EVALUATING PREVALENCE AND CONTROL METHODS OF GASTROINTESTINAL PARASITES OF MERINO SHEEP IN LESOTHO

BY

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Thesis

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Evaluating the prevalence, faecal egg count and control methods of gastrointestinal parasites of Merino sheep in Lesotho

SUMMARY

This research project incorporated two studies. The first study was based on farmer's awareness and control methods of gastrointestinal parasites of Merino sheep in Lesotho. The study was achieved by simple random sampling of 216 farmers from three agro-ecological zones (lowlands, foothills and mountains) covering the central and southern regions of the country. Qualitative data was collected from the focus group discussions and individual interviews conducted in three villages per agro-ecological zone. Over 78% of farmers in these agro-ecological zones are aware of different gastrointestinal parasites of sheep and associated this problem with high mortality rates of lambs. Majority of farmers (70%) in all agro-ecological zones reported high prevalence of gastrointestinal parasites in summer and autumn. Almost all farmers in their respective agro-ecological zones use anthelmintics as a control measure against gastrointestinal parasites; however, there are still some farmers who indicated ineffectiveness of the anthelmintics. Many farmers (81%) in the lowlands keep their sheep in non-roofed enclosures followed by the mountains (67%) and foothills (57%); however, cleaning of the enclosures is not done properly. In all agro-ecological zones more than 80% of farmers believed that communal grazing is the main source of gastrointestinal parasites transmission. The lower education level of farmers is believed to be the main contributor of improper management of the grazing systems and gastrointestinal parasites management practices.

The second study focused on the prevalence and faecal egg count of gastrointestinal parasites of Merino sheep in Lesotho. The aim was to evaluate the effect of agro-ecological zone, age, sex and different times of the year on the prevalence and faecal egg loads of gastrointestinal parasites. A total of 1,919 faecal samples were collected over a period of six months (July to

December) from the sheep sampled in different agro-ecological zones of Maseru and Quthing districts. The samples were examined using floatation method in McMaster technique and observed under the light microscope to find the faecal egg count per gram. Three types of gastrointestinal parasites eggs were identified (nematodes, cestodes and coccidia). Agro-ecological zones and the age of the animal had a significant effect ($p<0.05$) on both prevalence and faecal egg loads of gastrointestinal parasites. Nematodes were most prevalent with high faecal egg loads in the lowlands than other agro-ecological zones. Coccidian prevalence and faecal egg loads was significantly ($p<0.05$) affecting lambs than the adult sheep in both districts. Sex of the animal had no significant influence on both prevalence and faecal egg loads of gastrointestinal parasites. Gastrointestinal nematodes accumulate more with the increasing temperature and rain falls while coccidia prevails more in lower temperature of the winter months in both districts.

DECLARATION

I declare that this thesis is an original report of my research, has been written by me and has not been submitted in any previous degree or professional qualification. The experimental work is almost entirely my own work, the collaborative contributions have been indicated clearly and acknowledged. Due references have been provided on all supporting literature and sources.

Motšelisi Mahlehla

Signature:………………………………………………………

Date:…………………………………………………………..

DEDICATION

Every challenging work needs self-efforts as well as guidance of the fore runners and elders especially those who were very close to our hearts. This research is humbly dedicate to the Faculty of Agriculture, Department of Animal Science with their successful guidance in the fulfilment of this research. Finally, dedications of this work is directed to my husband, my families and my friends whose untiring support and assistance have made possible the fruition of my efforts.

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LIST OF ABBREVIATIONS

GIP= Gastrointestinal parasites

FEC= Faecal Egg Count

EPG= Eggs per Gram

G= Gram

^{0}C= Degrees Celsius

BOS= Bureau of Statistics

LMS= Lesotho Meteorological Services

Exp. = Exponential

B= Beta

Sig. = Significance

Jul= July

Aug= August

Sept= September

Oct= October

Nov= November

Dec= December

CHAPTER 1

1.0 INTRODUCTION

1.1 Background

Lesotho is a southern African country with a total land area of 30,355 square kilometres. The country is divided into four agro-ecological zones which are; the lowlands in the west, lying between altitudes of 1500m and 1830m and characterized by relatively high rainfall. This zone takes about 15% of the total country. The foothills are in the centre between 1830-2130 meters above sea level, covering about 8% of the country with lower rainfall and temperatures compared to the lowlands (Table 1). The Orange River valley runs from east to west across the country covering 11% of the total area. The valley is characterized by a low rainfall especially in the south-western part and it lies between 1500 and 2250 meters above sea level. The mountain range zone covers 66% of the total area and is characterized by very cold winters. It rises to elevation of 3500 meters and constitutes by far the largest, and yet the least densely populated part of the country. It is in the mountainous zone where rangelands are mostly found and livestock is commonly found. It comprises about 66% of the total area of Lesotho (Mafisa, 1993).

Table 1: Monthly average temperatures (^{0}C) in three agro-ecological zones of Lesotho in 2016

Agro-ecology	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug	Sept	Oct.	Nov.	Dec.
						Maseru						
Lowlands	30	29	27	24	19	16	15	19	23	25	26	29
Foothills	27	26	24	21	15	12	11	16	20	22	24	26
Mountains	23	22	19	16	10	6	5	10	15	18	20	22
						Quthing						
Lowlands	30	30	29	26	22	20	17	23	24	25	27	31
Foothills	27	26	25	22	17	14	12	18	21	22	24	27
Mountains	22	21	18	15	11	7	6	10	15	16	19	22

The highest population of Merino sheep in Lesotho is found in the mountainous region (50-55%) while with other regions it fluctuated over the years (Matebesi, 2014). The local Merino is described as hardy and well adapted to the environment of Lesotho. The latest statistics show that the population of merino sheep stands around one million three hundred and forty six thousand five hundred and ninety six (1,346,596) as reported by BOS (2014). This depicts a decrease of 15% from 2012.

Livestock plays a very crucial role in the economy of Lesotho by increasing the economic state of the rural poor. However, livestock are infected with different diseases due to improper care, dirty environment and poor grazing systems (Susan, 2013). Parasitism in sheep is a very serious problem afflicting many farmers globally. Gastrointestinal parasites infection is the most limiting factor in sheep productivity and has a highly detrimental effect on the sheep industry (Jones, 2001). Small ruminant diseases due to parasites take the lion's share in limiting the productivity of these animals all over the world (Ibrahim *et al.*, 2014). Despite the type of production system in which small ruminants are kept, there is still extreme susceptibility to the effects of helminths for both small scale and large scale farmers in developing countries leading to economic loss (Gana *et al.*, 2015). Common parasites of small ruminants include nematodes, coccidian, roundworms, tapeworms and liver flukes (Bagley, 1997). BOS (2014) shows that 8.66% of sheep died because of gastrointestinal parasites infection in 2013/2014.

Communal grazing significantly contributes to a wide spread and infection of gastrointestinal parasites in Lesotho. Apart from that, the situation is worsened by the fact that grazing systems are not properly practiced, like rotational grazing, in order to break the life cycle of the helminths. The prevalence of gastrointestinal helminths is related to agro-climatic conditions like quantity and quality of pasture, temperature, humidity and grazing behaviour of the host (Pal and Qayyum, 1993). Rangeland management in Lesotho is a shared responsibility between chiefs and land allocation committees (community councils) that decide on range management principles and practices that enhance animal production and productivity (Motsamai, 1990).

Gastrointestinal parasitism varies greatly from one year to the next and between different geographical locations depending on the prevailing climatic conditions (Odoi *et al.,* 2007). Lambs in comparison with adult sheep tend to have little or no natural immunity to gastrointestinal parasites especially at their first grazing period; hence, why the L_3 stage of gastrointestinal parasites on the pasture affect them easily and this brings high mortalities of naive lambs (Abbott *et al*., 2012). Males are more susceptible to gastrointestinal parasites than females due to the production of androgen hormone, which is known to reduce immunity. (Urquhart *et al.,* 1996).

Despite the large population of sheep and their economic importance in Lesotho, little is known about the prevalence, species diversity and the level of infestation of gastrointestinal parasites. Knowledge of the nature and level of gastrointestinal parasitism in different agro-ecological zones, months of the year, sex and age is very important in order to recommend the most cost-effective control measures. Therefore, the objective of this study was to evaluate the prevalence, faecal egg load and control measures of gastrointestinal parasites of sheep in the three agro-ecological zones of Lesotho.

Figure 1: Example of the merino sheep in Lesotho

1.2 Problem statement

Sheep production is one of the most economically important industries in Lesotho because of wool, production which is a valued export commodity contributing 5% to the GDP of the country (WAMP, 2014). However, one of the most noteworthy antagonistic factors to sheep farming is parasitic diseases. Basotho farmers are faced with a challenge of high mortality rates mostly seen in lambs and decreased wool yield per sheep (average of 2.27kg) (WAMP), which is believed to be caused by the gastrointestinal parasites of sheep. Despite the fact that farmers still use medication in their animals, the mortality rate is not reduced, which could be attributed to improper drugs administration. Sheep production is mainly in the hands of less educated and unskilled farmers and this itself is believed to be a constrained of expanding sheep production in Lesotho.

1.3 Objectives

1.3.1 General Objective

To evaluate the prevalence, faecal egg load and control methods of gastrointestinal parasites of sheep in Lesotho.

1.3.2 Specific Objectives

a) To evaluate the social characteristics of sheep farmers in Lesotho.

b) To evaluate the awareness of sheep farmers on gastrointestinal parasites.

c) To evaluate control methods of gastrointestinal parasites in sheep.

d) To evaluate animal and grazing management practices of sheep farmers.

e) To evaluate prevalence and faecal egg load of gastrointestinal parasites in different agro-ecological zones.

f) To evaluate prevalence and faecal egg load of gastrointestinal parasites between different age groups of sheep.

g) To evaluate prevalence and faecal egg load of gastrointestinal parasites between different sex groups of sheep.

h) To evaluate prevalence and faecal egg load of the gastrointestinal parasites of sheep over a period of six months (July to December).

1.4 Hypothesis

a) Farmer's social characteristics do not affect their sheep farming.

b) Farmers are aware of gastrointestinal parasites.

c) Control of gastrointestinal parasites does not differ between farmers.

d) The management on gastrointestinal parasites and the grazing systems practiced by farmers do not differ.

e) Prevalence and faecal egg loads of gastrointestinal parasites is not affected by agro-ecological zone.

f) Age and sex of sheep do not affect the prevalence and faecal egg loads of gastrointestinal parasites in sheep.

g) Gastrointestinal parasites are not affected by change in times of the year.

1.5 Justification

The results of this study would create awareness of the gastro-intestinal parasites that are affecting sheep production with a view of sensitizing farmers and stakeholders interested in sheep farming on how they can be controlled. Therefore, farmers will be in a position to treat their animals with the precise medication. Adoption of the appropriate and effective measures towards controlling the prevailing gastro-intestinal parasites, which include adhering to the dosing schedule would be practiced, and hence increased profits would be realized.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 Introduction

Gastrointestinal parasites are categorized into worms (helminths) and oocyst-forming protozoa known as coccidia. Nematodes, trematodes and cestodes are the three major types of parasitic helminths of economic importance (Kusiluka and Kambarage, 1996). Nematodes are the most serious parasites in terms of disease and production loss (Singh, 2013). Gastrointestinal parasites have become a problem for sheep production worldwide, especially when the movement or grazing of sheep on pastures is restrained and/or when their forage type or range is not controlled (Coffey and Hale, 2012 and Roeber *et al.,* 2013). This can increase the likelihood of sheep becoming infested and thus heightens the need for parasite control. This has led to the development of various chemical solutions, including the development of a wide array of anthelmintic drenches (Shalaby, 2013). The current financial and agricultural losses caused by parasites control and treatment have a substantial impact on farm profitability (Roeber *et al.,* 2013).

Globally, gastrointestinal parasites cost sheep farmers significant amount of money each year because of treatment cost, increased level of management, loss of production and mortality in severe cases (Brown and Tier, 2003, Matebesi, 2014). Furthermore, Fikru *et al.* (2006) reported that gastrointestinal parasites cause losses through lowered fertility, reduced work capacity, involuntary culling, a reduction in food intake and lower weight gains, lower milk production, treatment costs and mortality in heavily parasitized animals.

Parasites take an advantage of causing a disease when they are present in large numbers or when the host animal is weakened by another disease or by poor nutrition (Van, 2010). Higher prevalence and faecal egg load of gastrointestinal parasites can also result in impaired ability of the host animal to absorb nutrients, causing poor body condition (emaciation), unthriftiness, low milk production, and or poor hair coat or fleece growth. Some parasites cause a reduction in appetite by the host animal (Van, 2010).

Susan (2013) indicated that sheep are more vulnerable to internal parasites because they are slow to acquire immunity since it takes about 10-12 months for the lambs to develop immunity. This can also be aggravated by the fact that at lambing, sheep suffer a loss of immunity, which does not restore itself until approximately four weeks after lambing and their faecal pellets disintegrate easily hence the worm larvae are released on pastures (Susan, 2013).

In small ruminants, helminthiasis is determined by several factors governed by parasite -host-environment interactions. The major epidemiological variable influencing worm burdens of grazing ruminants is the infection rate from pastures, which is in turn influenced by the climatic requirement for egg hatching, larval development and survivability (Barger, 1999; Vlassoff *et al*., 2001).

Host-related factors are age, immunity, sex, species and genetic resistance; parasite-related factors include life history, duration of the histotropic phase, survival of larvae in the environment and their location in the host; environmental factors include climate, weather, season, type of vegetation and microclimate (Roeber *et al.,* 2013).

2.2 Effect of agro-ecological zone

The variation in prevalence of parasitic infestation depends upon differences in agro climatic conditions and availability of susceptible host (Singh *et al*., 2013). Macroclimate and microclimate play an important role in the epidemiology of ruminant helminthiasis.

Different factors combine to make up the macroclimate such as rainfall, temperature, cold, wind, humidity, etc. (Singh *et al*., 2013).

High nematodes prevalence is probably related to a relatively short generational interval and their ability to maximise conducive environments such as an average monthly maximum temperature of 18^0C or above and 50mm total rainfall (Raza *et al.,* 2007). Climatic conditions which vary from tropical to subtropical are conducive for the development of larval forms or the intermediate hosts of helminths with indirect life cycles. The free-living stages of nematodes favour the warm and moist summer for their survival and development. In most green pastures which are well irrigated or even waterlogged, the spread of helminths life cycle is assisted and the pasture larval prolificacy also increases (Raza *et al.,* 2007).

Transmission of coccidiosis to lambs favours warm and wet environmental conditions. Koinari *et al.* (2013) found that there is no significant difference between the prevalence and eggs per gram count (EPG) in different agro ecological zones. In their study they indicated that the mean EPG of coccidia is higher in the highlands than in the lowlands but their prevalence is higher in the lowlands than in the highlands. Koinari *et al*. (2012) found that between the lowlands and highlands, there is no significant difference in the occurrence of different types of gastrointestinal parasites except for *Emeria* species and Fasciola species whereby *Emeria* species are found to be occurring more in the highlands than in the lowlands but Fasciola species are most prevalent in the lowlands than in the highlands.

2.3 Effect of age on gastrointestinal parasites infestation

There is an inverse relationship between an age of sheep, the prevalence and FEC of gastrointestinal helminths in sheep (Horak *et al.,* 1991). Gastrointestinal nematodes burden decrease with host age, however, with *Teladorsagia* species of nematodes it becomes a different case since it increases until the age of two years (Craic *et al.,* 2006). The intensity of T. *axei* and T. *vitrinus* declines with host age. Craig *et al.* (2006) further indicated that decrease in intensity of T. *axei* is the result of sterilization of immune response. Although acquired immunity is said to be neutralising the infection of *Teladorsagia* species, this effect is not strong enough for T. *axei.* Furthermore, Waller *et al.* (1981) found that in lambs, there is a sudden reduction in T. *axei* burden which is normally found after reaching the threshold intensity of species, although *Teladorsagia* species have a continual density-dependent turnover, which occurs when adult worms are lost and replaced (Waller *et al.,* 1981).

Coccidiosis is generally associated with young animals because their immune system has not developed the ability to combat heavy infections as indicated by Joseph (2003). The author also observed that coccidiosis is very common in sheep, especially young, growing lambs. Older sheep serve as sources of infection for young sheep. The immune capability of lambs is initially low but increases with the magnitude and duration of exposure to infection (Vlassoff *et al.*, 2001).

Alade and Bwala (2015) reported that higher infestation of these parasites in suckling lambs is attributed to a weaker immunological response of young lambs but older animals recover quickly from parasitic infection because immunity increases with age due to repeated exposure to gastrointestinal parasites infection. Although *Emeria* species are frequently found in faecal samples, their appearance is influenced by age and immunity status of a host (Yakhchali and Zarei, 2008 and Hashemnia *et al.,* 2014).

Narsapur (1988) indicated that Monenzia (tape worm) infection in lambs causes a serious weight loss, convulsion and death. Other authors (Nilon and Feuvre, 2012) have shown that tapeworm have no significant effect on production and growth performance of sheep despite the intensity of infection. Furthermore, Lewis *et al.* (2016) found that lambs are very resilient towards tapeworms before weaning and adults though maybe infected with tapeworms, the effect is not severe except on heavy infection when they suffer intestinal blockages and pulpy kidney may result.

On contrary, Tehmina *et al.* (2014) found that the prevalence of gastrointestinal parasites are higher in sheep of two or more years old which are adult sheep, but lower in young sheep of one year and lower. Biu and Oluwafunmilayo (2004) also reported higher prevalence of gastrointestinal parasites in adult sheep than in young sheep on the other hand; Zvinorova *et al.* (2016) revealed the similar infection of coccidia, nematodes and other infectious gastrointestinal parasites for all age groups.

2.4 Effect of sex on gastrointestinal parasites infestation

Female sheep have higher faecal egg count of gastrointestinal parasites (nematodes and tapeworms) because of pregnancy and lambing periods which makes them to be more susceptible than the male sheep (Alade and Bwala, 2015). Similarly, Tehminas *et al.* (2014) and Magdy *et al.* (2009) also indicated that there is higher prevalence of gastrointestinal parasites in female sheep than male sheep. Ewes, at parturition stage are more exposed to gastrointestinal parasites and susceptible to infection than male sheep due to the loss of immunity at parturition. (Parkins and Holmes, 1989).

On contrary, *Strongyle* species are known for their detrimental effect in nematodes infection so much that it has been revealed that juvenile males are at high risk of susceptibility (Craig *et al* 2006). Strongyle egg counts are generally higher in males than females and they decrease significantly with age in females and to the yearling stage in males (Wilson *et al.* 2004).

In Addition, *Trichostrongylus* species are considerably causative agents of high counts for *strongyle* species, particularly in juvenile males given that *Trichostrongylus* species are four times more than *Teladorsagia* species in juvenile host; and the proportion of female to male adults is higher for *Trichostrongylus* species than *Teladorsagia* species (Craig *et al.,* 2006).

Furthermore, Urquhart *et al*, (1996) showed that the higher susceptibility of males is due to the production of androgen hormone which is known to reduce immune response in males. Mushtag and Tasawar (2011) also stated that the production of oestrogen in females stimulate immunity against gastrointestinal parasites. In addition, Raza *et al*. (2007) reported high prevalence and intensity of infestation in males than females except at parturition and a decrease of infestation with age of hosts in both sexes. Therefore, there is no possible explanation for host-sex differences among different ruminants except for variation in the stages of pregnancy.

2.5 Seasonal variation

For many gastrointestinal parasitic diseases whose developments outside the definitive host are sensitive to temperature and humidity, if there comes any change in the microclimate of a specific area, this will hypothetically have reflective effects on the parasite epidemiology. The seasonal dynamics of nematode infestation are the consequence of complex inter-relationships between the sheep, their husbandry and the prevailing climate.

The patterns of pasture contamination by nematode eggs and the larvae, and the subsequent levels of infestation in ewes and lambs are broadly similar throughout the year (Vlassoff, 2001). Numbers of infective larvae on pasture build up over summer to a peak in autumn/early winter within some years and a spring peak derived from the parturient rise in faecal nematode egg counts (FEC), expressed in eggs per gram of faeces (epg), in lactating ewes.

