season of the year.

The findings in this present study are in agreement with the report of Urquhart *et al*. (1996) who noted that high parasite prevalence might be as a result of intermittent relaxation of immunity at post periparturient periods. Kheirandish *et al*. (2014) also reported highest and lowest coccidial prevalence rates that were detected in winter and spring seasons respectively. In addition, Sharma *et al*. (2017) reported higher prevalence of coccidial infection in winter season followed by rainy and summer seasons.

As the prevalence of cestodes and trematodes by agro-ecological zone, age, sex and month in Maseru and Quthing districts were very low (not exceeding 2.10%), they were not subjected to any statistical analysis, however, prevalence values can be used as baseline data. The results showed that, no animals had cestode eggs in the foothills of both districts (Annex 7 and 8). Furthermore, trematode prevalence on the other hand was found in lowland (0.70%) of Quthing district but no animals in Maseru district had trematode infection. The results further showed that, cestodes prevalence was found in young goats of both districts while adult goats did not have cestodes infection. On the other hand, trematodes were only found in adult goat of Quthing district.

The results showed that cestode prevalence in male and female goats were 0.20% each in Maseru while 1.00% and 0.50% were prevalence values for female and male goats in Quthing. Female adults (0.40%) in Quthing were the only ones harbouring trematodes. The monthly prevalence for cestodes in Maseru was 1.40% in December while Quthing had 4.10% and 0.80% prevalence in October and December respectively (Annex 8). Unlike Maseru, Quthing district had trematodes infection of 0.70% and 0.80% monthly in November and December. The fact that these parasites (cestodes and trematodes) were not many could be that the worms did not have debilitating effects on the animalsô health and productivity.

4.3.6 Overall faecal egg load of gastrointestinal parasites

The faecal egg counts (FECs) were highly variable for each parasite and these ranged from 0 to 4900 for nematodes, 0 to 45 800 for coccidia and 0 to 200 for cestodes in Maseru district while in Quthing district, the FECs variability ranged from 0 to 6000 for nematodes, 0 to 50 000 for coccidia, 0 to 3400 for cestodes and 0 to 100 for trematodes. The faecal egg load in both districts was classified according to the three levels of infection intensity as presented in Table 7. In terms of nematode infection the results showed that 68.40% of the infected animals in Maseru district were lightly infected while those ones that were moderately and heavily infected accounted for 6.30% and 4.00% respectively. The same trend of results was also observed in Quthing district with the levels of nematode infection being 65.70%, 5.00% and 3.50% for lightly, moderately and heavily infected goats.

The majority (35.40%) of goats were lightly infected by coccidia followed by those that were heavily (10.30%) infected while the least number of goats was moderately (3.60%) infected in Maseru District. In Quthing district the number of goats that were heavily infected was 3.60%, those that were moderately infected with coccidia were 1.90% and those at lower risk were 30.60% respectively.

The proportion of goats that were lightly infected with cestodes in Maseru and Quthing districts were 0.20% and 33.30% respectively. Only 0.20% of the goats in Quthing were moderately or heavily infected with cestodes in Quthing district. Trematodes were not observed in the faecal samples from Maseru district while in Quthing only 0.20% of animals were lightly infected.

Table 7: Intensity levels of gastrointestinal parasites based on eggs per gram (EPG) counts of faeces of goats from Maseru and Quthing

Maseru			Quthing		
Intensity of infection	**No. goats infected (%)**	**EPG/OPG**	**Intensity of infection**	**No. goats infected (%)**	**EPG/OPG**
			Nematode		
Light	616 (68.40)	100-1200	Light	587 (65.70)	100-1200
Moderate	57 (6.30)	1201-2000	Moderate	45(5.00)	1201-2000
Heavy	36 (4.00)	>2000	Heavy	31 (3.50)	>2000
			Coccidia		
Light	319 (35.40)	100-1200	Light	274 (30.60)	100-1200
Moderate	57 (6.30)	1201-2000	Moderate	17(1.90)	1201-2000
Heavy	93 (10.30)	>2000	Heavy	32 (3.60)	>2000
			Cestode		
Light	2 (0.20)	100-1200	Light	3 (33.30)	100-1200
Moderate	0 (0.00)	1201-2000	Moderate	2 (0.20)	1201-2000
Heavy	0 (0.00)	>2000	Heavy	2 (0.20)	>2000
			Trematode		
Light	0 (0.00)	100-1200	Light	2 (0.20)	100-1200
Moderate	0 (0.00)	1201-2000	Moderate	0 (0.00)	1201-2000
Heavy	0 (0.00)	>2000	Heavy	0 (0.00)	>2000