The prevalence of gastrointestinal helminths is related to the agro-climatic conditions like quantity and quality of pasture, temperature, humidity and grazing behaviour of the host (Pal and Qayyum, 1993). The optimal temperature for hatching, larval development and L_3 survival varies by parasite. The incidence of liver fluke disease is greatly influenced by wet seasons, especially in areas which are not well drained, such areas which encourage the growth of snails which are the intermediate hosts for *Fasciola* parasite species (Owen, 1989 and Taylor, 2010).

In winter lambing systems, coccidia outbreaks are common in 3–4 weeks old lambs and kids (Joseph, 2003). *Emeria* species are present in sheep throughout the year but their intensity increases during the late fall and the entire winter (Yakhchali and Zarei 2008). The infestation of *Emeria* species favours rainfall but with lower temperature and high relative humidity. Climate influences infective larval availability and, therefore, rates of infestation, through direct effects on the development and survival of the free-living stages and translation of larvae onto pasture (O'Connor *et al.,* 2006).

Menzies *et al.* (2010) explained that the development of all parasites is favoured when temperatures range from 25^0C to 30^0C. However, if the weather is hot, the L_3 may die more rapidly because their metabolic rate increases and they outlive their stored nutrients (L_3 cannot feed) before infecting a host. At temperatures less than 10^0C, larval development and moulting do not occur. At temperatures less than 5^0C, the metabolic rate of L_3 is very low allowing prolonged survival, e.g. overwintering on pasture, (Menzies, *et al.,* 2010).

At faecal pellet or ground level the humidity should be greater 80% to allow for development. Although L_1 and L_2 will not, the L_3 can survive desiccation because of protection of the cuticle covering, even at freezing temperatures. Some species of L_3 (e.g. *Teladorsagia* species but not *Haemonchus*) can enter a state of "anhydrobiosis" which allows them to survive severe cold and desiccation, making them well suited for several conditions (Gadahi *et al.,* 2009).

During warm seasons and humid climates, gastrointestinal parasites find it conducive for them to multiply, even the spread becomes high. The optimal temperature of their larval growth is between 50°C and 80°C and the optimal rainfall is at least 5 centimetres. Most larvae die in very hot or very cold climates. In late winter and early spring larvae increase in numbers (Gadahi *et al.,* 2009).

2.6 Grazing systems and management of rangelands

Internal parasites pose a serious health limitation on grazing animals. Their infections most commonly occur when animals are communally grazing, particularly under conditions of poor sanitation and less rotational grazing practices (T'sotetsi and Mbali, 2003). Nwosu *et al*. (2007) stated that the management practices adopted by the farmers for rearing of sheep favours the occurrence of parasitic infestations, which is a serious health problem limiting the productivity of small ruminants including sheep due to associated morbidity, mortality, cost of treatment and control measures.

Overstocking is a major problem in large parts of the world particularly in Africa because it forces the animal to graze closer to faecal material which inexorably results in the uptake of higher number of infective larvae (Hansen and Perry, 1994). Grazing animals eat the encysted cercariae along with the grass for initial infection. Hay or fresh grass cut and carried can transfer metacercariae, which is the infective stage of liverflukes to confined animals. Lambs in lambing pens, intensive grazing areas, and feedlots are at greatest risk and stress often induces outbreaks of coccidiosis (Susan, 2013).

Pasture and rangelands management is done through the cut-and-carry technique, proper rotational grazing and avoiding marshlands. This strategy is ideal but is difficult to implement in the traditional production system (Ibrahim, 1998). However, it is important to develop awareness of grazing management techniques among the farmers. Susan (2013) also stated that a clean grazing land include pastures and rangelands that have not been grazed by sheep or goats for the past 6 to 12 months; rangelands which have been grazed by horses or cattle; pasture fields in which a hay or silage crop has been removed; pasture fields which have been rotated with field crops; and pastures that have been recently established or renovated by tillage.

Susan (2013) further indicated that while burning a rangelands will remove worm larvae, there are no treatments that will effectively eliminate or reduce worm larvae because some of them can live for years under conducive environments. Heavy stocking rates and insufficient rangeland rest period contributes to high prevalence of gastrointestinal parasites in sheep and lambs. Gastrointestinal parasites tend to be less of a problem in areas where the grazing system is done in such a way that there is pasture and rangelands rest between grazing seasons.

2.7 Animal management practices

Control of gastrointestinal parasites is best achieved through livestock management, chemotherapy, immunization and through a good knowledge of local epidemiology (Ibrahim, 1998). Internal parasite control starts with good management as elaborated by Susan (2013).

Sheep should not be fed on the ground and their feeders which cannot easily be contaminated with faeces, and water should be clean and free from faecal matter. As a way of controlling gastrointestinal parasites, Stephen (2011) emphasised that animals should be dosed based on their age groups (adults, yearlings, young animals, neonates).

If any drugs/natural products are long used, resistant worms will develop (Stephen, 2011). Infection is ubiquitous in grazing sheep and control of disease is generally achieved by frequent administration of anthelmintic drugs to suppress egg output and consequently infection pressure. However, the spread and increasing prevalence of anthelmintics resistance threatens the efficacy of this approach and the sustainability of nematode control in sheep (Coles, 2002 and Papadopoulos, 2008).

Therefore, there is increasing interest in alternative methods of control. Since none of the available options can provide adequate gastrointestinal parasites control on their own, their use must be integrated and applied in a targeted manner for maximum economic gain (Miller and Jackson, 2006). This relies on good understanding of the epidemiology of gastrointestinal nematodes, which is driven by climate and management. In addition, sustainable use of anthelmintics to control nematodes relies on preserving susceptible genotypes *in refugia* (Wyk *et al.*, 2001) and the contribution of helminthes *in refugia* to the next generation will itself depend on climate (Papadopoulos *et al.,* 2001).

Understanding the interactions between climate, larval availability and sheep management provides the key to designing effective and sustainable control practices, which can be adapted to changes in the industry and in climate itself (Barger, 1999). The anthelmintic drugs are expensive and there are several factors that highlight the need to alternative control strategies to parasite control (Marley *et al.*, 2003). For example, the rapid development of anthelmintic resistance has limited the success of gastrointestinal parasites nematode control in grazing ruminants. The use of anthelmintic drug has become a problem with their affordability, accessibility and the safety. Recently, it has been reported that they are toxic to human health and are present in foods derived from livestock (Waller, 1999; Nunomura *et al*., 2006; Dewanjee *et al*., 2007).

In many cases, ethno-medications do have apparent rationale and beneficial effects (Getchell *et al*., 2002). 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 farmer (Tabuti *et al*., 2003, Njoroge and Bussmann, 2006).

2.8 The life cycles of GIP

Knowledge of life cycles and their timing is important in controlling parasites as certain drugs are only effective against specific stages in parasite development. Sometimes control is possible by reducing the numbers of an intermediate host (O'Donoghue, 2010).

Generally, helminths form three main life-cycle stages being eggs, larvae and adults. The duration of the life cycles is 2.5 to 3 months depending on the parasite species (Ibrahim, 1998). Cestode eggs released from gravid segments embryonate to produce six-hooked embryos (hexacanth oncospheres), which are ingested by intermediate hosts. The oncospheres penetrate host tissues and become metacestodes (encysted larvae). When eaten by definitive hosts, they excyst and form adult tapeworms.

Trematodes have complex life-cycles where 'larval' stages undergo asexual amplification in snail intermediate hosts. Eggs hatch to release free-swimming (cilliated) miracidia, which actively infect snails and multiply in sac-like sporocysts to produce numerous rediae. These stages mature to cercariae which are released from the snails and either actively infect new definitive hosts or form encysted metacercariae on aquatic vegetation, which is eaten by definitive hosts.

Coccidia have a very complex life cycle, with many steps and various stages at which intestinal cells are damaged (Coffey 2014). The cycle begins when oocysts are passed in faeces and ingested by the animal. Once inside, the parasite invades cells and then reproduces and invades more cells. The original oocysts ingested can be multiplied many times and cause a great deal of damage to intestinal cells before the coccidia can be detected in the animals' faeces. Animals may die before showing any signs of coccidiosis if exposure is sudden and high (lots of oocysts in the young animals' environment) and if the animals are stressed (Smith and Sherman, 1994; Daugschies and Najdrowski, 2005; Chartier and Paraud, 2012). When an animal is gradually exposed on coccidial infection several times, its immune system can develop resistance that slows the rate of coccidial reproduction in the host's intestinal tract. Developing this resistance takes time (five to six months). Afterward the animal will still pick up infections and shed coccidia in its faeces, thus contaminating the environment, but it generally will not show signs of illness (Chartier and Paraud, 2012; Smith and Sherman, 1994).

2.9 References

Abbott, K.A., M. Taylor, L.A. Stubbings, 2012. *Sustainable Worm Control Strategies for sheep*, 4th Edition. Sustainable Control Of Parasites in Sheep, United Kingdom. http://www.scops.org.uk

Adams, F. and K.O. Yankyera, 2014. *Socio-economic Characteristics of Subsistent Small Ruminant Farmers in Three Regions of Northern Ghana*. Asian Journal of Applied Science and Engineering, 3(3):351-364.

Aga, T.S., Y.H. Tolossa and G. Terefe, 2013. *Epidemiology of gastrointestinal nematodes of Horro sheep in Western Oromiya*, *Ethiopia*. Journal of Veterinary Medicine and Animal Health, 5 (10): 296-304.

Alade, N. K. and M. D. Mbwala, 2015. *Gastrointestinal-parasites infestation in Yankasa sheep in a semi –arid environment*. Livestock research for rural development, 27(6).

Andrews, S.J., 1999. *The Life Cycle of Fasciola hepatica*. In: Fasciolosis, Dalton, J.P. (Ed.). CAB International, Oxon: 1-29.

Ayalew, T., B. Duguma, and T. Tolemariam, 2013. *Socio-economic and farm characteristics of smallholder cattle producers in Ilu Aba zone of Oromia regional state, South Western Ethiopia*. Global Veterinaria, 10(5): 607-613.

Bagley, C.V., 1997. *Internal Parasites*. Utah State University Extension, Logan, United States of America: 1-3.

Barger, I.A., 1999. *The role of epidemiological knowledge and grazing management for helminths control in small ruminants*. International Journal of Parasitology, 29: 41–47.

Biu, A.A. and A. Oluwafunmilayo, 2004. *Identification of some Paramphistomes infecting sheep in Maiduguri, Nigeria.* Pakistan Veterinary Journal, 24(4): 187-189.

Brown, D.J. and B. Tier, 2003. A*lternate methods for estimating breeding values for faecal egg count data from Merino studs across Australia.* Proceedings of the Association for the Advancement of Animal Breeding and Genetics, 15: 115-118.

Bureau of Statistics, 2014. *Statistical year book.* Bureau of Statistics Report No: 8 of 2014. http://www.kt.iger.bbsrc.ac.uk

Chartier, C. and C. Paraud, 2012. *Coccidiosis due to Eimeria in sheep and goats, a review.* Small Ruminants Research 103: 84-92. http://dx.doi.org

Coffey, L., 2014. *Coccidiosis: Symptoms, Prevention, and Treatment in Sheep, Goats, and Calves.* National Center for Appropriate Technology, America.

Coffey, L. and M. Hale, 2012. *Tools for managing Internal Parasites in Small Ruminant: Pasture Management. National Center for Appropriate Technology, Agriculture Specialists*: 1-20 http://www.attra.ncat.org.

Coles, G.C., 2002. *Cattle nematodes resistant to anthelmintics*: why so few cases? Veterinary Research, 33:481–489.

Craig, B.H., J.G. Pilkington and J.M. Pemberton, 2006. *Gastrointestinal nematodes species burdens and host mortality in feral sheep population*. Institution of Evolutionary Biology, Scotland: 485-496.

Dagnachew, S., A. Amamute and W. Temesgen, 2011. *Epidemiology of gastrointestinal helminthiasis of small ruminants in selected sites of North Gondar zone, Northwest Ethiopia*. Ethiopia veterinary journal, 15 (2): 57-68.

Dantankwa, A. and K. Asafu-Adjei, 2001. *Policies for improving the competitiveness of smallholder livestock producers in Ghana challenges and opportunities*. In: Ehui, S., Barry, M.B., Williams, T.O., Koffi-Koumi, M.P.Z. (Editions), Central Coridor of West Africa. Implications for trade and regional integration, Abijan, cote d'ivore.

Daugschies, A. and M. Najdrowski, 2005. *Eimeriosis in Cattle: Current Understanding.* Journal of Veterinary Medicine Series B, 52 (10): 417–427.

Dewanjee, S., Maiti A., Kundu M., S.C. Mandal, 2007. *Evaluation of Anthelmintic activity of crude extracts of Diospyros peregrine*, Coccinia grandis and Schima wallichii.Dhaka University Journal of Pharmaceutical Sciences, 6(2): 121-123

Esker, M. and H.W. Ploeger, 2000. *Value of present diagnostic methods for gastrointestinal nematodes infections in ruminants*. Cambridge University Press. Division of parasitology and tropical veterinary medicine, 37:609-610.

Eysker, M., J.H. Boersema, F.N.J. Kooyman and H.W. Ploeger, 2000. *Resilience of second year grazing cattle to parasitic gastroenteritis following negligible to moderate exposure to gastrointestinal nematode infections in their first year.* Veterinary Parasitology, 89:37-50.

FAO, 1988. Farm structures in tropical climates. http://www.fao.org

Fikru, R., S. Teshale, D. Reta and K. Yosef, 2006. *Epidemiology of Gastrointestinal Parasites of Ruminants in Western Oromia, Intern Ethiopia*: Journal of Applied Research Veterinary Medicine, 4 (1): 51-57.

Fitch, G. Q., 2006. *Internal Parasite Control in Sheep in Oklahoma*. United States of America. http://pods.dasnr.okstate.edu

Gadahi, J. A., M. J. Arshed, Q. Ali, S. B., Javaid and S. I. Shah, 2009. *Prevalence of Gastrointestinal Parasites of Sheep and Goat in and around Rawalpindi and Islamabad, Pakistan.* Veterinary World, 2(2): 51-53.

Gana, J.J., H. Makun, N., P. Chiezey and L.B. Tekdek, 2015. *Epidemiological study on abomasal nematodes in slaughtered small ruminants raised in the guinea savannah zone of Nigeria. Sokoto*. Journal of Veterinary Sciences, 13(2):26-33. http://dx.doi.org

Gauly, M., Schackert M., Hoffmann B., G. Erhardt, 2006. *Influence of sex on the resistance of sheep lambs to an experimental Haemonchus contortus infection.* Dtsch. Tierarztl. Wochenschr, 113: 178–181.

Getchell, J.K., Vatta, A.F., Motswatswe, P.W., Krecek, R.C., Moerane, R., Pell, A.N, Tucker, T.W. & Leshomo, S., 2002, '*Raising livestock in resource-poor communities in the North West Province of South Africa: A participatory rural appraisal study*', Journal of the South African Veterinary Association, 73(4):177-184

Joseph, V., 2003. Infectious and parasitic diseases of captive passerines. Seminars in Avian and Exotic Pet Medicine, 12(1): 21-28. http://dx.doi.org.

Hansen, J. and B. Perry, 1994. *The Epidemiology, Diagnosis and control of Helmiths Parasites of Ruminants.* International Laboratory for Research on Animal Disease, Nairobi, Kenya: 158-168.

Hashemnia, M., F. Rezaei, A. Chalechale, S. Kakaei and S. Gheichivand, 2014. *Prevalence and Intensity of Eimeria infection in sheep in Western Iran*. International Journal of Livestock Research, 4(1):107-112.

Holmes, P.H., 1993. *Interaction between parasites and nutrition*. Veterinary Consequences. Proceedings of Nutrition Society, 52:113-120.

Horak, I.G., M.M. Knight and E.J. Williams (1991). *Parasites of domestic and wild animals in South Africa.* Helminths and Arthropods of Angora goats and kids. Onderstepoort Journal of Veterinary Research, 58:253-260.

Sheep worm control, 2007. Parasites and disease; *Nematodes in the environment*. http://sydney.edu

Ibrahim, H., 1998. *Small ruminant production techniques*. ILRAD, Manual No.3, ILRI, Nairobi, Kenya: 1-36.

Ibrahim, N., M. Tefera, M. Bekele and S. Alemu, 2014. *Prevalence of Gastrointestinal Parasites of Small Ruminants in and Around Jimma Town, Western Ethiopia.* Acta Parasitologica Globalis, 5 (1): 12-18.

Jackson, F., J.E. Miller 2006. *Alternative approaches to control – Quo vadis*. Veterinary Parasitology, 139:371-384.

Jones, R. (2001): *Sheep Parasites and Diseases*. http://www.kt.iger.bbsrc.ac.uk

Koinari, M., S. Karl, U. Ryan and A. J. Lymbery, 2012. *Infection levels of gastrointestinal parasites in sheep and goats in Papua New Guinea*. Journal of Helminthiology, 87(4): 1-7.

Koinari, M., S. Karl, U. Ryan and A. J. Lymbery, 2013. Infection levels of gastrointestinal parasites in sheep and goats in Papua New Guinea. Journal of Helminthiology, 87(4): 409-415.

Kudrnacova, M. and I. Langrova, 2012. *Occurance and seasonality of domestic sheep gastrointestinal parasites.* Scintia Agricultuae Bohemica, 43(3):104-108.

Kusiluka, L. and D. Kambarage, 1996. *Diseases of small ruminants*: A hand book of Common diseases of sheep and goats in Sub-Saharan Africa. VETAID, Centre for Tropical Veterinary Medicine Overseas Development Administration Health Programme: 8-21.

Lashari, M.H. and Tasawar Z., 2011. Prevalence of Some Gastrointerstinal Parasites in sheep in Southern Punjab, Pakistan, Pakistan Veterinary Journal, 31(4): 295-298.

Lemma, D. and B. Abera, 2013. *Prevalence of ovine gastrointestinal nematodes in and around Asella, South Eastern Ethiopia*. Journal of Veterinary Medicine and Animal Health, 5(8): 222-228. http://www.academicjournals.org.

Lesotho Meteorological Services, 2013. *The climate of Lesotho*: Ministry of Energy, Meteorology and Water Affairs, Lesotho.

Lewis, M.D., A.F. Francisco, M.C. Taylor, S. Jayawardhana and J.M. Kelly, 2016. *Host and parasites genetics shape a link between Trypanosoma Cruzi infection dynamics and chronic cardiomyopathy.* Cellular Microbiology, 18(10): 1429-1443.

Mafisa, T., 1993. *Wool and Mohair Productioin Lesotho*. Future of livestock production industries in East and Southern Africa. International Livestock Centre for Africa, FAO, Roma, Italy.

Maingi, N., Bjorn, H., Thamsborg, S.M., Dangolla, A. & Kyvsgaard, N.C.. 1996a. *Worm control practices on sheep farms in Denmark and implications for the development of anthelmintic resistance.* Veterinary Parasitology, 66: 39–52.

Maingi, N., Bjorn, H., Thamsborg, S.M., Dangolla, A. & Kyvsgaard, N.C., 1996b. *A questionnaire survey of nematode parasite control practices on goat farms in Denmark.* Veterinary Parasitology, 66: 25–37.

Marinda, P., Bangura, A., and F. Heidhues, 2006. *Technical efficiency analysis in male and female managed farms, a study of maize production in West Pokot district, Kenya.* Gold Coast, Australia.

Marley, C.L., Cook R., Keatinge R., Barrett J. and Lampkin N.H., 2003. *The effect of birdsfoot trefoil (Lotus corniculatus) and chicory (Cichorium intybus) on parasite intensities and performance of lambs naturally infected with helminth parasites*. International Veterinary Parasitology, 112:147-155.

Matebesi, P., 2014. *Merino Breeding in Lesotho.* Merino 2014 South Africa.

Menzies, M, A. Reverter, N. Andronicos, P. Hunt, R. Windon, A. Ingham, 2010. *Nematode challenge induces differential expression of oxidant, antioxidant and mucous genes down the longitudinal axis of the sheep gut*. Parasite Immunology, 32 (1): 36-46

Motsamai B., 1990. *Management of communal range resources in Lesotho*. Unpublished report.