EPG refers to egg per gram, OPG refers to oocyst per gram

In this present study, the cut point for goats that needed anthelmintics was deduced from animals that were moderately infected although this procedure gave rise to lower percentages as shown in Table 7. This means that it would not be ideal to dose goats for the purpose of avoiding anthelmintic resistance rather farmers can employ herd management and strategic grazing to avoid infection. However, on closer observation of the present results, some animals though in small numbers were already heavily infected. Therefore, looking at parasites distribution and contribution of communal grazing in the spread of parasites, farmers are advised to start dosing to avoid more animals getting heavily infected within no time.

According to Andrew *et al*. (2010), as parasiteôs eggs do not have uniform appearance in the faeces of infected animals and as with FEC there is no specific protocol for determining a particular cut-point which indicates treatment is necessary. However, a threshold of 500 to 800 eggs is often used by veterinarians in an attempt to develop a control program based on monitoring. According to Coffey and Hale (2012), when deciding what cut-point to use, several factors like pasture rotation which allows dosing and moving animals to other pasture without carrying parasites into a clean pasture have to be considered.

4.3.7 Effect of agro-ecological zone on gastrointestinal parasite egg count

The means of gastrointestinal nematodes and coccidia infections by agro-ecological zones are shown in Table 8 and Annex 9. With reference to nematode infection the results showed that goats in the lowlands and foothills of Maseru and Quthing districts respectively had the highest loads of eggs than goats in all other agro-ecological zones with the foothills and lowlands in that order having the lowest nematode eggs. Goats in the mountains in both districts had a higher coccidial oocyst load followed by those in the foothills and in the lowlands respectively (Table 8).

In Maseru district, the results revealed the significant difference between the lowlands and foothills ($p<0.05$) with respect to nematode infection but the difference between the lowlands and mountains was not significant ($p>0.05$). The foothills were also significantly ($p<0.05$) different from the mountains with respect to nematode infection. These results suggest that the incidence of nematode infestation decreased by 58.00% and 11.00% between the lowlands and the foothills and the lowlands and the mountains respectively. The results further showed the mountains differed significantly ($p<0.05$) from the foothills by 52.00% exponentiated value in percentage.

Table 8: Means of gastrointestinal nematodes and coccidia infections by agro-ecology

Maseru				Quthing			
Agro-ecological zone	**Mean**	**Exp (B)**	**Exp (B) In %**	**Agro-ecological zone**	**Mean**	**Exp (B)**	**Exp (B) In %**
			Nematode				
Mountains	577.35^{a}	0.89	11.00	Mountains	565.61^{a}	0.89	11.00
Foothills	274.13^{b}	0.42	58.00	Lowlands	201.69^{b}	0.32	68.00
Lowlands	648.71^{a}	1	.	Foothills	633.94^{a}	1	.
			Coccidia				
Mountains	1070.17^{b}	1.86	86.00	Mountains	656.86^{b}	2.42	142.00
Foothills	739.31^{ab}	1.29	29.00	Lowlands	158.68^{a}	0.59	41.00
Lowlands	574.71^{a}	1	.	Foothills	271.28^{ab}	1	.

Means within the column with no common superscript differ significantly ($p<0.05$), No. refer to number, Exp (B) refer to exponentiated beta

In Quthing district, there was significant difference in the faecal egg load between goats in the foothills and those in the lowlands ($p<0.05$) while the difference between foothills and the mountains was not significant ($p>0.05$). The FEC intensity was also significantly ($p<0.05$) different between the goats in the lowlands and mountains. The results further showed that the incidence in terms of the number of nematode infections decreased by 68.00% and 11.00% from foothills to the lowlands and from the lowlands to the mountains respectively. The significant ($p<0.05$) difference in the faecal egg loads were observed between goats in the mountains to those in the lowlands and the incidence of infection decreased by 64.00% from the mountain to the lowlands.

In terms of coccidial infection of goats in Maseru district, it was found that a change from the lowlands to the foothills insignificantly ($p>0.05$) increased the coccidian infestation rate by 29.00% and significantly ($p<0.05$) by 86.00% from lowlands to the mountains. Moreover, the results showed that, the incidence of infection with coccidia decreased by 31.00% from the mountains to the foothills ($p>0.05$).

In Quthing district, the faecal egg count between goats from the foothills was insignificantly different from those in the lowlands and mountains. However, there was a significant difference in FEC intensity between goats in the mountains and the lowlands ($p<0.05$). The findings of this study suggest that an incidence of coccidial infection decreased by 41.00% from the foothills to the lowlands and by 142.00% from the foothills to the mountains. Furthermore, infection loads from the mountains to the lowlands decreased significantly ($p<0.05$) by 76.00%.

The results of the current study suggest that significant infection in goats between lowlands and foothills could be a result of change in the climatic conditions which favoured survival and development of nematodes. However, insignificant nematode infection in goats between the mountains and the lowlands in Maseru and mountains and foothills Quthing could be attributed to management system such as trans-humance that allow all different flocks from their respective zones and localities to mix especially during summer months giving rise to a good environment for cross infection.

The significant difference between Maseru lowlands and mountains with respect to coccidial counts could be attributed to differences in temperatures suggesting that coccidia thrive well in cooler areas. The coccidia oocyst loads seemed to be the same in the agro-ecological zones of Quthing possibly because of similar temperatures as in the lowlands where Senqu river valley contributes to the cool weather.

Koinari *et al*. (2013) who examined faecal samples of goats reported higher egg per gram for strongyles (nematodes) in the lowlands than in the mountains but strongyloides (nematodes) were higher in the mountains than the lowlands. The study of Mohammed *et al*. (2016) reported highest eggs per gram for nematodes (strongyles) in wet season than dry season in midland areas than highlands and lowlands. Odoi *et al*. (2007) found differences in the faecal egg count (FEC) between semi-humid zones (agro-ecological zone 3) and humid zones (agro-ecological zone 1) where the semi-humid were consistently having higher FEC than those in humid zone. This was attributed to the variations in the agro-ecological zones, which could affect survival and development of infective larval stages of nematodes thereby causing differences in the prevalence and egg loads of gastrointestinal parasites.

Waller and Chandrawathani (2005) outlined the remarkable adaptability of nematodes particularly *H. contortus* over a wide range of environments and the parasite occurs in almost all regions where small ruminants are raised regardless of the climatic zone (Besier *et al*., 2016). Koinari *et al*. (2013) similarly reported higher ($p<0.05$) coccidia (*Eimeria* spp.) oocyst per gram in the mountains but lower in the lowlands. Ratanapob *et al*. (2012) noted that environmental factors like agro-ecological zones, temperature and rainfall patterns are very important in hatching of viable eggs and parasite development all of which can give rise to high parasite infective stages (larvae, oocyst and intermediate hosts) and severity of the parasite.

4.3.8 Effect of age on gastrointestinal parasite egg counts

The results on the effect of age on gastrointestinal parasite egg load are shown in Table 9 and Annex 9. In both districts of Maseru and Quthing, adult goats have relatively higher means of nematode infestation than young goats while the opposite was true with coccidia infestation since young goats in both districts had higher oocyst loads than their adult counterparts. However, the results of the present study showed that the young goats were not significantly ($p>0.05$) different from adults in Maseru and Quthing districts in terms of the intensity of nematode infestation rate and the incidence of nematode infestation increased by 2.00% and 11.00% respectively (Table 9 and Annex 10).

Furthermore, the results of faecal egg loads of coccidia in Maseru and Quthing districts showed that young goats were significantly ($p<0.05$) different compared to the adult goats and the incidence of infection decreased by 80.00% from juveniles to adults in Maseru district while in Quthing district, the rate of infection decreased by 62.00% in terms of the incidence rate ratio.

Table 9: Means of gastrointestinal nematodes and coccidia infections by age

	Maseru				Quthing		
Age	**Mean**	**Exp (B)**	**Exp (B) In %**	**Age**	**Mean**	**Exp (B)**	**Exp (B) In %**
			Nematode				
Adults	471.89^{a}	1.02	2.00	Adults	439.30^{a}	1.11	11.00
Juveniles	464.64^{a}	1	.	Juveniles	395.13^{a}	1	.
			Coccidia				
Adults	340.85^{b}	0.20	80.00	Adults	187.20^{b}	0.38	62.00
Juveniles	1734.82^{a}	1	.	Juveniles	495.79^{a}	1	.