Muluneh, J., B. Bogale and M. Chanie, 2014. *Major Gastrointestinal Nematodes of Small Ruminants in Dembia District*. Northwest Ethiopia European Journal of Applied Sciences, 6(2): 30-36.

Mushtaq, H. L., and Z. Tasawar, 2011. *Prevalence of some gastrointestinal parasites in sheep in Southern Punjab, Pakistan*. Pakistan Veterinary Journal, 31:295-298.

Narsapur. V.S., 1988. Pathogens and Biology of anoplocephalinecestode of Domestic Animals. Annals of Veterinary Research journal, 19: 1-17.

Niezen, J.H., H.A. Robertson, A. Sidey and S.R. Wilson, 2002. *The effect of pasture species on parasitism and performance of lambs grazing one of the three grass white clover pasture swards.* Veterinary Parasitology, 105:303-315.

Njoroge, G. N. and R.W. Bussmann, 2006. *Herbal usage and informant consensus in ethnoveterinary management of cattle diseases among the Kikuyus (Central Kenya).* Journal of Ethnopharmacology, 108: 332-339.

Nunomura, R.C.S., F.C.C. Dasilva, D.F. Oliverira, A.M.Garcia, J.N. Boeloni, S.M. Nunomura and A.M. Pohlit, 2006. *In vitro studies of the anthelmintic activity of Picrolemma sprucei Hook.f. (Simaroubaceae).* Acta Amaz, 36(3):327–330.

Nwosu, C.O., P.P. Madu and W.S. Richards, 2007. *Prevalence and seasonal changes in the population of gastrointestinal nematodes of small ruminants in the semi-arid zone of north-eastern Nigeria*. Veterinary Parasitology, 144:118–124.

Nyamweya, N.J., 2010. *Prevalence and control of sheep nematodes in Kanyariri University farm, Kiambu county, Kenya* Degree dissertation: 1-30.

O'Connor, L.J., B. S.W. Walkden and L.P. Kahn, 2006. *Ecology of the free-living stages of major trichostrongylid parasites of sheep.* Veterinary Parasitology, 142(1/2):1–15

O'Donoghue, P., 2010. *Parasite helminths*. Australian Society of Parasitology, University of Queensland, Australia.

Odoi, A., J.M. Gathuma, C.K. Gachuiri and A. Omore, 2007. *Risk factors of gastrointestinal nematode parasite infections in small ruminants kept in smallholder mixed farms in Kenya*. BMC Veterinary Research, 3 (6): 1746-6148.

Orthman, J.N, Rizgar. R.S and Shadan H.A., 2014. *Prevalence of the gastrointestinal tract parasite in goats in sulaimani province.* Assiut Veterinary Medicine Journal, 60(141):25-28.

Owen, I.L., 1989. *The epidemiology of fasciolosis in Papua New Guinea.* Australian Veterinary Journal, 66:58–60.

Pal, R.A and M. Qayyum, 1993. *Prevalence of gastrointestinal nematodes of sheep and goats in upper Punjab, Pakistan.* Pakistan Veterinary Journal, 13(3): 138-141.

Papadopoulos, E., 2001. *Drought and flock isolation may enhance the development of anthelmintic resistance in nematodes.* Veterinary Parasitology, 97(4):253-259.

Papadopoulos, E., 2008. *Anthelmintics resistance in nematodes*. Small Ruminants Research, 76(1):99-103.

Parkins, J., and P. Holmes, 1989. *Effects of gastrointestinal helminths parasites on ruminant's nutrition.* Nutrition Research reviews, 2:227-246.

Pfukenyi, D.M. and S. Mukaratirwa, 2013. *A review of the epidemiology and control of gastrointestinal nematode infections in cattle in Zimbabwe*. Onderstepoort Journal Journal of Veterinary Research, 80 (1):1-12. http://dx.doi.org

Ploeger, H.W., A.F.G. Antonis, J.C. Verkaik, P. Vellema, and M.H. Bokma-Bakker, 2016. *Perceptions and actions of Dutch sheep farmers concerning worm infections.* Veterinary Parasitology, 229:150-158.

Raza, M. A., M. Younas and E. Schlecht, 2014. *Prevalence of gastrointestinal helminths in pastoral sheep and goat flocks in the cholistan desert of Pakistan.* The Journal of Animal and Plant Sciences, 24(1):127-134.

Raza, M. A., Z. Iqbal, A. Jabbar, M. Yaseen, 2007. *Point prevalence of gastrointestinal helminthiasis in ruminants in southern Punjab.* Pakistan Journal Helminthology, 81:323–328.

Regassa, F., Sori T., Dhuguma R., Y. Kiros, 2006. *Epidemiology of gastrointestinal parasites of ruminants in western Oromia, Ethiopia.* International Journal Applied Research Veterinary Medicine, 4(1):51.

Roeber, F., A. Jex and R.B. Gasser, 2013. *Impacts of gastrointestinal parasitic nematodes of sheep and the role of advanced molecular tools for exploring epidemiology and drug resistance.* Parasites and Vectors, 6(1):153.

Sangster, N., 2007. *How parasites affect production*. Australian Wool Innovation and The University of Sydney. http://sydney.edu

Shahid, R., Q. Abdul, S. A. Abdul and C.S. Hayat, 1997. *Parasitic infection of sheep and goats in quetta and kalat areas of balochistan,* Pakistan Veterinary Journal, 17(2):94-96.

Shalaby, H.A., 2013. *Anthelmintics Resistance; How to overcome it.* Iranian Journal of Parasitology, 8(1):18-32.

Sharma, D.K., A. Nimisha, M. Ajoy, N. Pooja and S. Bhushan, 2009. *Coccidia and gastrointestinal nematode infections in semi-intensively managed Jamunapari goats of semi-arid region of India*. Tropical and Subtropical Agro Eco-Systems, 11(1): 135-139.

Sharma, D.K., S. Paul, P.K. Rout, A. Mandal, S. Bhusan, N. Sharma and Y.K. Kushwah, 2017. *Caprine coccidiosis in semi-arid India: Dynamics and factors affecting faecal oocysts count*. Journal of Advanced Veterinary and Animal Research, 4(1): 52-57.

Singh, V., P. S.K. Varshney, H.P. Dash and Lal, 2013. *Prevalence of gastrointestinal parasites in sheep and goats in and around Mathura, India*. Veterinary World, 6 (5):260-262.

Singh, E, P.Kaur, L.D. Singla, and M. S. Bal, 2017. *Prevalence of gastrointestinal parasitism in small ruminants in western zone of Punjab, India*. Veterinary world, 10(1):61-66.

Smith, M. C., and D.M. Sherman, 1994. *Sheep and goat medicine*. Lippincott Williams and Wilkins, Philadelphia, PA: 312–318.

Soulsby, E.J.L., 1986. *Helminths, Arthropods and Protozoa of Domesticated Animals*. 7thEdition. Baillì ere Tindall. London.

Susan, S., 2013. *Sheep 201, a beginners' guide to raising sheep: Internal parasite (worm) control.* University of Maryland, United States of America.

Stephen, P., 2011. *Intestinal Parasites in Camelids and Small Ruminants.* University of Massachusetts, United States.

Tabuti, J. R. S., S.S. Dhillion and K.A. Lye, 2003a. *Ethnoveterinary medicines for cattle (Bos Indicus) in Bulamogi country,* Uganda: plant species and mode of use. Journal of Ethnopharmacology, 88: 279-286.

Tasawar, Z., F. Naz, M. H. Lashari, and C.S. Hayat, 2011. *Prevalence of Ostertagia spp. in a sheep herd*. Sarhad. Journal of Agriculture, 27:275-278.

Tay, S. C.K., S.Y. Gbedema and T.K. Gyampomah, 2011. *Accuracy of diagnosis of intestinal helminth parasites in a reference diagnostic laboratory in the Ashanti region of Ghana*. International Journal of Parasitology Research, 3(1):12-16.

Taylor, M. A., 2010. *Parasitological examinations in sheep health management.* Small Ruminant Research, 92 (1-3): 120-125.

Taylor, M.A., R.L. Coop, R.L. Wall, 2007. *Parasites of sheep and goats* In: Veterinary Parasitology, 3rd Edition, Oxford UK: Blackwell Publishing: 398-562.

Tehmina, S., R. Shahina, A. Razzaq, I.B. Marghazani and A.N. Khosa, 2014. *Prevalence of Paramphistomum cervi in different sheep breeds of Balochistan (Pakistan).* Paramphistomum cervi en ovejas. Revista Veteterinaria, 25: (1)12-15.

Terefe, D., D. Demissie, D. Beyene and S. Haile, 2012. *A prevalence study of internal parasites infecting Boer goats at Adami Tulu.* Journal of Veterinary Medicine Animal Health, 4:12-16.

Theodoropoulos, G., H. Theodopolous, G. Zervas and E. Bartziokas, 2001. *Nematode parasite control practice of sheep and goat farmers in the region of Trikal*, Greece Journal of Helminthology, 74:89-93.

Tsotetsi, A.M., Mbati P.A., 2003. *Parasitic helminths of veterinary importance in cattle, sheep and goats on communal farms in the north eastern Free State,* South Africa. Journal of the South African Veterinary Association, 74: 45–48

Urquhart, G.M., J. Armour, J.L. Duncan, A.M. Dunn and F.W. Jennings, 1994. *Veterinary Parasitology*. 1st Edition Longmann; Singapore.

Urquhart, G.M., J. Aremour, J.L. Dunchan, A.M. Dunn and F.W. Jeninis, 1996. *Veterinary parasitology* 2nd Edition. The University of Glasgow, Blackwell Sciences, Scotland: 3-137.

Van, D.M., 2010. *Gastrointestinal Parasites in Sheep and Goats*: Colorado State University Extension, United States of America.

Villarroel A. (2013). *Internal Parasites in Sheep and Goats.* Oregon State University: 1-4 http://oregonstate.edu.

Vlasoff, A., D.M. Leathwick and A.C.G. Heath, 2001. *The epidemiology of nematode infections of sheep.* New Zealand Veterinary Journal, 49:213-221.

Waller, P.J., A.D. Donald and R.J. Dobson, 1981. *Arrested development of intestinal Trichostrongylus spp. in grazing sheep and seasonal changes in the relative abundance of T. colubriformis and T. vitrinus*. Research of Veterinary Science; 30(2):213–216.

Waller, P.J., K.M. Dash, I.A. Barger, L.F. Jambre and J. Plant, 1995. *Anthelmintic resistance in nematode parasites of sheep*. Veterinary Record, 136: 411 – 413.

Waller, P.J., 1999. *International approaches to the concept of integrated control of nematode parasites of livestock.* International Journal Parasitology, 29:155–164.

Whittier, D.W., A. Zajac and S.H. Umberger, 2009. *Control of internal parasites in sheep.* Virginia Cooperative Extension: 1-8 http://pubs.ext.vt.edu.

Whittier, W.D., A. Zajac and S.H. Umberger, 2003. *Control of internal parasites in sheep*. Virginia State University, St Petersburg.

Wool and Mohair Promotion Project (WAMP), 2014. *Project design*. IFAD, Lesotho.

Wyk, J.A., G.F. Bath, H.T. Groeneveld, M.O. Stenson and F.S. Malan, 2001. *Extensive testing of the FAMACHA system for accuracy of clinical evaluation of anaemia caused by Haemonchus spp.* Proceedings of the 5th International Sheep Veterinary Congress, Stellenbosch, South Africa.

Yakhchali, M. and M.R. Zarei, 2008. *Prevalence of Eimeria infection in sheep of Tabriz suburb.* Iran. Iranian Journal of Veterinary Research, 9 (3): 277-280.

Zeryhun, T., 2012. *Helminthiosis of sheep and goats in and around Haramaya, Southeastern. Ethiopia*. Journal of Veterinary Medicine and Animal Heath, 4(3): 48-55.

Zvinorova, P.I., T.E. Halimani, F.C. Muchadeyi, O. Matika, V. Riggio and K. Dzama, 2016. *Prevalence and risk factors of gastrointestinal parasitic infections in goat in low-input-output farming systems in Zimbabwe.* Small Ruminants Research, 143:75-83.

CHAPTER 3

Awareness and control methods of gastrointestinal parasites of Merino sheep in Lesotho

Abstract

This study evaluated the prevalence and control methods of gastrointestinal parasites in sheep in the three agro-ecological zones of Lesotho. Data was collected using a simple random sampling from 216 farmers in the lowlands, foothills and mountains. The majority of farmers (78%) were aware of the gastrointestinal parasites. During warm seasons (summer and autumn) tape worms and nematodes were problematic and the liver flukes (trematodes) were higher in dry seasons (winter and spring). More farmers (70%) reported higher prevalence of gastrointestinal parasites and the associated lamb mortality in summer and autumn. Farmers use anthelmintics for treating gastrointestinal parasites in animals and 93% of them reported the effectiveness of the drugs. The results revealed that 81%, 57% and 64% of farmers from the lowlands, foothills and mountains respectively keep their sheep in non-roofed enclosures cleaned only after rains to avoid the mud. Communal grazing is used as a main source of animal feeding of which different livestock species share the same rangelands. The majority of farmers (83%) believed that grazing lands were the main source of gastrointestinal parasites. Farmers have little knowledge on proper management of gastrointestinal parasites.

Keywords: Lowlands, foothills, mountains, gastrointestinal parasites, Merino sheep, farmers.

3.1 INTRODUCTION

In Lesotho like in any other Sub-Saharan African countries, subsistent agriculture production remains the main employer of the labour force of which livestock farming assumes a critical role (Ogunmefun and Achike, 2015). Livestock has potential to increase income for all farmers especially the rural poor and could serve as an insurance against food deficit during extended droughts (Adama and Yakyera, 2014 and Dantankwa and Asafu-Adjei, 2001). However, livestock farming is mostly in the hands of illiterate or less educated men than women in most developing countries (Ayelew *et al.,* 2013 and Marinda *et al.,* 2006).

The health and productivity of grazing sheep is at threat due to prevalence of gastrointestinal parasites and as a control measure, farmers depend mostly on the use of anthelmintics (Pfukenyi and Mukaratirwa, 2013). However, currently the effectiveness of these anthelmintics is lessened by the development of anthelmintics resistance in many animals and this phenomenon has been a great problem for different regions in the world (Theodoropoulos *et al.,* 2000 and Ploeger *et al.,* 2016). This problem is caused by incorrect anthelmintic use coupled with lack of skills by farmers to control or apply medication (Maingi *et al.,* 1996). Anthelmintics use is so widespread that without it, researchers believe that sheep industry could suffer a lot. Anthelmintics have proved successful control in different gastrointestinal parasites especially when their use is integrated with good farm management practices (Theodopoulos *et al.,* 2000 and Stear *et al.,* 2007). According to Tabuti *et al*. (2003), the use of ethnic medicine for control of gastrointestinal parasites is gaining popularity especially in the developing countries because of being readily accessible, easy to prepare and administer and farmers access them at little or no cost at all.

Since in most developing countries, the system of grazing that is preferred is communal grazing, rotational grazing between sheep and cattle should be considered a practical approach to reducing contamination of pastures with parasites (Mafisa, 1993). Alternating different species ease the breakdown with species of parasites life cycles. Hansen and Perry (1994) indicated that the comparison of intensive grazing with small scale grazing when applied under rotational grazing system coupled with anthelmintics use, showed that intensive grazing lead to reduced pasture and rangelands contamination with parasites. Githigia *et al.* (2001) further indicated the necessity of moving weaned lambs to a clean pasture before the expected mid-summer rise in parasitic infection. In addition, Neizen *et al*. (2002) indicated that some herbage species like white clover could be used to reduce production losses caused by internal parasitism.

Therefore, the objective of this study was to evaluate the awareness and control methods of gastrointestinal parasites of sheep in Lesotho.

3.2 MATERIALS AND METHODS

3.2.1 Study site

This research project was conducted in the three agro-ecological zones (lowlands, foothills and mountains) of Lesotho covering Maseru and Quthing districts. Each agro-ecological zone was represented by three villages under one woolshed. The meetings were held in their respective woolsheds.

3.2.2 Selection of farmers per agro-ecological zone

A cross sectional study was conducted using a simple random sampling procedure in which a total of 216 respondents was engaged in data collection. Prior to selection of farmers, a brainstorming session was held with the Director of Livestock Services, Extension Officers and Lesotho Wool and Mohair Growers Association on the objectives of the study and farmers selection criteria. The ILRI Feed Assessment Tool (FEAST) methodology was used for sampling (ILRI, 2015). The FEAST method involved a set of forms and procedures intended to help a facilitator sample and collect data related to local conditions and agricultural practices. The focus group discussion was formed with 15 famers per village and a group was guided in this discussion. In addition to focus group discussion, the individual farmers interviews composed of nine farmers per village selected from those who participated in a focus group discussion were conducted. To achieve individual interviews, farmers were categorised into three groups forming small, medium and large holder's categories respectively for less than 50, 51-100 and over 100 sheep herds. Each category was represented by 3 farmers.

3.2.3 Data analysis

Data collected during the focus group discussions and individual interviews were captured into the Microsoft excel in order to produce reports and graphs. Data were analysed with Statistical Package for Social Sciences (SPSS, 20.00). Descriptive statistics were employed in order to have a summary description of data collected. This involved the use of percentages, means and frequency distributions to describe the socioeconomics characteristics of farmers, gastrointestinal parasites awareness and control.

3.3 RESULTS AND DISCUSSION

3.3.1 Socio-economic characteristics of sheep farmers from three agro-ecological zones

Majority (37%) of farmers in the lowlands were 31-40 years old while in the foothills (51.8%) and mountains (32%) farmers were above 50 years old as indicated in Table 2. Over 80% of farmers in all agro-ecological zones are men of which 74% are married. Sheep production farming is dominated by farmers with only primary education comprised of 74.1%, 57.5% and 40% respectively for the lowlands, foothills and mountains. The highest number of farmers (32%) who did not attend school at all is found in the mountains as compared to those in the foothills (24%) and lowlands (15%).

Table 2: Farmers respondents on their social characteristics

Profile	Category	Lowlands (%)	Foothills (%)	Mountains (%)
Age	<30	11.10	16.65	16.00
	31-40	37.00	24.05	28.00
	41-50	18.50	7.40	24.00
	>50	33.30	51.80	32.00
Gender	Male	81.50	90.50	84.00
	Female	18.50	9.25	16.00
Occupation	Farmer	100.00	100.00	100.00
Education	No education	14.80	24.05	32.00
	Primary	74.10	57.40	40.00
	Secondary	7.40	11.10	16.00
	High school	3.70	7.40	12.00
Experience	1-5	29.60	29.50	20.00
	6-10	11.10	29.50	20.00
	11-20	33.30	14.80	32.00
	>20	25.90	25.90	28.00

The lowlands and mountains have farmers who have been in sheep industry for 11 to 20 years while in the foothills 29.5% farmers have a maximum of five years' experience in sheep farming. The majority of farmers (100% in lowlands, 99% in foothills and 96% in the mountains) were members of farmers' associations despite only 50% of them claiming to benefit positively from the associations through workshops.

Livestock farming seems to be the major source of living in all agro-ecological zones. The percentage gender distribution of farmers from lowlands showed that sheep farming is in the hands of male farmers who are middle aged and this could make it easier for them to adapt new techniques required for the improvement of sheep industry. However, it would really be a challenge as most of farmers had attained only primary education qualification which did not go deep in livestock farming (more than 58%). This observation is not surprising as culturally livestock farming activity is perceived as more or less tedious work that needs a lot of energy and strength. This case is supported by Adamas and Yankyera (2014) and Ayalew *et al.* (2013) who stated that it is common in the developing countries that culturally men are responsible for household productive assets.

As seen from the results, most farmers in the foothills and mountains are older men (50 years) and this means that it would be difficult for them to keep up with modern technologies intended to improve sheep productivity, especially when those with primary education only and those who did not go to school at all constitute 40% and 32% respectively in the mountains, 57% and 24.05% respectively for the foothills. The young active men who should form a bulk of work force in sheep industry are very few and seem to be deserting farming. Apparently this trend does not encourage the improvement of livestock farming which is left in the hands of old farmers who are illiterate and less energetic. The significance of education in farming is attested by Marinda *et al.* (2006) who emphasised that without education sheep farming improvements and technologies cannot be applied. Lack or shortage of training sheep farmers suggests the need to strengthen the extension services.