Means within the column with no common superscript differ significantly ($p<0.05$), No. refer to number, Exp (B) refer to exponentiated beta

Lack of significant differences in nematode infestation between the young goats and adults could be because of the same exposure to management and contaminated grazing land. Moreover, some of these animals to some extent might have developed immunity against some parasites. As Hansen and Perry (1994) noted overstocking is a major problem in many

African communal pastures and this might have contributed to the observed increase in the number of nematode egg loads on pastures.

The means of oocyst loads were significantly high in young goats than adult goats. The higher oocyst loads in young goats could be related to the poor management particularly housing and cleaning of the kraals that might have allowed coccidia build up and increased chances of young goats getting infected during nursing.

The present results are in agreement with the findings of Gana *et al*. (2015) who noted that adult goats had higher mean FEC than young animals as a result of ground and extensive grazing. Similarly, Nwoke *et al*. (2015) reported heavy helminth worm burden in adult animals than young ones. Zeryehun (2012) noted that older animals recover from parasitic infection more quickly as their immunity increases with age. Contrarily, Khajuria *et al*. (2013) reported significantly higher mean FEC in young goats as compared to adults and attributed these differences to low levels of immunity in young animals compared to adults. Similarly, Mokhtaria *et al*. (2015) found kids with higher mean gastrointestinal *strongyles* eggs counts per gram of faeces than adult goats.

The lower FEC in adult goats could be due to the fact that adults have a tendency of expelling ingested parasites (Odoi *et al*., 2007). Zvinorova *et al*. (2016) noted that age is a factor affecting FEC with young animals being more susceptible and having higher FEC than the adult goats. Gwaze *et al.* (2009) also reported higher nematode egg counts ($p < 0.05$) in kids than in adult goats.

These findings are similar to those of Zvinorova *et al*. (2016) who reported higher egg loads of coccidial infestation in young goats and linked it with higher rainfall. Sharma *et al*. (2017) also reported higher faecal oocyst count (FOC) in young goats than in adult goats arising from age-wise grouping of animals among other things. Gwaze *et al*. (2009) reported higher egg loads of coccidial infestation in both classes of goats (kids and adults). Mokhtaria *et al*. (2015) reported kids had the highest mean oocysts counts per gram of faeces of *Eimeria* spp than adult goats. Nevertheless, Kahan and Greiner (2013) indicated that the well developed resistance observed in adult goats appear to be relative rather than absolute since adults continue to harbour *Eimeria* spp oocytes in faeces which can be a source of infection for younger goats.

4.3.9 Effect of sex on gastrointestinal parasite egg count

The results in Table 10 showed that sex of an animal plays an important role on gastrointestinal faecal egg load. The male goats had more of both nematodes and coccidial eggs than the female ones.

Table 10: Means of gastrointestinal nematodes and coccidial infections by sex

	Maseru				Quthing		
Sex	**Mean**	**Exp (B)**	**Exp (B) In %**	**Sex**	**Mean**	**Exp (B)**	**Exp (B) In %**
			Nematode				
Male	472.56^{a}	1.02	2.00	Male	424.21^{a}	1.04	4.00
Female	463.98^{a}	1	.	Female	409.19^{a}	1	.
			Coccidia				
Male	869.07^{a}	1.28	28.00	Male	389.52^{a}	1.64	64.00
Female	680.40^{a}	1	.	Female	238.27^{a}	1	.

Means within the column with no common superscript differ significantly (p<0.05), No. refers to number, Exp (B) refers to exponentiated beta

The findings in this study showed non-significant (P>0.05) difference of nematode faecal egg loads between male and female goats in Maseru and Quthing districts. The results further showed that the incidence rate in terms of nematode infection increased by 2.00% from females to males (Table 10 and Annex 11). In Quthing district, the incidence rate in terms of the number of nematodes eggs per gram increased by 4.00% from female to male goats.

In the case of coccidial infection in Maseru, the incidence rate of infection increased by 28.00% whereas in Quthing district, the incidence rate of infection increased by 64.00% from female to male goats (Table 10 and Annex 11). The non- significant differences between male and female goats with respect to nematode and coccidia infections could be attributed to similar management in which the research animals were exposed to and the environment in which they were reared.