3.3.2 Farmers' Perceptions on Gastrointestinal Parasites

Gastrointestinal Problem in different age groups

The higher percentage of farmers in the lowlands (93%), foothills (87%) and mountains (100%) indicated gastrointestinal parasites as a major problem in sheep industry as indicated in Figure 2. Majority of farmers (over 88%) in all agro-ecological zones indicated that the gastrointestinal parasites affect the wool, animal health, and lead to increased mortality rates.

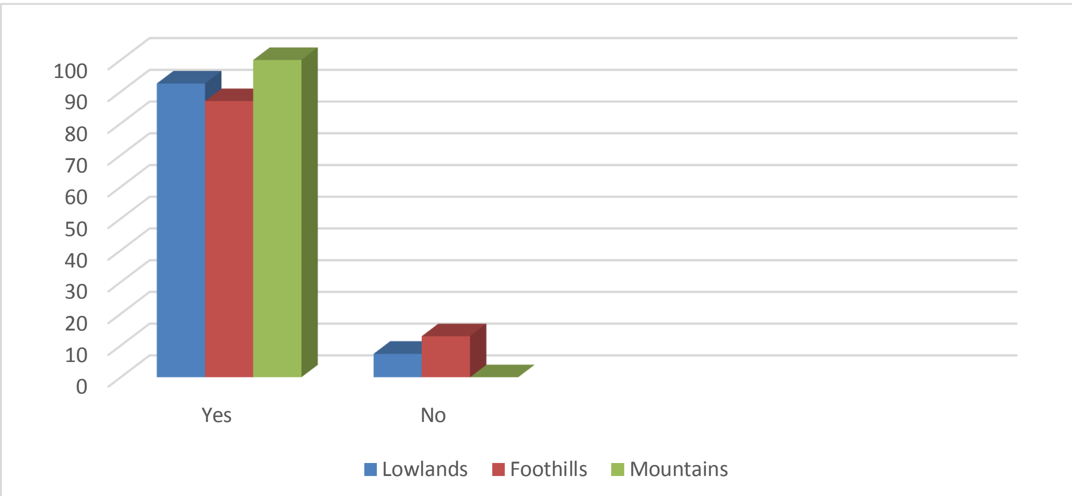


Figure 2: Farmers responses on gastrointestinal parasites problem in their herds

Most farmers in the lowlands (63%), foothills (74.1%) and mountains (80%) regarded lambs to be more vulnerable to deaths caused by gastrointestinal parasites compared to other age groups of sheep and the apparent symptom that they mentioned was diarrhoea. (Figure 3).

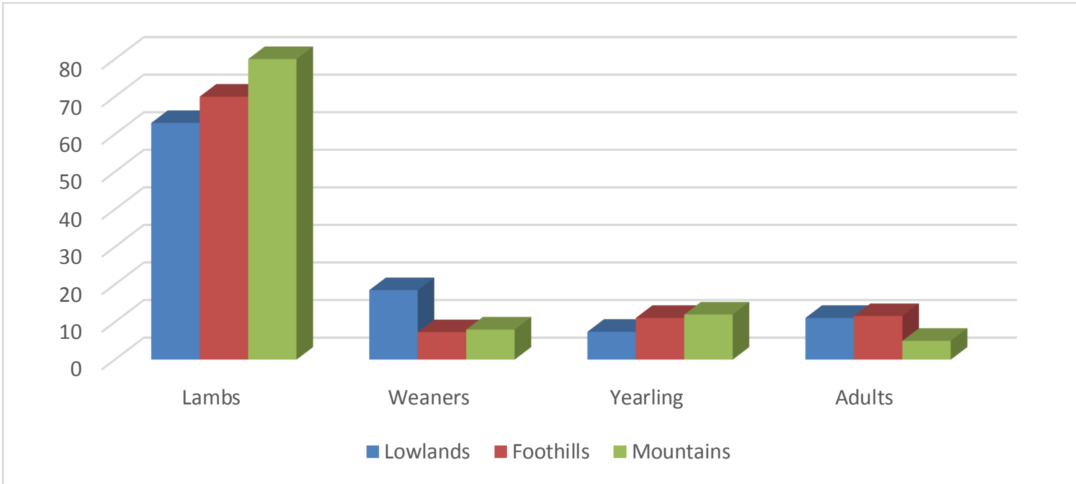


Figure 3: Farmers responses on mortality rates by different age groups in agro-ecological zones

Farmers perceive gastrointestinal parasites as a major threat to sheep production and consider lambs to be severely affected (Figure 3). It is believed that the susceptibility of sheep to internal parasites is caused by the ability of faecal pellets to disintegrate very easily thus releasing the worm larvae on the pastures and rangelands, therefore enhance the spread of gastrointestinal parasites (Susan, 2003).

Furthermore, sheep become more vulnerable because they graze very close to the soil hence easily pick up the hatched larvae and oocysts. This is even worsened by the fact stated by farmers in their focus group discussion that rangelands have deteriorated greatly so much that animals could easily pick up infective stages of parasites or even eggs of the parasites. The severity of gastrointestinal parasites effect seen mainly in lambs is usually associated with high mortality rates (Figure 3). Several authors (Joseph, 2013, Vlassoff *et al.*, 2001 and Horak *et al.*, 1991) associated lambs mortality with severe diarrhoea caused by coccidiosis and continued to say that coccidiosis is generally seen in young animals because their immune system has not developed the ability to combat heavy infections, which therefore, would explain the high lamb mortality in this study. Lambs most probably get exposed to the parasites from their mothers during suckling soiled teats especially when farmers rarely clean the kraals. Therefore, older sheep can serve as a source of infection for lambs. Alade and Bwala (2015) had also indicated that susceptibility of lambs to gastrointestinal parasites is also attributed to weaker immunological response.

Gastrointestinal parasites occurrence in different seasons

Farmers indicated that their herds experience the highest gastrointestinal parasites infections in summer and autumn (Table 3). Tapeworms (Cestodes) are considered to be the most prevalent type of gastrointestinal parasites followed by nematodes (Figure 4). During the focus group discussions farmers indicated that gastrointestinal parasites (nematodes, trematodes and cestodes) are mostly abundant during the rainy seasons. However, the stomach bots were reported to be common in winter.

Table 3: Farmers response on the seasonal occurrence of gastrointestinal parasites in different agro-ecological zones

Category	**Lowlands (%)**	**Foothills (%)**	**Mountains (%)**
		Summer	
High	92.60	88. 90	100.00
Moderate	7.40	11.10	0.00
Low	0.00	0.00	0.00
		Autumn	
High	14.80	25.90	40.00
Moderate	63.00	64.85	60.00
Low	22.20	9.25	0.00
		Winter	
High	3.70	3.70	4.00
Moderate	14.80	22.20	40.00
Low	81.50	74.10	56.00
		Spring	
High	25.90	33.3	8.00
Moderate	40.70	25.90	48.00
Low	33.30	40.70	44.00

The fact that farmers are aware of some gastrointestinal parasites as indicated in Figure 4 suggests that the control of gastrointestinal parasites should not be a difficult task as a solution to a problem can only be found when the problem is known. Farmers in all agro-ecological zones believed that gastrointestinal parasites prevalence is a big challenge for sheep production in summer and autumn but stomach bots is attacking animals in winter. However, they have shown that the parasite (stomach bots) was initially known to be attacking horses but recently it attacks even the sheep. This might possibly be caused by communal grazing with mixed species grazing together, which allows cross infection among different animals.

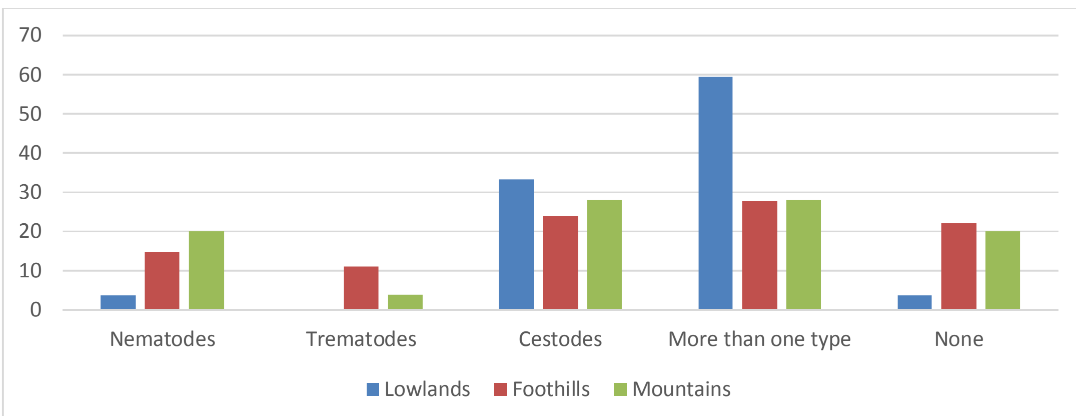


Figure 4: Farmers acquaintance to different gastrointestinal parasites in different agro-ecological zones

Gastrointestinal parasites prevalence varies depending on temperatures and rain fall patterns as it was indicated by Papadopoulos *et al.* (2001). This is also in line with Singh *et al.* (2013), Varadharajan and Vijayalakshmi (2009) who indicated that variation in prevalence of parasitic infestation depends upon difference in agro climatic conditions and availability of susceptible host. In addition, the results of this study are in agreement with Kudrnáčová and Langrová (2012) who indicated higher prevalence of gastrointestinal parasites in warm/wet seasons.

3.3.3 Control methods of gastrointestinal parasites

Treatment of gastrointestinal parasites and frequency of medication used

Use of anthelmintic drugs is the most common method of controlling gastrointestinal parasites in all agro-ecological zones and more than 90% of farmers use their own funds to buy anthelmintics. The anthelmintics are estimated at M1500 per farmer in a year. As indicated in Figure 5, the frequency of administering anthelmintics to sheep varies greatly from farmer to farmer in different agro-ecological zones.

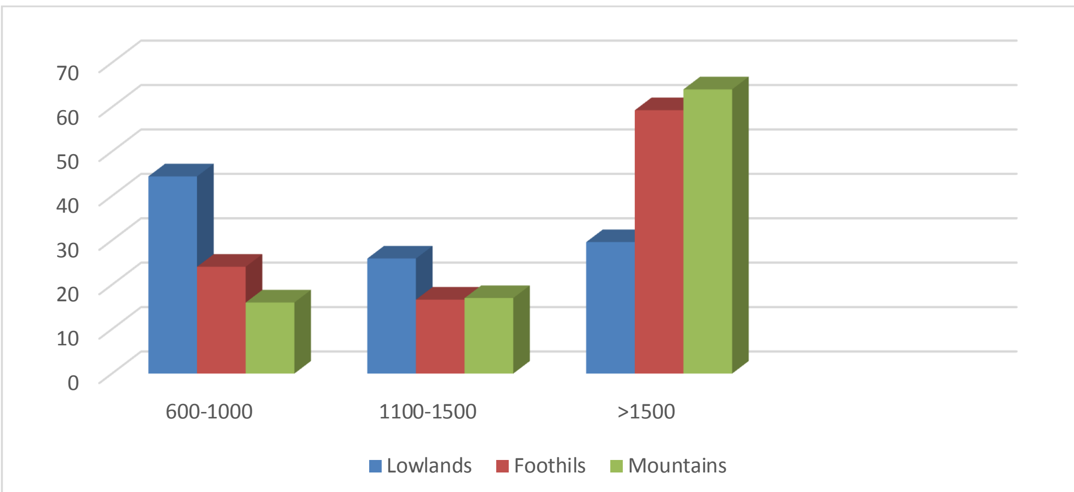


Figure 5: Expenses incurred on anthelmintics

The findings also revealed that 41%, 56% and 56% of farmers in the lowlands, foothills and mountains respectively, use the ethnic medicines (traditional medicine) in addition to anthelmintics whenever is necessary.

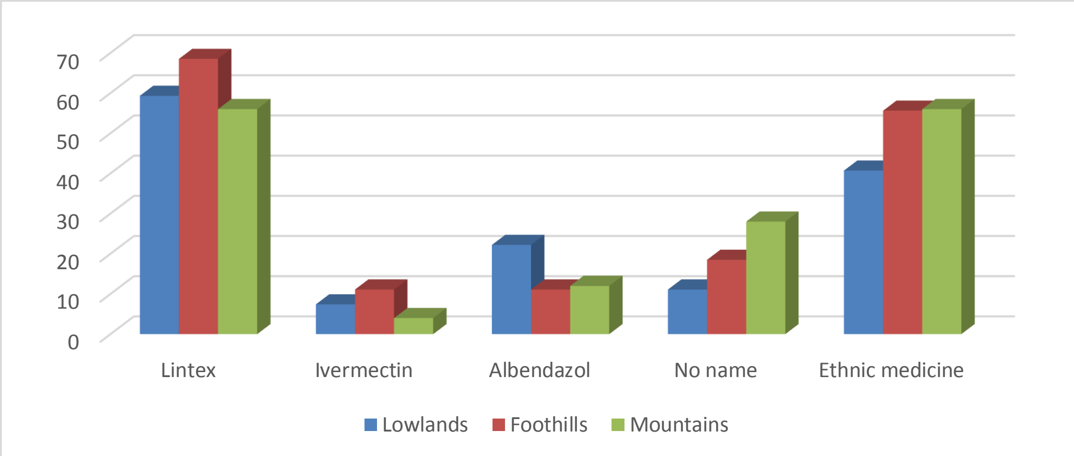


Figure 6: Anthelmintics used by farmers in different agro-ecological zones

Over 80% of farmers in all agro-ecological zones indicated that their animals recover after the treatment. However, it was also revealed that 7.4%, 18.5% and 16.2% of farmers from the lowlands, foothills and mountains respectively were of the view that anthelmintics are not effective, as their sheep continued to die irrespective of being dosed.

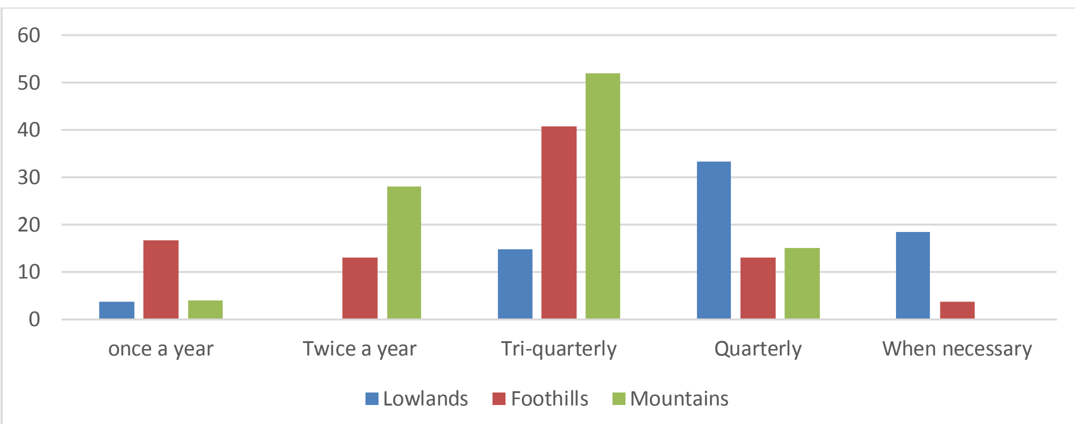


Figure 7: Frequency of anthelmintics use by farmers in different agro-ecological zones

Farmers admitted to administering anthelmintics to animals as a matter of routine, i.e., without seeing any sign or a predisposing factor to gastrointestinal parasites. Routine administration of drugs can result in their underuse/under-dosage or overuse/over-dosage both of which lead to the development of resistance by gastrointestinal parasites (Roeber *et* *al*., 2013 and Coffey and Hale, 2012). This might be the reason why some farmers complained that their animal still died even after drugs administration. Routine use of anthelmintics might be attributed to the lower level of education which makes them to use medication inappropriately. Majority (Over 50%) of farmers' responses indicated that they spend a lot of money (over M1500) on anthelmintics use per year.

Some farmers reported using numerous traditional drugs to prevent mortality and improve the health of their livestock. In many cases, these medications have apparent rationale and beneficial effects (Getchell *et al*., 2002). 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 farmer (Tabuti *et al*., 2003; Njoroge and Bussmann, 2006). The use of ethnic medication was said to be working well with some farmers and this might be because most farmers were found to be old and illiterate hence the use of traditional agriculture is what they are good at.

3.3.4 Grazing and Animal management practices

<u>Grazing systems</u>

The study revealed that more than 90% of farmers showed that rangelands are the source of feeding to their animals. Despite the fact that farmers rely on rangelands as source of animal feeding 70% of farmers regard rangelands as the major source of gastrointestinal parasites transmission due to the fact that animals share the same rangelands (communal grazing). Farmers (70%) believe that the transmission of parasites is worsened by overgrazing of the rangelands caused by overstocking and mixed livestock species on one rangeland. During the focus group discussion, farmers mentioned that predisposing factors of gastrointestinal parasites are poor rangelands which lack palatable grass but only invaders available which leave sheep in danger of grazing very close to the soil hence picking the parasites. Rangelands management differ with different areas of agro-ecological zones. In the lowlands, farmers normally graze animals continually on rangelands closer to the villages from May to January giving the rangelands rest period of four months which is not enough to cut the live cycle of gastrointestinal parasites. In foothills and mountains, the rangelands are rested for five months and the animals graze on rangelands closer to villages from April to November before transhumance.

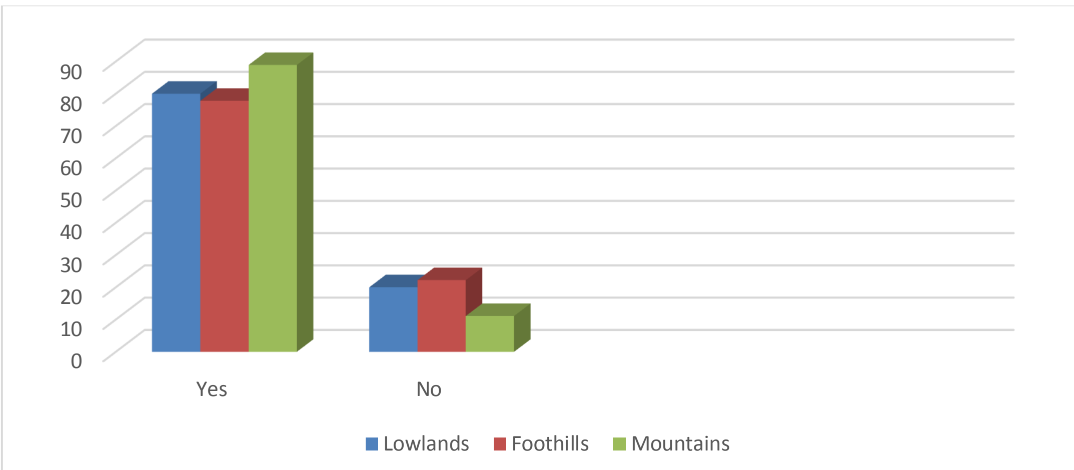


Figure 8: Farmers responses on rangelands as a source of gastrointestinal parasites transmission in their herds

Many (over 70%) farmers consider communal grazing to be a serious problem on management and control of animal diseases. In support of these results Tsotetsi and Mbati (2003) demonstrated that communal grazing favours the development and scattering of gastrointestinal parasites. The findings of the current study are not in agreement with Susan (2013) and Coffey and Hale (2012) who suggested that the grazing areas should be left to rest for 6 to 12 months in order to cut the life cycle of some parasites through killing some stages. Knowledge of life cycles and their timing is important in controlling parasites as certain drugs are only effective against specific stages in parasite development, sometimes control is possible by reducing the number of an intermediate host (O'Donoghue, 2010). Generally, the duration of most gastrointestinal parasites takes about 3-4 months which the farmers at least should be aware of when doing rotational grazing. Rotational grazing could work best if is done immediately after dosing to allow sheep to move to clean grazing areas after shedding larvae and eggs at the previous grazing land. The control of gastrointestinal parasites must be an integration of drug use and good grazing systems, i.e. different species should graze at different times on different rangelands for maximum economic gain (Jackson and Miller, 2006). Farmers believe that the different species of animals that graze together in one rangeland is the major factor for the animals end up having common gastrointestinal parasites.