The results of the present findings are similar to the studies of Odoi *et al*. (2007) and Zvinorova *et al*. (2016) who reported the non-significant association between sex and helminths number of eggs per gram (EPG). Similarly, Sharma *et al*. (2017) also found non-significant association between sexes with the variations in FEC. Zeryehun, (2012) also found no significant difference between the degree of FEC and sex, which was attributed to the individual host ability to detect or tolerate certain levels of infection without showing susceptibility. Gana *et al*. (2015) on the other hand, found females with higher mean FEC than males.

The findings in this present study are in agreement with report of Sharma *et al*. (2009) who reported that sex did not have effect on FOC as females had higher oocyst loads than males. However, Sharma *et al*. (2017) reported that effect of sex on faecal oocyst count (quantum of infection) revealed significance difference as males showed higher faecal oocyst count (FOC) when compared to females. Zvinorova *et al*. (2016) observed that male goats of all ages were more susceptible to GIP infections than females. Dabasa *et al*. (2017) reported higher *Eimeria* oocysts in male animals than females with no significant difference.

4.3.10 Gastrointestinal parasites trend by months

In this present study, means of nematode infestation decreased from July to August in both Maseru and Quthing districts but increased from August to September (spring season) in Maseru district and became steady to October where it dropped throughout December while in Quthing district, means of infections dropped from September to October where it started increasing throughout December (Figure 9).

Based on trends throughout the study period, coccidial infestation or oocyst accumulation were high in winter (July) but dropped drastically there after (Figure 10).

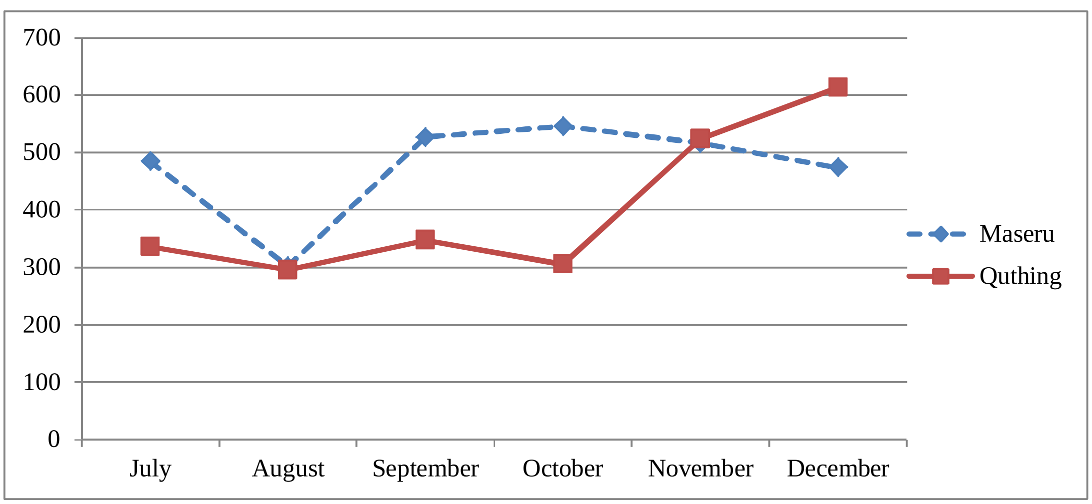

Figure 9: Means of gastrointestinal nematode infection on Angora goats over 6 month period

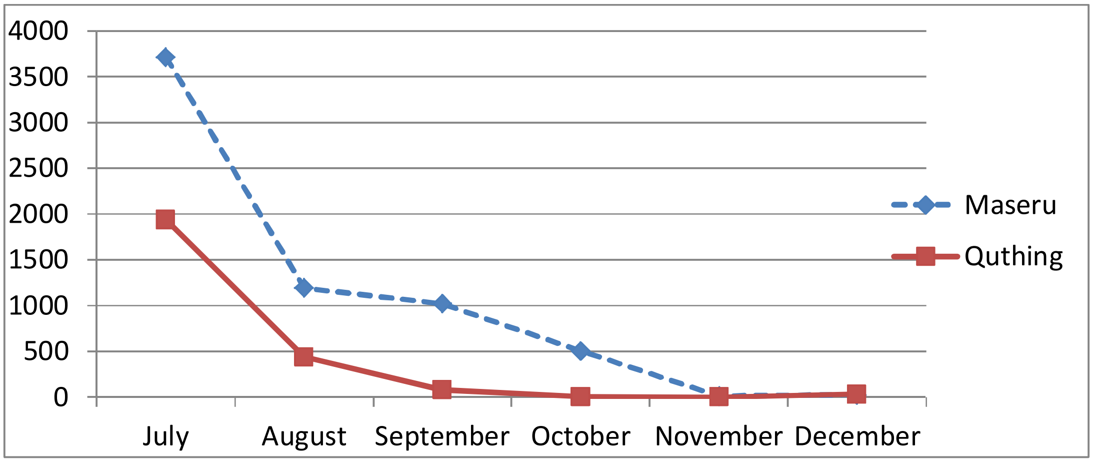

Figure 10: Means of gastrointestinal coccidial infection in Angora goats over 6 month period

The reason for the decrease in the means of nematode infections in July in figure 9 could be because farmers dosed their animals at the beginning of the season to protect them from spring infection. However, an increase in nematode infections from August could be attributed to differences in farm management as in this study; goats from different smallholder farmers practising communal grazing were used. In Maseru district, nematode levels that decreased from October to December could be an indication that farmers have used anthelmintics to protect their goats from summer infection whereas an increase in the means of infection from October to December in Quthing could possibly be an indication of drug resistance.

In the case of coccidia, higher mean infestation in colder months could be because of the prevailing unfavourable climate which might have affected moisture that normally supports grass growth and also browse shrubs which might have dried off and shed at this time possibly forced goats to graze close to faecal materials from where they might have picked much of the infective oocysts. However, The drop in oocyst loads that started immediately after winter and also continued to the warmer months implied a negative relationship between coccidial infestation and temperature suggesting that changes from colder to warmer conditions may be associated with alteration of animal physiological functioning.

On the other hand, lower coccidia infection in warmer months may be contributed by availability of browse which might have reduced grazing hours of goats to the ground thereby reducing the chances of picking infective stages of parasites.

The results of the present study are consistent with the findings of Singh *et al*. (2017) who reported highest mean values of EPG load of helminth infection in monsoon (July - October) followed by winter and then summer. Similarly, Khajuria *et al*. (2013) when comparing months for gastrointestinal helminths in small ruminants reported that the lowest egg per gram (EPG) were recorded during January and the highest during August with two peaks that occurred during August and May in Jammu province, north India.

Kheirandish *et al*. (2014) reported similar results of higher FOC in winter season even though no obvious seasonal patterns were shown in the faecal levels of coccidial oocysts (OPG) in goats in their study. Bakunzi *et al*. (2010) observed higher oocyst counts during the months of January to March (winter season), peaking in March Mafikeng, North West province of South Africa, because those months are associated with heavy rains and higher temperatures that provide a proper environment for oocyst sporulation. The present findings are not consistent with the findings of Sharma *et al*. (2017) who reported high faecal oocyst count in Caprine in summer (March-June) and rainy season (July-October) in India.

4.4. CONCLUSION

Based on the results of this study, nematodes and coccidia were the most commonly identified internal parasites of Angora goats. Lowlands and foothills in Maseru and Quthing districts respectively had higher nematode prevalence and faecal egg loads while coccidia were highly prevalent with higher oocyst loads in the mountains. The prevalence and faecal oocyst loads were higher in young goats. Goats had the same prevalence and faecal egg/oocyst loads regardless of gender. More than 50% of the goats were infected with nematodes from July to December in Maseru and Quthing districts but the intensity of infection was higher from October to December. Coccidial infection was more problematic during the colder months of the year.

4.5 RECOMMENDATIONS

In order to have an integrated control programme for parasites of goats in Lesotho, it is recommended that:

- The effect of agro-ecological zones, age and month of the year be taken into consideration.
- Anthelmintics should be used quarterly in a year (to reduce risk of infection even in all seasons).
- Control measures for coccidia should be aimed more on juveniles in the mountains in winter months and goats should be treated for nematodes regardless of age and sex.
- Continuity research on the parasite ecology and specie composition identification is recommended to be done for twelve months in all the districts of the country covering all the agro-ecological zones to give a clear picture on the pattern of gastrointestinal parasite infections.

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4.7 ANNEXES

Annex 1: Different structures of goatsô kraals

Annex 2: Total number of goats faecal samples examined from 2 districts of Lesotho.