Animal housing and cleaning

Majority of farmers as presented in figure 8 house their animals in non-roofed kraals, (70.3% in the lowlands, 59.2% foothills and 64% mountains). However, 11%, 7.5% and 16.5% of farmers in the lowlands, foothills and mountains respectively leave their animals unconfined. It was also noted that farmers in the lowlands (37%), foothills (52%) and mountains (32%) clean their animal enclosures, only after rains to remove the mud.

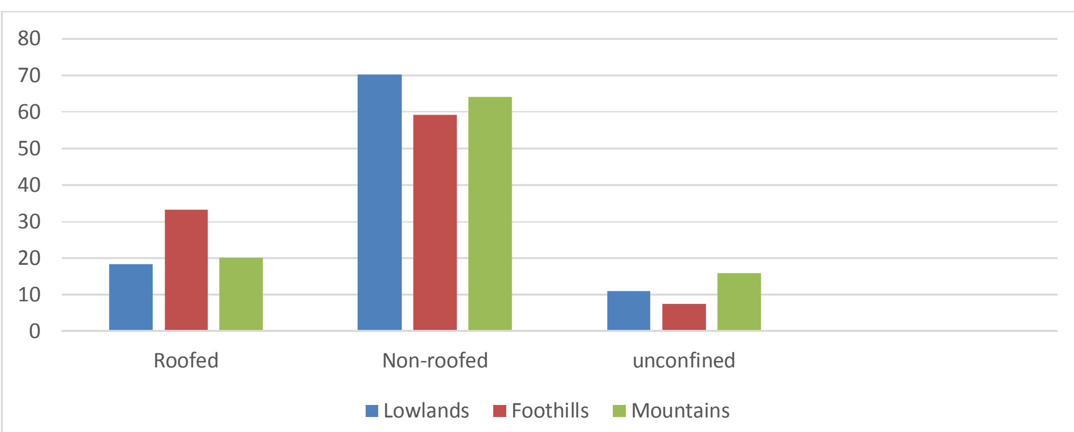


Figure 9: Different housing structures used by sheep farmers

The fact that most farmers keep sheep in structures that are not roofed could be one of the reasons for gastrointestinal parasites infection. This is supported by report of FAO (1988) which indicated that sheep housing can be a bit of a problem as it may cause stress to animals. Lambs exposed to coldness could be susceptible to coccidial infection because of stress (Yakhali and Zarei, 2008).

The failure of farmers to regularly clean their animal enclosures could lead to accumulation of animals' droppings which could harbour parasites eggs or even the larval stages. Also, transmission to suckling lambs could be easy as the possibility of suckling on the soiled teats cannot be avoided and therefore dams can be the source of transmission to the lambs (Joseph, 2003 and Coffey and Hale, 2012).

3.4 CONCLUSION AND RECOMMENDATIONS

3.4.1 Conclusion

Most sheep farmers in Lesotho are of low education level and skills hence the farming system they practice is traditional. Farmers are aware of gastrointestinal parasites and do apply control methods to combat these gastrointestinal parasites in Merino sheep with the use of anthelmintics. Among other age groups lambs were reported to be the ones having high mortality rates in this study. Most gastrointestinal parasites occur in warm and wet seasons which is normally summer and autumn in Lesotho. Farmers practice communal grazing in their different agro-ecological zones and they believe that communal grazing is the main source of gastrointestinal transmission. Most farmers in this study keep their animals in open enclosures that are rarely cleaned.

3.4.2 Recommendations

a) Farmers should consider drenching their animals with the anthelmintics specific for a certain gastrointestinal parasites and this should be done based on seasonal prevalence of gastrointestinal parasites.

b) Farmers should be trained on the proper animal management practices against gastrointestinal parasites including grazing systems and housing sanitation.

c) Farmers need to be helped to form cooperatives in which government will subsidies the anthelmintics prices and be easily accessible.

3.5 References

Adams, F. and K.O. Yankyera, 2014. *Socio-economic Characteristics of Subsistent Small Ruminant Farmers in Three Regions of Northern Ghana*. Asian Journal of Applied Science and Engineering, 3(3):351-364.

Alade, N. K. and M. D. Bwala, 2015. *Gastrointestinal-parasites infestation in Yankasa sheep in a semi –arid environment*. Livestock Research for Rural Development, 27(6).

Ayalew, T., B. Duguma, and T. Tolemariam, 2013. *Socio-economic and farm characteristics of smallholder cattle producers in Ilu Aba zone of Oromia regional state, South Western Ethiopia*. Global Veterinaria, 10(5): 607-613.

Coffey, L. and M. Hale, 2012. *Tools for managing Internal Parasites in Small Ruminant: Pasture Management. National Center for Appropriate Technology, Agriculture Specialists*: 1-20 http://www.attra.ncat.org.

Dantankwa, A. and K. Asafu-Adjei, 2001. *Policies for improving the competitiveness of smallholder livestock producers in Ghana challenges and opportunities*. In: Ehui, S., Barry, M.B., Williams, T.O., Koffi-Koumi, M.P.Z. (Eds.), Central Coridor of West Africa. Implications for trade and regional integration, Abijan, cote d'ivore.

FAO, 1988. *Farm structures in tropical climates.* Rome, Italy. http://www.fao.org

Getchell, J.K., Vatta, A.F., Motswatswe, P.W., Krecek, R.C., Moerane, R., Pell, A.N, Tucker, T.W. & Leshomo, S., 2002, '*Raising livestock in resource-poor communities in the North West Province of South Africa: A participatory rural appraisal study*', Journal of the South African Veterinary Association, 73(4):177-184.

Githigia, S.M., S.M. Thamsborg, W.K. Munyua, N. Maingi, 2001. *Impact of gastro-intestinal helminths on production in goats in Kenya*. Small Ruminants Research, 42:21–29.

Hansen, J. and B. Perry, 1994. *The Epidemiology, Diagnosis and control of Helmiths Parasites of Ruminants.* International Laboratory for Research on Animal Disease, Nairobi, Kenya: 158-168.

Horak, I.G., M.M. Knight and E.J. Williams, 1991. *Parasites of domestic and wild animals in South Africa.* Helminths and Arthropods of Angora goats and kids. Onderstepoort Journal of Veterinary Research, 58:253-260.

ILRI. 2015. Feed Assessment Tool (FEAST) focus group discussion guide. Nairobi, Kenya: 1-27.

Jackson, F., J.E. Miller, 2006. *Alternative approaches to control – Quo vadis*. Veterinary Parasitology, 139:371-384.

Joseph P.T., 2003. *Internal Parasite Control in Grazing Ruminants*. Virginia State University, St.Petersburg: 1-15.

Kudrnacova, M. and I. Langrova, 2012. *Occurance and seasonality of domestic sheep gastrointestinal parasites.* Scintia Agricultuae Bohemica, 43(3):104-108.

Mafisa, T., 1993. *Wool and Mohair Production in Lesotho*. Future of livestock production industries in East and Southern Africa. International Livestock Centre for Africa. FAO, Rome, Italy.

Maingi, N., Bjorn, H., Thamsborg, S.M., Dangolla, A. and N.C. Kyvsgaard, 1996a. *Worm control practices on sheep farms in Denmark and implications for the development of anthelmintic resistance.* Veterinary Parasitology, 66: 39–52.

Maingi, N., Bjorn, H., Thamsborg, S.M., Dangolla, A. and N.C. Kyvsgaard, 1996b. *A questionnaire survey of nematode parasite control practices on goat farms in Denmark.* Veterinary Parasitology, 66: 25–37.

Marinda, P., Bangura, A., and F. Heidhues, 2006. *Technical efficiency analysis in male and female managed farms, a study of maize production in West Pokot district, Kenya;* Gold Coast, Australia, August: 12-18.

Niezen, J.H., H.A. Robertson, A. Sidey and S.R. Wilson, 2002. *The effect of pasture species on parasitism and performance of lambs grazing one of the three grass white clover pasture swards.* Veterinary Parasitology, 105:303-315.

Njoroge, G. N. and R.W. Bussmann, 2006. *Herbal usage and informant consensus in ethnoveterinary management of cattle diseases among the Kikuyus (Central Kenya).* Journal of Ethnopharmacology, 108: 332-339.

O'Donoghue, P., 2010. *Parasite helminths*: PARA-SITE. Australian Society of Parasitology, University of Queensland, Australia.

Ogunmefun, S.O. and A.I. Achike, 2015. *Profitability analysis of selecting informal insurance measures for selected enterprises by rural farmers in Odogbolu local government area.* Russian Journal of Agricultural and Socio-Economic Science, 3(39):25-37.

Papadopoulos, E., 2001. *Drought and flock isolation may enhance the development of anthelmintic resistance in nematodes.* Veterinary Parasitology, 97(4):253-259.

Papadopoulos, E., 2008. *Anthelmintics resistance in nematodes*. Small Ruminants Research, 76(1):99-103.

Pfukenyi, D.M. and S. Mukaratirwa, 2013. *A review of the epidemiology and control of gastrointestinal nematode infections in cattle in Zimbabwe*. Onderstepoort Journal Journal of Veterinary Research, 80 (1):1-12. http://dx.doi.org

Ploeger, H.W., A.F.G. Antonis, J.C. Verkaik, P. Vellema, and M.H. Bokma-Bakker, 2016. *Perceptions and actions of Dutch sheep farmers concerning worm infections.* Veterinary Parasitology, 229:150-158.

Roeber, F., A. Jex and R.B. Gasser, 2013. *Impacts of gastrointestinal parasitic nematodes of sheep and the role of advanced molecular tools for exploring epidemiology and drug resistance.* Parasites & Vectors, 6(1):153.

Singh, V., P. Varshney, S.K. Dash and H.P. Lal, 2013. *Prevalence of gastrointestinal parasites in sheep and goats in and around Mathura, India.* Veterinary World, 6 (5): 260-262.

Susan, S., 2013. *Sheep 201, a beginners' guide to raising sheep: Internal parasite (worm) control.* University of Maryland, United States of America.

Stear M. J., L. Fitton, G.T. Innocent, L. Murphy, K. Rennie and L. Matthews, 2007. *The dynamic influence of genetic variation on the susceptibility of sheep to gastrointestinal nematode infection.* The Royal Society Publishing, 4(16): 767-776.

Tabuti, J. R. S., S.S. Dhillion and K.A. Lye, 2003a. *Ethnoveterinary medicines for cattle (Bos Indicus) in Bulamogi country,* Uganda: plant species and mode of use. Journal of Ethnopharmacology, 88: 279-286.

Theodoropoulos, G., H. Theodopolous, G. Zervas and E. Bartziokas, 2001. *Nematode parasite control practice of sheep and goat farmers in the region of Trikal*, Greece Journal of Helminthology, 74:89-93.

Theodoropoulos, G., G. Zervas, A. Kouneli, B. Martinez-Gonzales, G. Petrakos, J Kostopoulos, 2000. *Seasonal patterns of strongyle infections in grazing sheep under the traditional production system in the region of Trikala, Greece*. Veterinary Parasitology, 89:327–335.

Tsotetsi, A.M., P.A. Mbati, 2003. *Parasitic helminths of veterinary importance in cattle, sheep and goats on communal farms in the north eastern Free State, South Africa*. Journal of the South African Veterinary Association, 74: 45–48.

Varadharajan, A. and R. Vijayalakshmi, 2009. *Prevalence and seasonal occurance of gastrointestinal parsitesbin small ruminants of coastal areas of Tami Nadu*. International Journal of Scientins and Research Publications, 5(2):1-3.

Vlasoff, A., D.M. Leathwick and A.C.G. Heath, 2001. *The epidemiology of nematode infections of sheep.* New Zealand Veterinary Journal, 49:213-221.

Yakhchali, M. and M.R. Zarei, 2008. *Prevalence of Eimeria infection in sheep of Tabriz suburb, Iran*. Iranian Journal of Veterinary Research, 9 (3): 277-280.

CHAPTER 4

Prevalence and faecal egg load of gastrointestinal parasites of Merino sheep in Lesotho

Abstract

This study was conducted for a period of 6 months (July to December) in different agro-ecological zones Maseru and Quthing districts. The objective was to evaluate the prevalence, faecal egg load and control of gastrointestinal parasites of Merino sheep. A total of 1,919 faecal samples were collected and examined using floatation method in McMaster Technique. Three types of gastrointestinal parasites (nematodes, coccidia and cestodes) were identified. Overall prevalence was found to be 53.9%, 46.5% and 4.3% of nematodes, coccidia and cestodes in Maseru district. Quthing district had 65.0%, 38.2% and 0.9% respectively for nematodes, coccidia and cestodes. Overall faecal egg counts for Maseru district ranged from 0-20,300, 0-90,000 and 0-600 eggs per gram respectively for the nematodes, coccidia and cestodes. In Quthing district faecal egg count ranged from 0-8000, 0-6700 and 0-2000 eggs per gram for nematodes, coccidia and cestodes respectively. Majority (over 69%) of animals in both districts had a lower faecal egg counts (100-800) per gram. Agro-ecological zone affected the nematodes infestation in both districts and coccidia in Quthing was higher in the mountains. In Maseru districts, the infestation of nematodes were not affected by age, however, in Quthing district prevalence was higher in juveniles than in adults. Age and sex did not affect the prevalence and faecal egg counts of nematodes and coccidia. The coccidian faecal egg loads were higher in females than in males. The nematodes infections were more prevalent in the warmer months of the year while coccidia affected sheep mostly in winter months.

Key words: Agro-ecological zones, age, sex, month, gastrointestinal parasites, prevalence and faecal egg count per gram.

4.1 INTRODUCTION

In both small and large scale farms gastrointestinal parasites are recognised as a major threat that causes a detrimental loss in farming industry (Sangster, 2007). In most humid sub-tropical and tropical regions of the world there is a substantial prevalence of gastrointestinal parasites in small ruminants (Koinari *et al.,* 2012). Losses from gastrointestinal parasites could include direct effect of severe clinical signs such as oedema, anaemia, anorexia and diarrhoea (Esker and Ploeger, 2000). The prevalence of gastrointestinal parasites is mostly dependent on the agro-climatic conditions in different regions and seasons, the quality and quantity of pasture and grazing behaviour of the host also have effect on the prevalence of gastrointestinal parasites (Shahid *et al.,* 1997).

Dagnachew *et al.* (2011) and Andrew (1999) observed the variation of gastrointestinal parasites across the agro-ecological zones and reported that the lowlands are heavily loaded with gastrointestinal parasites compared to the foothills and the mountains and the reason for the variation was that gastrointestinal helminths multiply and develop well in warm and moist climates. However, Aga *et al.* (2013), Demelash *et al.* (2006) and Waller *et al.* (1995) contradict with other authors because they found high gastrointestinal loads in the foothills than other agro-ecologies.

Lower or undeveloped immunity of the host animal especially the lambs, attribute to susceptibility of animals to gastrointestinal parasites infection but in older animals it could be due to malnutrition resulting from grazing in deteriorated rangelands (Shahid *et al.,* 1997). In both lambs and older sheep, *Haemonchus contortus* (nematode species) and *Fasciola hepatica* (Liver fluke) cause the most problem especially during moist seasons/climates (Abbott *et al.,* 2012). Lambs are very susceptible to coccidian infection and this is believed that young sheep gets infection from the older (Johns, 2001).

Infestation of these gastrointestinal parasites is also related to the sex of a host animal because of their differences in hormonal secretion which ultimately affect their immunity. For that matter, males are mainly susceptible to these parasites than females (Ragassa *et al.,* 2006; Aga *et al.,* 2013 and Lemma and Abera, 2013). However, some authors (Raza et al., 2014; Alade and Mbwala, 2015) indicated different results that females are more susceptible especially during their parturition period and pregnancy.

Aga et al. (2013) found that gastrointestinal parasites multiply rapidly in rainy seasons and warm temperature, therefore, this shows that months that form summer season make a conducive environment for gastrointestinal parasites. Soulby (1986) further indicated that during rainy seasons salt molarities in soil are added and this is an important factor for ecdysis process.

Therefore, the objective of this study was to evaluate the effect of agro-ecological zone, age, sex and month of the year on the prevalence and faecal egg load of gastrointestinal parasites of sheep in Lesotho.

4.2 MATERIALS AND METHODS

4.2.1 Study site

This research project was conducted in the three agro-ecological zones of Lesotho covering the central and southern regions. The agro-ecological zones were the lowlands, foothills and mountains respectively represented by Matsieng, Nyakosoba and Semonkong for central region and Quthing town, Mount Moorosi and Lebelonyane for southern region.

4.2.2 Study Population

A sample size of 360 sheep was randomly selected and subjected to qualitative and quantitative coprological examination. The study was carried using sheep kept under both extensive and semi-intensive systems of production. In each agro ecological zone, three villages were randomly selected and further stratified into one farmer per village. For every farmer, 20 sheep were taken as experimental units composed of 10 males and 10 females. Each sex group was further divided equally into adults and juveniles. Same animals were used for sample collection for the period of 6 months.

4.2.3 Study design and methodology

A cross sectional study was used in this study for a period of 6 months (July to December). Samples were collected from 360 animals in Maseru and Quthing districts. The data was collected with respect to agro-ecological zone, age, sex, and the month of the year. Age of the animals was determined based on dentition and the experimental animals were divided into young and adults. The young animals comprised of weaners and yearlings while adult animals were those above two years of age.

Fresh faecal samples were collected directly from the rectum of sheep using the disposable gloves. The faecal samples were put in the labelled air and water tight bottles for each animal. The sample bottles were then kept in the cooler box to avoid eggs from hatching while still at the field and were kept refrigerated until the laboratory analysis were done.

In the laboratory, each sample was crushed and out of the whole matter 2g was weighed to be mixed with 58ml of sodium chloride (Floatation solution). After sieving, few drops of Amyl Alcohol were added for treatment of bubbles. Lastly, with the pipette, a sample was drawn, put inside the McMaster slide and then observed under light microscope. This method is called McMaster counting technique and it gives parasites eggs per gram of faeces. Eggs found per sample were multiplied by a factor of 100 which is specific to the ratio of faeces (2g) to floatation solution (58ml). Each egg observed represents 100 eggs/gram, therefore, this procedure did not detect less than 100 eggs/gram which was equivalent to observing one parasite egg in the McMaster slide.

The presence of worm eggs in the faeces provides an evidence that an animal is infected. The animals were categorised as lightly, moderately and heavily infested with parasites according to their eggs per gram of faeces (EPG) counts. The degree of infection was categorized as light with 100-800, moderate with 800-1200 or heavy with >1200 eggs per gram of faeces as described by Urquhart *et al.* (1994).

4.2.4 Data analysis

The prevalence of gastrointestinal parasites was calculated by dividing the number of animals harboring a given parasite by the total number of animals examined. Statistical package for Social Sciences (SPSS 20.00) was used for Generalised Estimating Equations (GEE) under model of binary logistic regression to find the significance differences for the prevalence and it was in this analysis whereby results were expressed in odds ratio. Faecal Egg Count (FEC) data was analysed with GEE for repeated measures, and results were expressed in terms of exponential Beta (Exp. B) in percentages. The effect of month was analysed with Generalised Linear Model for repeated measures to find the significance of each month. In all the analyses, confidence level was held at 95% and $p < 0.05$ was set for significance level.

Cestodes were too low in numbers to be subjected to statistical package consequently the significance levels are not reflected against them.