		Lesotho district						
		Maseru			**Quthing**			
Age	**Sex**	**Lowland**	**Foothill**	**Mountain**	**Lowland**	**Foothill**	**Mountain**	**Total**
Juvenile	Female	72	76	63	64	108	76	459
	Male	87	59	56	57	69	64	392
Adult	Female	90	94	81	119	82	75	541
	Male	75	84	64	60	51	69	403

Annex 3: Eggs of parasites identified during the study period

Annex 4: Relationship between agro-ecology and gastrointestinal parasites infections in goats

Maseru					Quthing				
Parameter	**B**	**Std error**	**Sig Level**	**Exp (B)**	**Parameter**	**B**	**Std error**	**Sig Level**	**Exp (B)**
				Nematode					
Agro-ecology									
Mountains	1.510	0.2459	0.000	4.529	Mountains	-1.069	0.2593	0.000	0.343
Foothills	1.731	0.2755	0.000	5.649	Lowlands	-1.810	0.2216	0.000	0.164
Lowlands	0[a]	.	.	1	Foothills	0[a]	.	.	1
				Coccidia					
Agro-ecology									
Mountains	-0.340	0.1153	0.003	0.712	Mountains	-0.879	0.1455	0.000	0.415
Foothills	0.385	0.1128	0.001	1.469	Lowlands	0.250	0.1387	0.071	1.284
Lowlands	0[a]	.	.	1	Foothills	0[a]	.	.	1

Annex 5: Relationship between goatsô age and gastrointestinal parasites infections

		Maseru					Quthing		
Parameter	**B**	**Std error**	**Sig Level**	**Exp (B)**	**Parameter**	**B**	**Std error**	**Sig Level**	**Exp (B)**
				Nematode					
Age									
Adults	0.141	0.2031	0.488	1.151	Adults	-0.025	0.2051	0.903	0.975
Juvenile	0[a]	.	.	1	Juvenile	0[a]	.	.	1
				Coccidia					
Age									
Adults	0.462	0.0924	0.000	1.588	Adults	0.348	0.1167	0.003	1.416
Juvenile	0[a]	.	.	1	Juvenile	0[a]	.	.	1

Annex 6: Relationship between sex of the goats and gastrointestinal parasites infections

		Maseru					Quthing		
Parameter	**B**	**Std error**	**Sig Level**	**Exp (B)**	**Parameter**	**B**	**Std error**	**Sig Level**	**Exp (B)**
				Nematode					
Sex									
Males	-0.128	0.1922	0.507	0.880	Males	-0.303	0.2000	0.130	0.739
Females	0[a]	.	.	1	Females	0[a]	.	.	1
				Coccidia					
Sex									
Males	-0.146	0.0918	0.112	0.864	Males	0.041	0.1184	0.726	1.042
Females	0[a]	.	.	1	Females	0[a]	.	.	1

Annex 7: Prevalence of cestodes and trematodes by agro-ecology, age and sex in Maseru and Quthing

Maseru				Quthing			
Risk factor	**No. Samples Examined**	**No. Samples Infected**	**Prevalence (%)**	**Risk factor**	**No. Samples Examined**	**No. Samples Infected**	**Prevalence (%)**
			Cestodes				
Agro-ecology							
Lowland	324	1	0.30	Lowland	300	1	0.30
Foothill	313	0	0.00	Foothill	310	0	0.00
Mountain	264	1	0.40	Mountain	284	6	2.10
Goats age							
Juvenile	413	2	0.50	Juvenile	438	7	1.60
Adult	488	0	0.00	Adult	456	0	0.00
Sex							
Female	476	1	0.20	Female	524	5	1.00
Male	425	1	0.20	Male	370	2	0.50
			Trematode				
Agro-ecology							
Lowland	0	0	0.00	Lowland	300	2	0.70
Foothill	0	0	0.00	Foothill	310	0	0.00
Mountain	0	0	0.00	Mountain	284	0	0.00
Goats age							
Juvenile	0	0	0.00	Juvenile	438	0	0.00
Adult	0	0	0.00	Adult	456	2	0.40
Sex							
Female	0	0	0.00	Female	524	2	0.40
Male	0	0	0.00	Male	370	0	0.00

Annex 8: Monthly prevalence of gastrointestinal cestodes and trematodes of goats from two districts of Lesotho in 6 months period