4.2.5 The Model

$Y_{ijkl} = X_i + X_j + X_k + X_l + Eijklm$

Where;

X_i = Agro-ecological zone

X_j = Age

X_k= Sex

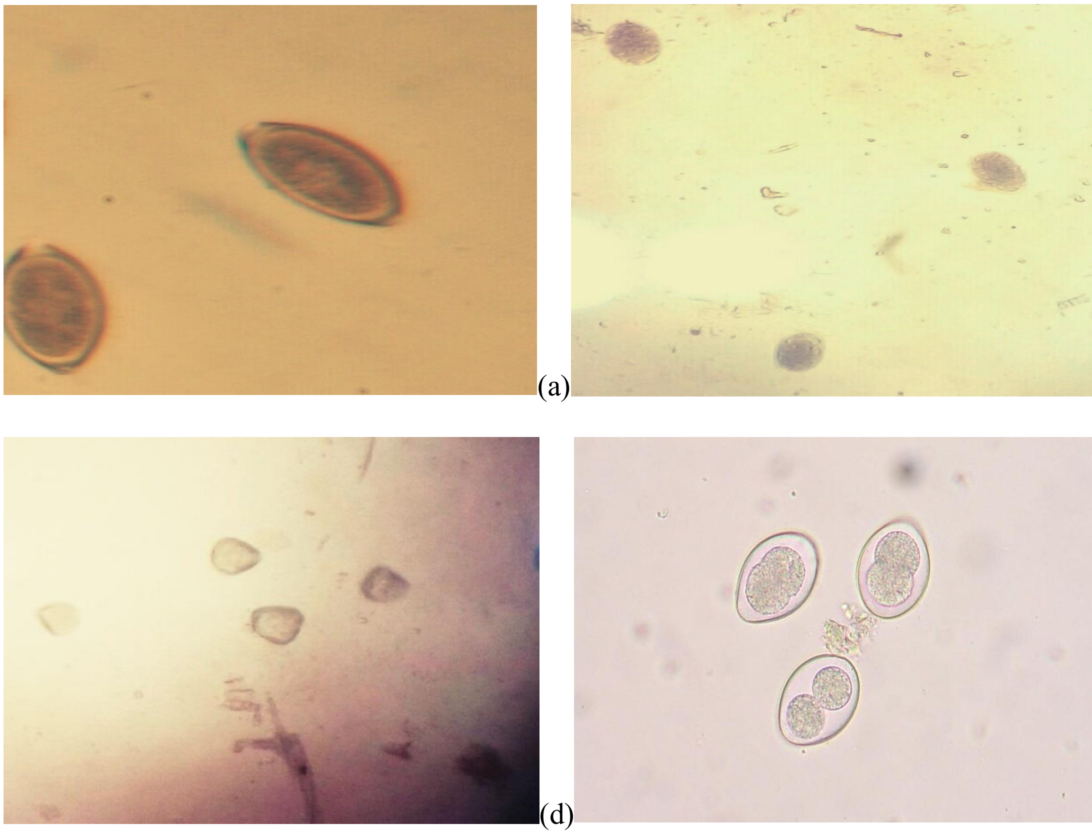
X_l = Months of the year

E_{ijkl} = Error term.

4.3 RESULTS AND DISCUSSIONS

4.3.1 Overall prevalence of gastrointestinal parasites in Maseru and Quthing districts

From the population of 360 sheep which were examined for six months from July to December, 2016, the total samples made for coprological examination were 1,919. In this study, three types of gastrointestinal parasites were observed with different infestations and these were nematodes, coccidia and cestodes. Trematodes were not identified in the current study and this might be influenced by the method used which was floatation McMaster Technique. Normally, trematodes are identified under sedimentation McMaster Technique because of the nature of their eggs being very large as compared to other parasites eggs and it is believed that their density is greater than Sodium Chlorite solution being used.


(a) (b) (d) (c)

(a) Nematodes, (b) Nematodes, (c) Cestodes, (d) Coccidia.

Figure 10: Specimen of nematodes, cestodes and coccidia eggs detected.

Out of the total number of samples collected and examined 542 samples were found positive with nematodes, 468 samples were positive with coccidia and 43 samples were positive with cestodes in Maseru district. For the district of Quthing, total number of samples collected and examined were 913 and out of which 593, 349 and 8 samples were infected with nematodes, coccidia and cestodes eggs respectively.

4.3.2 Prevalence of gastrointestinal parasites on different agro-ecological zones

The results on how the agro-ecological zone affects the prevalence of nematodes in Maseru and Quthing districts are presented in Table 4 and Appendix 1. The prevalence was 62.35%, 42.94% and 55.88% respectively for the lowlands, foothills and mountains of Maseru district.

The likelihood of decrease in nematodes from the lowlands to the foothills was 2.44 times which was found to be significant ($p<0.05$) and from the lowlands to the mountains the chance of decrease was 1.29 which was statistically not significant ($p>0.05$).

In Quthing district, the nematodes prevalence of 51.52%, 78.35% and 66.67% respectively from the lowlands, foothills and mountains was recorded. These results showed that from the lowlands to the foothills the chances of nematodes increase were 0.22 times ($p<0.05$) while from the lowlands to the mountains the decrease are 0.410 times ($p<0.05$).

The prevalence of coccidian infestation as illustrated in Table 4 and Appendix 1 was found to be 45%, 41.72%, 52.65% respectively for the lowlands, foothills and mountains of Maseru district. The chances of decreased coccidian infection from the lowlands to the foothills were 1.65 times ($p<0.05$). Coccidian infection also increased insignificantly ($p>0.05$) by 0.641 chances from the lowlands to the mountains.

In Quthing district, there was coccidian prevalence of 34.24%, 36.08% and 45.02% respectively for the lowlands, foothills and mountains (Table 4). These results revealed the significant increase of 1.157 times from the lowlands to the foothills while from the lowlands to the mountains an increase was 0.722 times ($p<0.05$).

The results on Table 4 reflect that the cestodes prevalence was 7.65%, 4.91% 0.29% respectively for the lowlands, foothills and mountains of Maseru district. In Quthing district the cestodes prevalence was recorded as 1.52%, 0.69% and 0.34% respectively for the lowlands, foothills and mountains.

Table 4: Agro-ecological zones effect on prevalence of gastrointestinal parasites

	Maseru			Quthing		
Agro-ecology	**Samples examined**	**Prevalence %**	**Exp. B**	**Samples examined**	**Prevalence %**	**Exp. B**
			Nematodes			
Mountains	340	55.88^{b}	1.29	291	66.67^{a}	0.41
Foothills	326	42.94^{a}	2.44	291	78.35^{b}	0.22
Lowlands	340	62.35^{b}	1	331	51.52^{c}	1
			Coccidia			
Mountains	340	52.65^{b}	0.64	291	45.02^{a}	0.72
Foothills	326	41.72^{a}	1.65	291	36.08^{a}	1.16
Lowlands	340	45.00^{b}	1	331	34.24^{a}	1
			Cestodes			
Mountains	340	0.29		291	0.34	
Foothills	326	4.91		291	0.69	
Lowlands	340	7.65		331	1.52	

Means with different superscript differed significantly ($p<0.05$) from each other

Exp. B= Exponential Beta

Although nematodes infection in Maseru district occur in all agro-ecological zones, it's prevalence decreases from the lowlands to mountainous areas with lowlands being significantly ($p<0.05$) different from the foothills but not significantly different from the mountains ($p>0.05$) . The prevalence of nematodes from the mountains were significantly different from those in the foothills ($p<0.05$). This pattern is normal based on the survival conditions of nematodes and their living stages. These results are in compliant with the consensus that gastrointestinal parasites vary greatly from region to region corresponding to agro-ecological zones and climatic diversity as well as the availability of the host.

Regassa (2006), Aga *et al. (*2013) and Koinari *et al.* (2012) explained that gastrointestinal nematodes prefer moist, warm climates for their larval development and multiplication in the presence of susceptible host and this explains why the prevalence of nematodes was higher in the lowlands in this study. In the mountains the prevalence was lower because of the coldness which does not favour survival of gastrointestinal nematodes larvae; again the situation of this country (Lesotho) is such that the mountain areas are very prone to snowfall which accelerates the coldness of these areas (Lesotho Meteorological Services 2013).

Nematodes prevalence in Quthing district was affected by the agro-ecological zone since prevalence in each agro-ecological zone was significantly different ($p<0.05$) from one another. The nematodes prevalence was higher ($p<0.05$) in foothills followed by mountains and lastly the lowlands. Regassa *et al*. (2006) also found high prevalence in the mid-altitudes. The reason for lower prevalence in the lowlands might be due to effect of Senqu valley region which lays predominantly in the lowlands than all other agro-ecological zones and the more coverage it takes in a region the colder it becomes hence the condition does not favour larval development (sheep worm control, 2007). Despite the higher altitude of the foothills than that of the lowlands, nematode prevalence is found to be high in the foothills due to the fact that the foothills are warmer than the lowlands in Quthing district since the lowlands have an average winter temperature of -6.3^0C while the one for the foothills is -0.6^0C (LMS, 2013).

The prevalence of coccidia was high in the mountains of both Quthing and Maseru districts. The higher prevalence was due to the fact that coccidian oocysts prefer rainfall but with lower temperatures and relatively high humidity as it was indicated by Yakhchali and Zarei (2008). In addition, Whittier *et al.* (2009) reported that coccidian infection takes chances and multiply rapidly when host animals are under stress due to coldness or any disease that can affect immune response.

Cestodes prevalence in both Maseru and Quthing decreases from the lowlands to the mountains, behaved more or less like the nematodes. This is supported by Owen (1989) who indicated that Platyhelminthes species are more prevalent in the lowlands than in the highlands because of warm and wet areas as well as conducive humidity.

4.3.3 Prevalence of gastrointestinal parasites in different sheep age groups

The results on how age affects the prevalence of gastrointestinal nematodes on sheep are illustrated in Table 5. The findings showed the prevalence of 55.25% in adults and 52.50% in juveniles for Maseru district. This indicate that there was an increase of 0.880 times from the juveniles to the adults despite being insignificant ($p>0.05$), as reflected in Appendix 1. In Quthing district, the nematodes prevalence was 67.90% and 61.95% respectively for adults and juveniles. This suggests that from the juveniles to the adults the likelihood of increase was 0.682 times. Gastrointestinal nematodes were infecting adult sheep more than juveniles and this was similar for both Maseru and Quthing districts, however, the differences were not statistically significant ($p>0.05$, Appendix 1). Generally, the prevalence of nematodes was higher in Quthing district in comparison with Maseru district.

In terms of coccidia (Table 5 and Appendix 1) the findings indicated the prevalence of 40.40% in adults and 52.69% in juveniles for Maseru district. The juveniles had significantly ($p<0.05$) more chances (2.659) of infection than the adults. In the district of Quthing the prevalence was 32.54% in adults and 44.03% in juveniles. The chances of increased coccidian infection from adults to juveniles was 2.079 times ($p<0.05$).

The findings on prevalence of cestodes as stipulated in Table 5 reflect that the juveniles (6.39%) were more vulnerable than adults (2.18%) in Maseru district. The records for the

Quthing district showed that the cestodes prevalence was 0.87% for the adults and 0.88% for the juveniles.

Table 5: Effect of age on prevalence of gastrointestinal parasites

	Maseru			**Quthing**		
Age	**Samples examined**	**Prevalence %**	**Exp. B**	**Samples examined**	**Prevalence %**	**Exp. B**
			Nematodes			
Adults	505	55.25^{a}	0.89	461	67.90^{a}	0.68
Juvenile	501	52.50^{a}	1	452	61.96^{b}	1
			Coccidia			
Adults	505	40.40^{a}	2.66	461	32.54^{a}	2.08
Juvenile	501	52.69^{b}	1	452	44.03^{b}	1
			Cestodes			
Adults	505	2.18		461	0.87	
Juvenile	501	6.39		452	0.88	

Prevalence with different superscript within a column differed significantly ($p<0.05$) from each other

Exp. B= Exponential Beta.

The results of the current study are supported by Tehmina *et al.* (2014) and Biu and Oluwafunmilayo (2004) who indicated that sheep aged two years and above have higher prevalence of gastrointestinal helminths than the juveniles. The higher prevalence of nematodes in adults might be because older sheep get the infective larval stage of helminths on the rangelands where they communally graze with other animal species but in some villages juveniles are often left behind at homes to be fed.

Coccidian infection was found to be significantly ($p<0.05$) higher in juvenile sheep than in adult sheep in both districts of Maseru of Quthing despite Maseru district having the high number of infected animals. This depicts that juveniles are highly susceptible to coccidia because of weaker immunological response which has not developed enough to combat heavy infections. Adult sheep because of being exposed to the infection repeatedly have developed enough immunity against coccidian infection, this may explain why they do not appear susceptible.

These results tally with those of Joseph (2003), Alade and Mbwala (2015) and Vlassoff *et al.* (2001) who reported higher prevalence of coccidia in lambs than adult sheep. Yakhchali and Zarei (2008) and Hashemnia *et al.* (2014) supported the fact that coccidia species are frequently found in faecal samples but their appearance is influenced by age and immunity status of a host, which in the present study was seen mainly in juveniles. Another influencing factor might be of the farmer's management including cleanness and good sanitation. Juveniles might catch infection from suckling soiled teats of a dam if the kraal is not regularly cleaned and disinfected (Joseph, 2003).

Similarly, cestodes infection were higher in juveniles than in adults, which of course confirms the fact that juveniles are highly susceptible to gastrointestinal helminths because of their weaker immunity as they have not been exposed to the infections repeatedly to strengthen their immunity against such parasites. The fact that in most cases, the juveniles are grazing together with the adults on a communal grazing system, could lead them to be infected easily which is believed was the case in this study.

4.3.4 Prevalence of gastrointestinal parasites in different sex groups of sheep

The results obtained as demonstrated in Table 6 and Appendix 1 show the effect of sex on gastrointestinal nematodes prevalence whereby 56.14% was in male and 51.93% in females for Maseru district. However, the differences seen between the two sexes were statistically not significant ($p<0.05$) and the likelihood of change from females to males was 0.796 times.

In Quthing district, the prevalence was 66.53% in males and 63.53% in females which was found to be statistically insignificant (p>0.05) and this depicts the likelihood decrease of 0.829 times from the males to females.

The coccidian infection showed the prevalence of 48.07% in females and 45.03% in males for Maseru district (Table 6) and the difference between the two sexes was not statistically significant (p>0.05). The results of the current study revealed the likelihood increase of 1.192 times from the females to males (Appendix 1).

In Quthing district, coccidian infection prevalence was 37.50% in females and 39.03% in males which depicted the likelihood increase of 0.975 times from females to males. However, all the differences were statistically not significant (p>0.05).

Prevalence of cestodes was also obtained with the following prevalence rates; 5.68% in females, 2.92% in males for Maseru district and 1.46% in females, 0.23% in males for Quthing district as illustrated in Table 6.

Table 6: Effect of sex on prevalence of gastrointestinal parasites

	Maseru			Quthing		
Sex	**Samples examined**	**Prevalence %**	**Exp. B**	**Samples examined**	**Prevalence %**	**Exp. B**
			Nematodes			
Male	513	56.14^a	0.80	433	66.53^a	0.83
Female	493	51.93^a	0^a	480	63.54^a	0^a
			Coccidia			
Male	513	45.03^a	1.19	433	39.03^a	1.00
Female	493	48.07^a	1	480	37.50^a	1
			Cestodes			
Male	513	2.92		433	0.23	
Female	493	5.68		480	1.46	

Means with different superscript differed significantly (p<0.05) from each other.

Exp. B= Exponential Beta.

Nematodes and coccidia infection had been reported by Maingi and Munyua (1994), Hashemnia *et al.* (2014), Craig *et al.(* 2006) and Nyamweya, (2015) who indicated the similar results as those of the current study. The authors explained that male sheep are susceptible to gastrointestinal helminths because of the production of androgen hormones which seem to be suppressing the immune response of the male animals and this is exactly what the present study revealed although the differences were not significant ($p<0.05$). Similarly Urquhart *et al*. (1996) reported that male sheep have high prevalence of gastrointestinal Nematodes. Mushtag and Tasawar (2011) also indicated that production of oestrogen by female sheep stimulate their immune response and this explains why the prevalence is low in females compared to males. Zeryhun (2012), Gualy *et al*. (2006) and Raza *et al*. (2007) also reported higher prevalence of gastrointestinal helminths in rams.

However, the results of the current study are in contradiction with those of Muluneh *et al.* (2014) who indicated that females are prone to helminths infection due to the fact that they undergo periparturient stage which affect immune response. Similarly, Dagnachew *et al.* (2011) also reported high prevalence of helminths infection in females.

4.3.5 Prevalence of gastrointestinal parasites over the period of six months

The prevalence of nematodes from July to December is explained in Figure 11. High prevalence of gastrointestinal nematodes is seen from October to December in both districts but with extremely high percentages in October of which 80% was observed in Maseru and 92.57% in Quthing district. However, there was a decline of nematodes prevalence from October to December in both districts. The decline in the prevalence of gastrointestinal parasites was due to the fact that farmers dose their animals between the months of October and November.

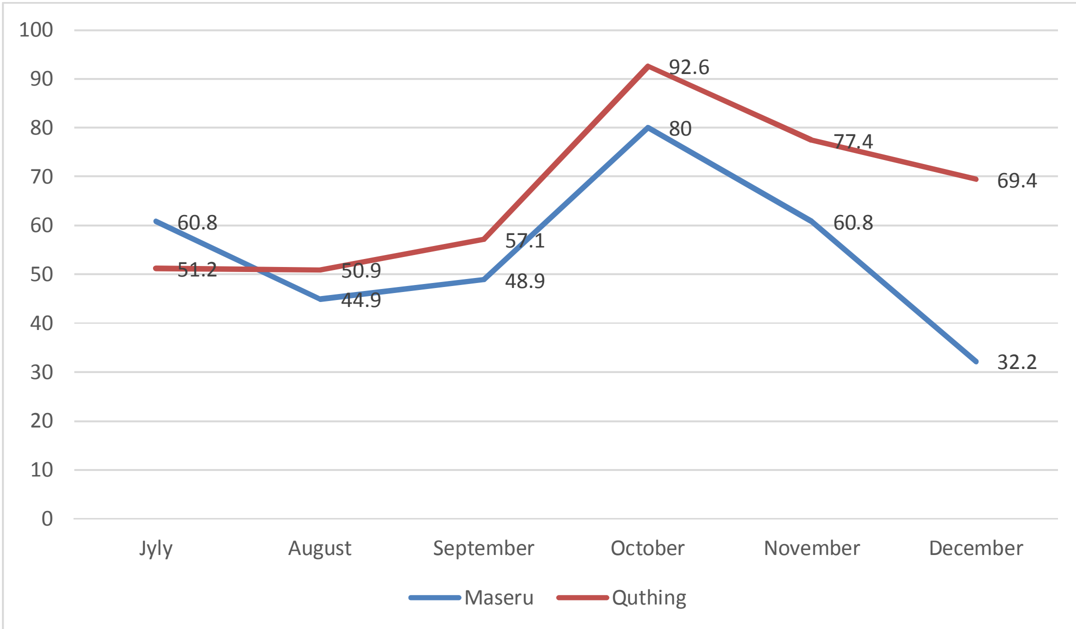


Figure 11: Prevalence of gastrointestinal nematodes by month in Maseru and Quthing districts

High prevalence of nematodes in October could be attributed to direct relationship between prevalence and humidity and temperature as it was indicated by Varadharajan and Vijayalakshimi (2009) that heavy rainfall and relatively high humidity predispose to heavy nematodes infection. Micro-climatic conditions also prejudiced dispersion of larvae in the herbage which of course increased the chance of contact between host and larvae. In addition, during wet or rainy months, high gastrointestinal helminths infestation might be the attribute of suitable salt molarity present in the soil which is due to the factor of ecdysi process.

During the cold months of the year, the results show that the infection rate was not heavy because the climate did not favour the growth or development of nematodes larvae. The occurrence of these gastrointestinal nematodes is largely influenced by seasonal variation in rainfall patterns and temperature levels.

The results presented in Figure 12 indicate that the prevalence of coccidia was high from July to September in both Maseru and Quthing districts. The decline of coccidian prevalence was observed during the months of October, November and December. The prevalence of coccidia from September to December deteriorated by 85.1% and 46.4% respectively for Maseru and Quthing districts. However, the overall prevalence showed Maseru to be higher (46.52%) than Quthing (38.23%) in coccidian infection.

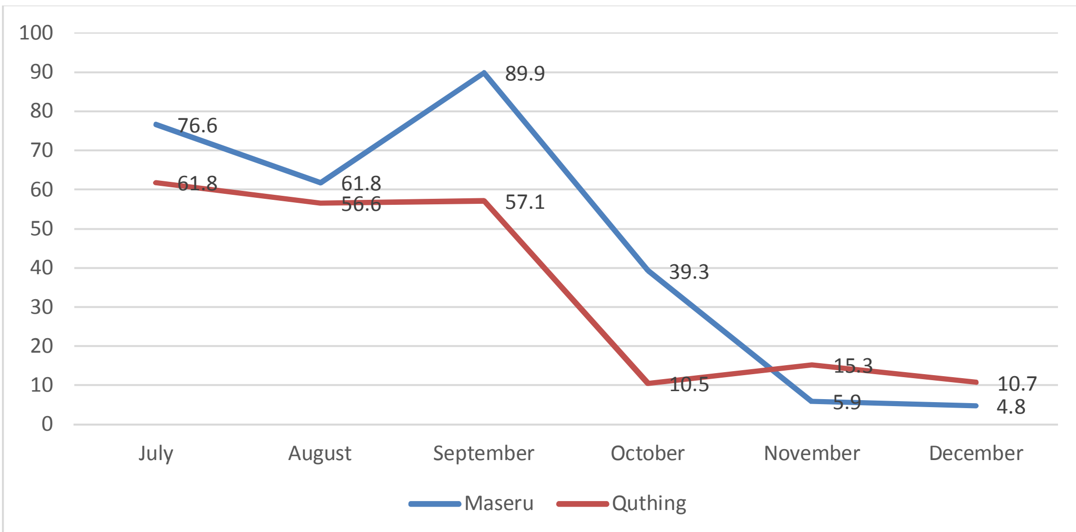


Figure 12: Percentage prevalence of coccidia oocysts in Maseru and Quthing districts

These results suggest that coccidial infestation is more prevalent in July, August and September and the temperatures are still lower at this time in Lesotho. Conditions such as extremely cold and wet weather precipitate various diseases to animals and this explains why coccidia infection takes opportunity in such cases leading to high prevalence subsequently. These results are supported by Taylor (2010) and Nyamweya (2015) who indicated that coccidia prevalence peaks in spring.

This is so because by this time, winter lambs are three to eight weeks and are vulnerable to coccidial infection due to their weak immune response. In winter lambing systems, coccidia outbreaks are common in 3–4 weeks old lambs and kids (Joseph, 2003). In addition, Yakhchali and Zarei (2008) reported that coccidia species are present in sheep throughout the year but their intensity increases during the late fall as well as in winter. This indicates that infection of coccidia species favours rainfall but with lower temperature and high relative humidity. Even though infestation seemed to be decreasing from July to December, the rise and fall of the prevalence of coccidia in sheep probably dependent on the climatic conditions.

Prevalence of cestodes was high in October, November and December in both Maseru and Quthing districts. The higher numbers of cestodes were noticed in Maseru district as compared to Quthing district.

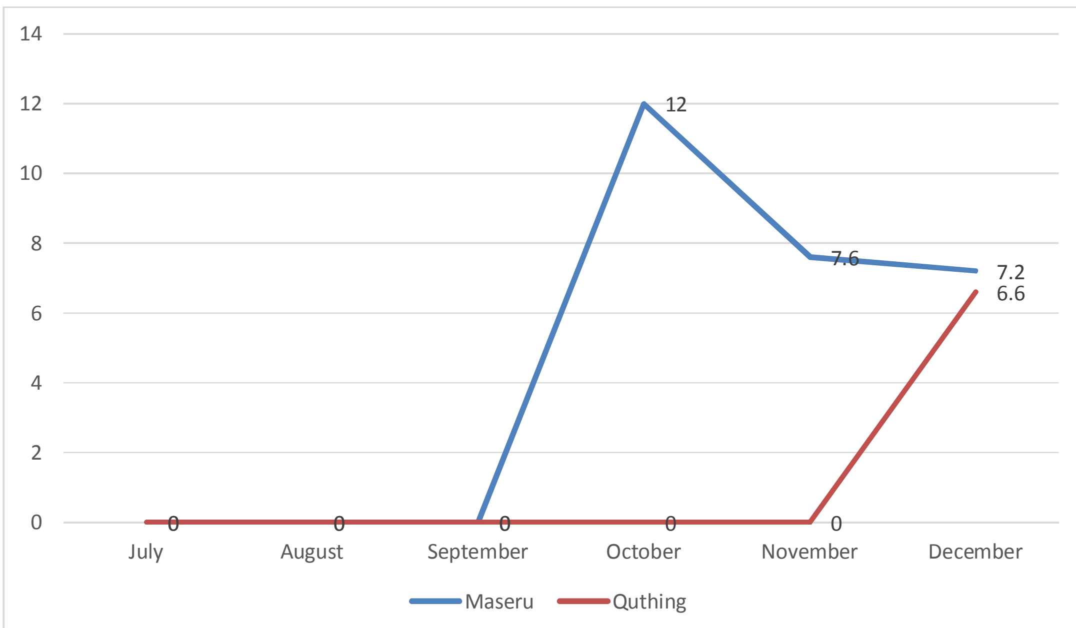


Figure 13: Percentage prevalence of gastrointestinal cestodes in Maseru and Quthing districts

Prevalence of cestodes was high in warm and rainy months which depicts that the larval stages of cestodes develop well in such condition. In support of these results, Dagnachew *et al.* (2011) and Ibrahim (2014) indicated that most of gastrointestinal parasites are susceptible to desiccation in dry climatic conditions that could even lead to failure of L_3 to develop, but rather grow well in moist, warm climatic conditions.

4.3.6 Overall faecal egg counts of gastrointestinal parasites in Maseru and Quthing districts

In Maseru district, gastrointestinal parasites eggs ranged from 0-20,300, 0-90,000 and 0-600 repectively for nematodes, coccidia and cestodes. In Quthing district, gastrointestinal faecal egg counts ranged from 0-8000, 0-6700 and 0-2000 repectively for nematodes, coccidia and cestodes.

Table 7: Degree of parasitic infestation in Maseru and Quthing

Degree of infestation	Maseru		Quthing	
		Nematodes		
Light	387	71.4%	411	69.3%
Moderate	48	8.9%	55	9.3%
Heavy	107	19.7%	127	21.4%
		Coccidia		
Light	387	82.7%	305	87.4%
Moderate	32	6.8%	16	4.6%
Heavy	49	10.5%	28	8.0%
		Cestodes		
Light	43	100%	6	75%
Moderate	0	0	0	0
Heavy	0	0	2	25%

The majority of sheep in Maseru district (71.4%) and Quthing district (69.3%) were lightly infested with nematodes. Those heavily infested with nematodes ranked second with 19.7% and 21.4% for Maseru and Quthing districts respectively. The least number of animals were found moderately infested with nematodes in Maseru being 8.9% and in Quthing district comprising 9.3%. Coccidia infestation followed the same trend as nematodes but cestodes infestation revealed that 100% of sheep were lightly infested in Maseru and 75% in Quthing district. Only 25% were heavily infested with cestodes in Quthing district. There were no moderate cestodes infestation in both districts.

While looking at the degree of gastrointestinal parasites infestation in Maseru and Quthing districts, many sheep samples reported a lower infestation of gastrointestinal parasites and fewer animals having moderate to heavy infestation. Similar observation was reported by Koinari *et al.* (2013) and Fikru *et al.* (2006). Despite the fewer number of sheep having heavy gastrointestinal parasites infestation, this should act as warning to farmers to treat and control internal parasites. Parasite management at this stage will ensure that there is no spread and accumulation of gastrointestinal parasites to a large percentage of sheep

The similar view shared by Villarroe (2013) who suggested that sheep infected with nematodes should be treated when faecal egg counts are exiting 500 eggs per gram. Any number of liver fluke eggs found in faeces indicates that such animals should be treated while with cestodes, treatment should be done when eggs exeet 500 eggs per gram. Coccidia infested sheep need to be treated when eggs are more than 1000 eggs per gram .

4.3.7 Faecal egg counts of gastrointestinal parasites in different agro ecological zones

The results on the effect of agro-ecological zone on faecal egg count (FEC) of nematodes are shown in Table 8 and Appendix 2. The intensity of FEC per gram was 541.59, 212.65 and 459.00 eggs for the lowlands, foothills and mountains respectively. The exponential Beta in percentages portrays that from the lowlands to the foothills the intensity of FEC significantly ($p<0.05$) decreased by 60.7%. From the lowlands to the mountains there was a decrease of 15.3% FEC, however, the difference was not statistically significant ($p>0.05$). The results also reported that rearing sheep in the mountains rather than in the foothills would significantly (p<0.05 decrease the chances of FEC by 45.4%.

In Quthing district, the FEC means of nematodes were 550.73, 661.01 and 527.47 eggs for the lowlands, foothills and mountains respectively. The nematode FEC increased by 163.6%

from the lowlands to the foothills and the change was statistically significant ($p<0.05$). From the lowlands to the mountains, there was an increase of 110.4% faecal egg load which was significant at 5% significant level while a change of faecal egg load in sheep from the mountains to the foothills was 53.2% ($p<0.05$).

The results on the effect of agro-ecological zone on the FEC of coccidia are presented in Table 8 and Appendix 2. In Maseru district, the findings display that there was no effect of agro-ecological zone on coccidian FEC. Despite the non-significant differences, the FEC infestation from the lowlands to the foothills and mountains decreased by 12.6% and 48.2% respectively. From the foothills to the mountains, the faecal egg load increased by 35.6% ($p>0.05$).

Table 8: Gastrointestinal parasites in different agro-ecological zones

	Maseru			**Quthing**		
Agro-ecology	**EMM**	**Exp. B**	**Exp. B (%)**	**EMM**	**Exp. B**	**Exp. B (%)**
			Nematodes			
Mountains	459.00^{a}	0.85	15.30	527.47^{a}	2.10	110.00
Foothills	212.65^{b}	0.39	60.70	661.01^{b}	2.64	163.00
Lowlands	541.59^{a}	1	1	250.73^{c}	1	1
			Coccidia			
Mountains	106.01^{a}	0.52	48.20	67.28^{a}	1.68	67.80
Foothills	179.05^{a}	0.87	12.60	54.08^{b}	1.35	38.80
Lowlands	204.85^{a}	1	1	40.11^{b}	1	1

Values within rows followed by different letters (a, b, c) are significantly different ($p<0.05$)

EMM=Estimated Marginal Means. Exp. B= Exponential Beta.

In Quthing, the coccidian FEC loads were 40.11, 54.08 and 67.28 eggs per gram for the lowlands, foothills and mountains respectively. The faecal egg load insignificantly ($p>0.05$) increased by 34.8% from the lowlands to the foothills. From the lowlands to the mountains there was an infestation increase of 67.8% and difference was statistically significant ($p<0.05$). The difference between the mountains and the foothills was 33% with the mountains having a higher ($p<0.05$) FEC load.

Infection intensity of nematodes across the different agro-ecological zones in Maseru district decreased from the lowlands to the mountains because nematodes larvae prefer warm and moist agro-climatic conditions. The lower FEC intensity in the lowlands of Quthing can be attributed to the Senqu valley which affects the temperature levels of that region resulting in condition not conducive for the nematodes larvae development.

Other findings confirmed that larvae multiply well and rapidly in temperatures ranging from 25^0C to 37^0C and most larvae die in very hot or very cold climates (Gadahi *et al*., 2009). Similarly, Koinari (2013) reported that major gastrointestinal nematodes develop and survive well in temperatures ranging from 25^0 to 37^0C. These results are also in agreement with those of Demelash *et al.* (2006) and Waller *et al.* (1995) who found that nematodes survive well in warm climates. Furthermore, Aga (2013) indicated that the nematode egg load can be influenced by the variations in geographic and climatic conditions existing between the different zones.

Faecal coccidial egg counts in Maseru was high in the lowlands followed by foothills and lastly the highlands and the differences were not significant ($p>0.05$). However, as indicated in Table 4, it was observed that the prevalence of coccidia was high in the mountains as compared to other agro-ecological zones. This shows that despite the fact that the higher percentage of animals were infected with coccidia in the mountains the intensity or severity of infection was low as compared to the animals in the lowlands ($p>0.05$). This scenario could be traced to the style and practice of dosing against coccidial infection done by farmers in different areas. Similar results were also observed by Dagnachew *et al.* (2011) and Andrew

(1999) who indicated that the probable reason for the decrease might be due to unfavourable conditions of the mountains.

In Quthing district, the different trend of coccidial infection was found in comparison to Maseru district. The FEC loads were higher ($p<0.05$) in the mountains than in the lowlands. Similarly, Koinari (2013) reported high coccidian oocysts (*Eimeria*) in the mountains than other agro-ecological zones. The results indicated that the higher the prevalence of coccidia, the higher the degree of infestation. This would mean that there was a positive correlation between the prevalence rate and the degree of infestation.

4.3.8 Faecal egg counts of gastrointestinal parasites in different age groups of sheep

The results on the effect of age on FEC of nematodes in Maseru and Quthing districts are presented in Table 9 and Appendix 2. In Maseru district, the intensity of FEC was 432.29 eggs in Juveniles and 325.84 eggs in adults. This is indicating that the degree of nematodes infestation increased by 32.7% from juvenile to adults. However, the difference was not statistically significant ($p>0.05$). In Quthing district, the FEC loads were 388.58 eggs in juveniles and 506.98 eggs in adults with an increase of 30.5% from juvenile to adults and the difference was not statistically significant ($p>0.05$).

In Maseru district, the results on coccidial infection as reflected in Table 9 and Appendix 2 show FEC loads of 313.03 eggs in juveniles and 79.00 eggs in adults. The FEC percentage from juveniles to adults significantly ($p<0.05$) increased by 74.8%. In Quthing district, FEC for coccidia FEC load was higher in juveniles (117.94 eggs) and lower in adults (23.50 eggs). These results can be translated into significant increase of 80.1% from juveniles to adults ($p<0.05$).

Table 9: Effect of age on nematodes and coccidian FEC infestation in Maseru and Quthing districts

	Maseru			Quthing		
Age	**EMM**	**Exp. B**	**Exp. B (%)**	**EMM**	**Exp. B**	**Exp. B (%)**
			Nematodes			
Adults	432.29^{a}	1.33	32.70	506.98^{a}	1.31	30.50
Juveniles	325.84^{a}	1	1	388.58^{a}	1	1
			Coccidia			
Adults	79.00^{b}	0.25	74.80	23.50^{b}	0.20	80.10
Juvenile	313.03^{a}	1	1	117.94^{a}	1	1

Values within rows followed by different letters (a, b) are significantly different ($p<0.05$)

EMM= Estimated Marginal Means, Exp. B= Exponential Beta.

The results on how age affects the faecal nematodes egg counts showed an increase of the degree of infestation from the juveniles to the adults in both districts, though the differences were not significant ($p>0.05$). The results of the current study are in line with Tehmina *et al.* (2014) and Villarroel (2013) who indicated that infestation of gastrointestinal helminths is insignificantly higher in animals of two or more years of age than the younger ones. Dagnachew *et al.* (2011) added that older animals due to repeated exposure to parasitic infections might have developed some resistance and act as carriers of gastrointestinal parasites.

The severity of infection in young animals as compared to adults as reflected by the results of this study is consistent with previous findings (Maingi and Munyua, 1994; Hashemnia *et al.*, 2014 and Yakhchali and Golami, 2008). Alade and Bwala (2015), Vlassoff *et al.,* (2001) and Joseph (2003) reported that the lambs shed more oocytes in comparison to adults and this is made by attainment of immunity by adults over periods of time which will therefore suppress *Eimeria* infection. This suggests that juveniles are prone to coccidial infection and high infestation because of weak immune response to parasitic infections.

4.3.9 Faecal egg counts of gastrointestinal parasites in different sex groups of sheep.

The results on the effect of sex on FEC of nematodes in Maseru and Quthing districts are illustrated in Table 10 and Appendix 2. The FEC means were 395.71 eggs in females and 355.95 eggs in males for Maseru district. The degree of nematodes FEC decreased by 10% from the females to males though the difference was not statistically significant ($p>0.05$). In Quthing district, FEC means were 450.36 eggs in females and 437.38 eggs in males with the insignificant ($p>0.05$) chance of decrease by 2.9% from the females to males.

The results on how host sex affects coccidial FEC in Maseru and Quthing districts are presented in Table 10. The results of the current study show the FEC means of 175.63 eggs for females and 140.80 eggs for males in the Maseru district. The males were 19.8% least infected compared to females, however, the difference was not statistically significant ($p>0.05$). The similar trend of infection was recorded in Quthing with females being more infected with coccidia than males by 7.5% though the difference was not statistically significant ($p>0.05$).

Table 10: Sheep sex effect on nematode and coccidia in Maseru and Quthing districts.

	Maseru			Quthing		
Sex	**EMM**	**Exp. B**	**Exp. B (%)**	**EMM**	**Exp. B**	**Exp. B (%)**
			Nematodes			
Female	395.71^{a}	0.90	10.00	450.36^{a}	0.97	2.90
Male	355.95^{a}	1	1	437.38^{a}	1	1
			Coccidia			
Female	175.63^{a}	0.80	19.80	54.75^{a}	0.93	7.50
Male	140.80^{b}	1	1	50.62^{b}	1	1

Values within rows followed by different letters (a, b) are significantly different ($p<0.05$)

EMM= Estimated Marginal Means, Exp. B= Exponential Beta

The higher degree of nematodes FEC in females though not significant may be due to the fact that females become prone to parasitic diseases because of lower immune response during pregnancy and parturition. Parkins and Holmes (1989) attributed this to the loss of immunity at parturition and the possible impact of larval challenge on the digestive efficiency of immune host. Similarly, Alade and Bwala (2015), Tehminas *et al.* (2014) and Dagnachew *et al.* (2011) reported higher infestation of nematodes in females.

The results of present study are in contrary with those of Urquhart *et al*. (1996) who indicated that males are susceptible to parasitic diseases and can have high FEC than female animals because of the effect of androgen hormone that supress the immune response of animal host. These results reflect the negative relationship between the number of animals infected (prevalence rate) and the degree of faecal egg count infestation. This means that even though the higher percentage of males were infected but the ones that were heavily loaded with faecal eggs were females.

Coccidian infestation was found to be high in females than males in both districts, however the difference was not statistically significant ($p>0.05$). These could be caused by the fact that both male and female sheep are subjected to the same rangelands and therefore, they have equal chances of infection.

However, Sharma *et al*. (2009) found high number of coccidian oocysts in females. The same author (Sharma *et al.,* 2017) found the opposite results eight years which depicted high coccidian oocysts in males than in females.

4.3.10 Accumulation of gastrointestinal parasites over a period of six months

The results in Figure 14 show how FEC of nematodes were accumulating in sheep over a period of six months (July-December). The faecal egg count means for Maseru district indicate that the degree of nematode infestation was lower between July and September. From September to October the FEC intensity increased from 230 eggs to 1343.10 eggs ($p<0.05$). The significant ($p<0.05$) decrease in the infestation of nematodes FEC was also from October to December by 948.46 eggs. In Quthing district, the nematodes infestation showed that the faecal egg loads for the first three months of the study (July, August and September) were significantly ($p<0.05$) lower in comparison to those in October, November and December. From September to October there was an increase of FEC by 285.84 eggs. A slight decline of 1.89 eggs ($p>0.05$) from October to November was observed while from November to December the infestation of FEC insignificantly ($p>0.05$) increased by 7.55 eggs.