	Maseru				Quthing		
Month	**No.Samples Examined**	**No. Samples Infected**	**prevalence (%)**	**Month**	**No.Samples Examined**	**No. Samples Infected**	**prevalence (%)**
			Cestode				
July	163	0	0.00	July	138	0	0.00
August	154	0	0.00	August	170	0	0.00
September	160	0	0.00	September	167	0	0.00
October	125	0	0.00	October	148	6	4.10
November	157	0	0.00	November	138	0	0.00
December	142	2	1.40	December	133	1	0.80
			Trematode				
July	0	0	0.00	July	138	0	0.00
August	0	0	0.00	August	170	0	0.00
September	0	0	0.00	September	167	0	0.00
October	0	0	0.00	October	148	0	0.00
November	0	0	0.00	November	138	1	0.70
December	0	0	0.00	December	133	1	0.80

Annex 9: Loads of gastrointestinal nematodes and coccidia by agro-ecological zone

		Maseru					Quthing		
Parameter	**B**	**Sig Level**	**Exp (B)**	**Exp (B) In %**	**Parameter**	**B**	**Sig Level**	**Exp (B)**	**Exp (B) In %**
				Nematode					
Agro-ecology									
Mountains	-0.117	0.266	0.890	11.0	Mountains	-0.114	0.342	0.892	10.8
Foothills	-0.861	0.000	0.423	57.7	Lowlands	-1.145	0.000	0.318	68.2
Lowlands	0^a	.	1	.	Foothills	0^a	.	1	.
				Coccidia					
Agro-ecology									
Mountains	0.622	0.002	1.862	86.2	Mountains	0.884	0.101	2.421	142.1
Foothills	0.252	0.258	1.286	28.6	Lowlands	-0.536	0.295	0.585	41.5
Lowlands	0^a	.	1	.	Foothills	0^a	.	1	.

Annex 10: Loads of gastrointestinal nematodes and coccidia by age of the goats

		Maseru					Quthing		
Parameter	**B**	**Sig Level**	**Exp (B)**	**Exp (B) In %**	**Parameter**	**B**	**Sig Level**	**Exp (B)**	**Exp (B) In %**
				Nematode					
Age									
Adults	0.015	0.864	1.016	1.60	Adults	0.106	0.285	1.112	11.20
Juvenile	0^a	.	1	.	Juvenile	0^a	.	1	.
				Coccidia					
Age									
Adults	-1.627	0.000	0.196	80.40	Adults	-0.974	0.000	0.378	62.20
Juvenile	0^a	.	1	.	Juvenile	0^a	.	1	.

Annex 11: Means of gastrointestinal nematodes and coccidia infections by sex

		Maseru					Quthing		
Parameter	**B**	**Sig Level**	**Exp (B)**	**Exp (B) In %**	**Parameter**	**B**	**Sig Level**	**Exp (B)**	**Exp (B) In %**
				Nematode					
Sex									
Males	0.018	0.836	1.018	1.80	Males	0.036	0.718	1.037	3.70
Females	0^a	.	1	.	Females	0^a	.	1	.
				Coccidia					
Sex									
Males	0.245	0.165	1.277	27.70	Males	0.492	0.160	1.635	63.50
Females	0^a	.	1	.	Females	0^a	.	1	.

CHAPTER 5

5.0 GENERAL CONCLUSION

The current study was aimed at assessing farmersô awareness and control methods for gastrointestinal parasites of Angora goats; determining the prevalence and GIP egg loads of Angora goats for over 6 months. Farmers were aware of more than one parasite and tapeworm was the most common GIP known by farmers. Farmers were not familiar with coccidia. Gastrointestinal parasites were found to be the major constraint of goat production and young goats were mostly affected. Higher infections by GIPs were observed in summer months. Farmers depended on commercial anthelmintics and traditional medicines to treat their animals. Most of farmers kept their flocks in open kraals that were not regularly cleaned. Rangelands were communally used and grazing management like rotation and zero grazing were practised as range management.

Agro-ecological zone was found significant where lowlands and foothills had highest prevalence and egg loads of nematode in Maseru and Quthing respectively while the mountains had higher coccidia prevalence and oocyst loads. Young goats were significantly infected by coccidia. Sex did not have any influence on the prevalence and egg/oocyst loads of both nematode and coccidia across the two districts. Higher number of ova of nematodes was observed in July and September in Maseru and Quthing districts respectively although the higher intensity of infection per animal was observed in October and December. As coccidial infestation was intense in July therefore, the prevalence and egg/oocyst loads of nematodes and coccidia observed in the study suggest that holistic approach by relevant stakeholders should be employed in order to reduce or control the problems associated with gastrointestinal parasites.