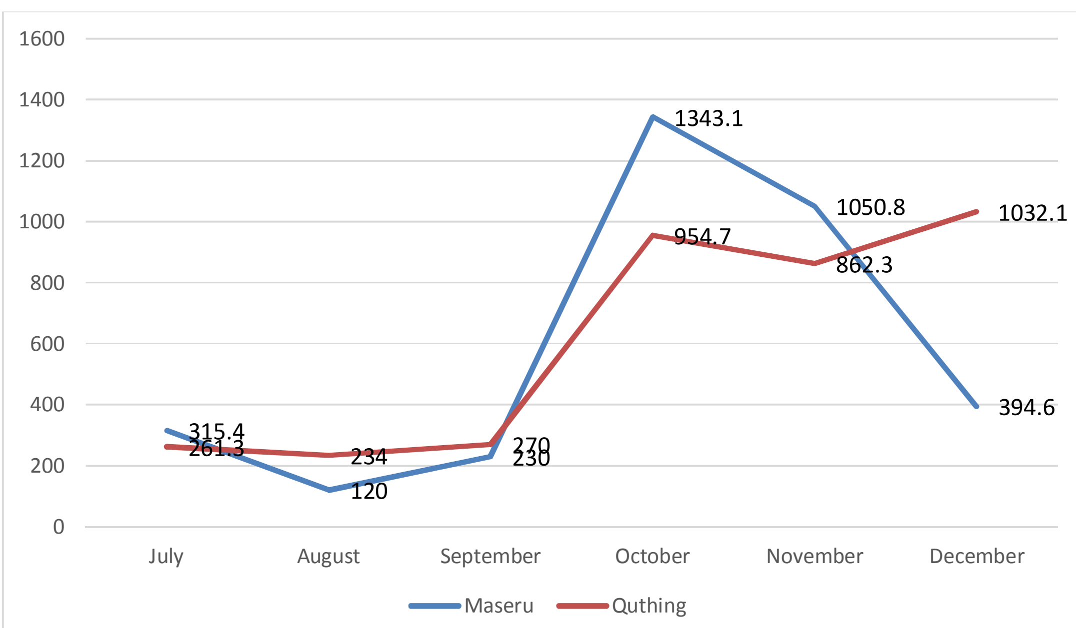


Figure 14: Faecal egg count means for nematodes in Maseru and Quthing districts

The higher infestation of nematodes FEC in October to December could be caused by the fact that some ewes were lambing at this time while others were on gestation, therefore, it is possible that the high levels of periparturient rise for FEC were in such female sheep because of lower immune response during parturition or gestation (Roeber *et al.*, 2013). High FEC of gastrointestinal helminths during this period could also be linked to sufficient moisture that occurred during of the rainy seasons. It encourages the development of infective larvae in the pastures and rangelands and high chances of infective larvae uptake by sheep. Vlassoff *et al.* (2001) also found that higher egg loads of gastrointestinal helminths occurs in summer seasons. The lower intensity of nematodes in July, August and September as found in this study tally with the findings of Pal and Qayyum (1993) who indicated that gastrointestinal helminths depend mostly on agro-climatic conditions such as the quality and quantity of forage. In Lesotho, during winter or dry months of the year the forage quantity and quality decreases and this could be possible cause for the sheep to have lower intensity of nematodes FEC during this period.

The FEC mean differences for coccidia in the district of Maseru were significantly ($p<0.05$) different between the months of August, September and November indicating high coccidial infestation in August than in November. The FEC load was significantly ($p<0.05$) higher in September than in August and November. In Quthing district, the coccidian faecal egg load was significantly ($p<0.05$) higher in July, August and September as compared to October, November and December.

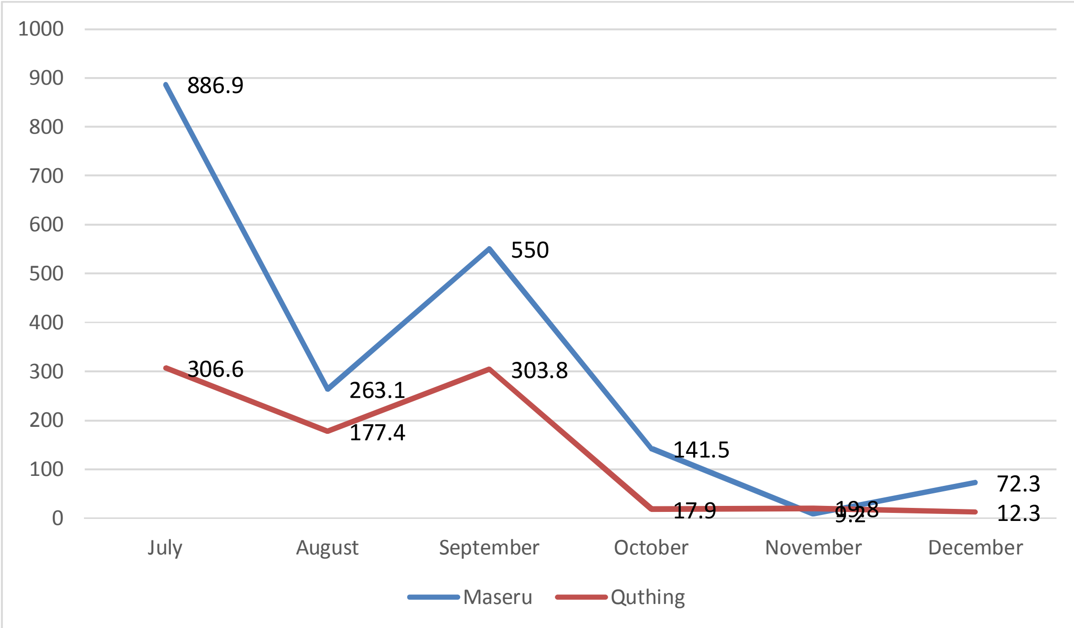


Figure 15: the faecal egg count means for coccidia in Maseru and Quthing districts

Furthermore, the results demonstrate the faecal egg count means of coccidial eggs were higher in July and lower in November in both Maseru and Quthing districts (Figure 15). The degree of coccidial infestation decreased gradually from July to December. However, in September an increase of faecal egg load was observed which is believed to be the result of variation in environmental temperature. This shows that coccidial oocysts multiply rapidly during the conditions in which an animal is subjected to stress such as cold temperatures. Yakhchali and Zarei (2008) also stated that coccidia favours rainfalls provided the temperatures are low.

4.4 CONCLUSION AND RECOMMENDATIONS

4.4.1 Conclusion

The results of this study showed that merino sheep in Lesotho are mostly infected with gastrointestinal nematodes and protozoan coccidia that can tremendously affect their health and productivity. The gastrointestinal prevalence positively correlated with the faecal egg loads. Nematodes and coccidian infestations were higher in the lowlands of Maseru district and foothills of Quthing district. Adult sheep were more infected with nematodes while coccidia were prevalent in juveniles. Males and females were affected by gastrointestinal parasites equally. Nematodes were more prevalent from October to December while coccidia was problematic July to September.

4.4.2 Recommendations

a) The monthly influence on the gastrointestinal prevalence should be considered when designing control strategies of the gastrointestinal parasites. The dosing programs should be in a way that sheep are dosed against coccidia prior to winter and be dosed against nematodes before it gets warmer in order to minimize the infections.
b) The control of nematodes should focus more in warm places while for coccidia the focus should be where the temperatures are normally low.
c) The treatment of the gastrointestinal parasites should be mostly aimed at reducing the infections in juveniles, especially for coccidia treatment, by vaccinating pregnant ewes for passive immunity and by ensuring that young animals graze with adults that have received gastrointestinal parasites treatment.
d) Further studies should be conducted and for a period of 12 months so that the pattern of gastrointestinal parasites infection can be known throughout the whole year. The future studies should cover the 10 districts of Lesotho. The floatation and sedimentation techniques should be used in order to increase the chances of identifying all gastrointestinal parasites of economic importance.

4.5 References

Abbott, K.A., M. Taylor, L.A. Stubbings, 2012. *Sustainable Worm Control Strategies for sheep*, 4th Edition. Sustainable Control Of Parasites in Sheep, United Kingdom. http://www.scops.org.uk

Aga, T.S., Y.H. Tolossa and G. Terefe, 2013 *Epidemiology of gastrointestinal nematodes of Horro sheep in Western Oromiya*, *Ethiopia*. Journal of Veterinary Medicine and Animal Health, 5 (10): 296-304.

Alade, N. K. and M. D. Mbwala, 2015. *Gastrointestinal-parasites infestation in Yankasa sheep in a semi –arid environment*. Livestock Research for Rural Development, 27(6).

Andrews, S.J., (1999). *The Life Cycle of Fasciola hepatica*. In: Fasciolosis, Dalton, J.P. (Ed.). CAB International, Oxon: 1-29.

Biu, A.A. and A. Oluwafunmilayo, 2004. *Identification of some Paramphistomes infecting sheep in Maiduguri, Nigeria.* Pakistan Veterinary Journal, 24(4): 187-189.

Craig, B.H., J.G. Pilkington and J.M. Pemberton, 2006. *Gastrointestinal nematodes species burdens and host mortality in feral sheep population*. Institution of Evolutionary Biology, 485-496.

Dagnachew, S., A. Amamute and W. Temesgen, 2011. *Epidemiology of gastrointestinal helminthiasis of small ruminants in selected sites of North Gondar zone, Northwest Ethiopia* Ethiopia Veterinary Journal, 15 (2): 57-68.

Demelash, B., J., Yilma and C. Hessen, 2006. *Ovine helminthiosis, a major constrained to productivity of sheep in Ethiopia*. Animal Health Research Reviews, 7(2): 107-118.

Esker, M. and H.W. Ploeger, 2000. *Value of present diagnostic methods for gastrointestinal nematodes infections in ruminants*. Cambridge University Press. Division of parasitology and tropical veterinary medicine, 37:609-610.

Fikru, R., S. Teshale, D. Reta and K. Yosef, 2006. *Epidemiology of Gastrointestinal Parasites of Ruminants in Western Oromia, Intern Ethiopia*: Journal of Applied Research Veterinary Medicine, 4 (1): 51-57.

Gadahi, J. A., M. J. Arshed, Q. Ali, S. B., Javaid and S. I. Shah, 2009. *Prevalence of Gastrointestinal Parasites of Sheep and Goat in and around Rawalpindi and Islamabad,* Pakistan Veterinary World, 2(2): 51-53.

Gauly, M., Schackert M., Hoffmann B. and G. Erhardt, 2006. *Influence of sex on the resistance of sheep lambs to an experimental Haemonchus contortus infection.* Dtsch. Tierarztl. Wochenschr, 113: 178–181.

Hashemnia, M., F. Rezaei, A. Chalechale, S. Kakaei and S. Gheichivand, 2014. *Prevalence and Intensity of Eimeria infection in sheep in Western Iran*. International Journal of Livestock Research, 4(1):107-112.

Ibrahim, N., M. Tefera, M. Bekele and S. Alemu, 2014. *Prevalence of Gastrointestinal Parasites of Small Ruminants in and Around Jimma Town, Western Ethiopia.* Acta Parasitologica Globalis, 5 (1): 12-18.

Jones R., 2001. *Sheep parasite and diseases*. http://www.kt.iger.bbsrc.ac.uk

Koinari M., S. Karl, U. Ryan and A. J. Lymbery, 2012. *Infection levels of gastrointestinal parasites in sheep and goats in Papua New Guinea*. Journal of Helminthiology, 87(4): 17.

Koinari M., S. Karl, U. Ryan and A. J. Lymbery, 2013. Infection levels of gastrointestinal parasites in sheep and goats in Papua New Guinea. Journal of Helminthiology, 87(4): 409-415.

Lemma, D. and B. Abera, 2013. *Prevalence of ovine gastrointestinal nematodes in and around Asella, South Eastern Ethiopia*. Journal of Veterinary Medicine and Animal Health, 5(8): 222-228. http://www.academicjournals.org

Lesotho Meteorological Services, 2013. *The climate of Lesotho*: Ministry of Energy, Meteorology and Water Affairs, Lesotho.

Maingi, N, W.K. Munyua, 1994. *The prevalence and intensity of infection with Eimeria species in sheep in the Nyandarua district of Kenya*. Veterinary Research Communications, 18: 19–25.

Muluneh, J., B. Bogale and M. Chanie, 2014. *Major Gastrointestinal Nematodes of Small Ruminants in Dembia District*. Northwest Ethiopia European Journal of Applied Sciences, 6(2): 30-36.

Mushtaq, H. L., and Z. Tasawar, 2011. *Prevalence of some gastrointestinal parasites in sheep in Southern Punjab, Pakistan*. Pakistan Veterinary Journal, 31:295-298.

Nyamweya N.J., 2015. *Prevalence and control of sheep nematodes in Kangariri Universoty farm, Kiambu county, Kenya*. Degree Dissertation.

Owen, I.L., 1989. *The epidemiology of fasciolosis in Papua New Guinea.* Australian Veterinary Journal, 66:58–60.

Pal, R.A and M. Qayyum, 1993. *Prevalence of gastrointestinal nematodes of sheep and goats in upper Punjab, Pakistan.* Pakistan Veterinary Journal, 13(3): 138-141.

Parkins J., and P. Holmes (1989). *Effects of gastrointestinal helminths parasites on ruminant's nutrition.* Nutrition Research Reviews, 2:227-246.

Raza, M. A., M. Younas and E. Schlecht, 2014. *Prevalence of gastrointestinal helminths in pastoral sheep and goat flocks in the cholistan desert of Pakistan.* The Journal of Animal and Plant Sciences, 24(1):127-134.

Raza, M. A., Z. Iqbal, A. Jabbar, M. Yaseen, 2007. *Point prevalence of gastrointestinal helminthiasis in ruminants in southern Punjab.* Pakistan Journal Helminthology, 81:323– 328.

Regassa, F., Sori T., Dhuguma R., Y. Kiros, 2006. *Epidemiology of gastrointestinal parasites of ruminants in western Oromia, Ethiopia.* International Journal Applied Research Veterinary Medicine, 4(1):51.

Sangster, N., 2007. *How parasites affect production*. Australian Wool Innovation and The University of Sydney. http://sydney.edu.

Shahid, R., Q. Abdul, S. A. Abdul and C.S. Hayat, 1997. *Parasitic infection of sheep and goats in quetta and kalat areas of balochistan,* Pakistan veterinary journal, 17(2):94-96.

Shalaby, H.A., 2013. *Anthelmintics Resistance; How to overcome it.* Iranian Journal of Parasitology, 8(1):18-32.

Sharma, D.K., A. Nimisha, M. Ajoy, N. Pooja and S. Bhushan, 2009. *Coccidia and gastrointestinal nematode infections in semi-intensively managed Jamunapari goats of semi-arid region of India*. Tropical and Subtropical Agro Eco-Systems, 11(1): 135-139.

Sharma, D.K., S. Paul, P.K. Rout, A. Mandal, S. Bhusan, N. Sharma and Y.K. Kushwah, 2017. *Caprine coccidiosis in semi-arid India: Dynamics and factors affecting faecal oocysts count.* Journal of Advanced Veterinary and Animal Research, 4(1): 52-57.

Soulsby, E.J.L., 1986. *Helminths, Arthropods and Protozoa of Domesticated Animals*. 7thEdition. Baillì ere Tindall. London.

Taylor, M. A., 2010. *Parasitological examinations in sheep health management.* Small ruminant research, 92 (1-3): 120-125.

Tehmina, S., R. Shahina, A. Razzaq, I.B. Marghazani and A.N. Khosa, 2014. *Prevalence of Paramphistomum cervi in different sheep breeds of Balochistan (Pakistan)*. Paramphistomum cervi en ovejas. Revista Veteterinaria, 25: (1)12-15.

Urquhart, G.M., J. Armour, J.L. Duncan, A.M. Dunn and F.W. Jennings, 1994. *Veterinary Parasitology*. 1st edition. Longmann; Singapore.

Urquhart, GM, Aremour J, Dunchan JL, Dunn A. M and F.W. Jeninis, 1996. *Veterinary parasitology* 2nd edition. The University of Glasgow, Blackwell Sciences, Scotland: 3-137.

Varadharajan, A. and R. Vijayalakshmi, 2009. *Prevalence and seasonal occurance of gastrointestinal parsitesbin small ruminants of coastal areas of Tami Nadu*. International Journal of Scientins and Research Publications, 5(2):1-3.

Villarroel, A., 2013. *Internal Parasites in Sheep and Goats.* Oregon State University: 1-4. http://oregonstate.edu.

Vlasoff, A., D.M. Leathwick and A.C.G. Heath, 2001. *The epidemiology of nematode infections of sheep.* New Zealand Veterinary Journal, 49:213-221.

Waller, P.J., K.M. Dash, I.A. Barger, L.F. Jambre and J. Plant, 1995. *Anthelmintic resistance in nematode parasites of sheep*. Veterinary Record, 136: 411 – 413.

Waller, P.J., 1999. *International approaches to the concept of integrated control of nematode parasites of livestock.* International Journal Parasitology, 29:155–164.

Whittier, D.W., A. Zajac and S.H. Umberger, 2009. *Control of internal parasites in sheep.* Virginia Cooperative Extension:1-8 http://pubs.ext.vt.edu

Yakhchali, M. and Zarei M. R., 2008. *Prevalence of Eimeria infection in sheep of Tabriz suburb.* Iran. Iranian Journal of Veterinary Research, 9 (3): 277-280.

Yakhchali, M and E. Galami, 2008. *Emeria infection (Coccidia; Emeridae) in sheep of different age groups in Sanandaj city.* Iran Verterinarski Archive, 78(1): 57-64.

Zeryhun, T., 2012. *Helminthiosis of sheep and goats in and around Haramaya, Southeastern. Ethiopia*. Journal of Veterinary Medicine and Animal Health, 4(3): 48-55.

4.5 APPENDICES

Appendix 1: Parameter estimates of gastrointestinal parasites under Generalised Estimating Equations (Binary logistics analysis)

	Maseru				Quthing		
Parameter	**B**	**Sig.**	**Exp.(B)**	**Parameter**	**B**	**Sig.**	**Exp.(B)**
				Nematodes			
intercept	-0.695	0.005	0.499	**intercept**	1.043	0.000	2.838
Male	-0.228	0.144	0.796	**Male**	-0.187	0.327	0.829
Female	0[a]	.	1	**Female**	0[a]	.	1
Adults	0.128	0.411	0.880	**Adults**	-0.383	0.055	0.682
Juveniles	0[a]	.	1	**Juveniles**	0[a]	.	1
Mountains	0.252e	0.225	1.286	**Mountains**	-0.893	0.000	0.410
Foothills	0.891	0.000	2.439	**Foothills**	1.513	0.000	0.220
Lowlands	0[a]	.	1	**Lowlands**	0[a]	.	1
				Coccidia			
Parameter	**B**	**Sig.**	**Exp.(B)**	**Parameter**	**B**	**Sig.**	**Exp.(B)**
Intercept	-1.892	0.000	0.151	**intercept**	-0.785	0.000	0.456
Male	0.175	0.319	1.192	**Male**	0.025	0.883	0.975
Female	0[a]	.	1	**Female**	0[a]	.	1
Adults	0.978	0.000	2.659	**Adults**	0.732	0.000	2.079
Juveniles	0[a]	.	1	**Juveniles**	0[a]	.	1
Mountains	-0.444	0.056	0.641	**Mountains**	-0.326	0.087	0.722
Foothills	0.501	0.022	1.650	**Foothills**	0.146	0.489	1.157

Lowlands	0^a	.	1	**Lowlands**	0^a	.	1

B= Beta, Exp. B = Exponential Beta, Sig.= Significant.

Appendix 2: Parameter estimates of gastrointestinal parasites under Generalised Estimating Equation analysis (Negative binomial).

	Maseru				**Quthing**		
Parameter	**B**	**Sig.**	**Exp.(B)**	**Parameter**	**B**	**Sig.**	**Exp.(B)**
				Nematodes			
Intercept	5.859	0.000	350.263		4.629	0.000	102.372
Mountains	-0.165	0.462	0.847	**Mountains**	0.744	0.000	2.104
Foothills	-0.935	0.000	0.393	**Foothills**	0.969	0.000	2.636
Lowlands	0^a	.	1	**Lowlands**	0^a	.	1
Adults	0.283	0.120	1.327	**Adults**	0.266	0.067	1.305
Juveniles	0^a	.	1	**Juveniles**	0^a	.	1
Male	-0.106	0.570	0.900	**Male**	-0.029	0.844	0.971
Female	0^a	.	1	**Female**	0^a	.	1
				Coccidia			
Intercept	7.583	0.000	1.964E3	Intercept	6.277	0.000	531.980
Mountains	-0.659	0.231	0.518	**Mountains**	0.517	0.011	1.678
Foothills	-0.135	0.813	0.874	**Foothills**	0.299	0.326	1.348
Lowlands	0^a	.	1	**Lowlands**	0^a	.	1
Adults	-1.377	0.000	0.252	**Adults**	-1.613	0.000	0.199
Juveniles	0^a	.	1	**Juvenile**	0^a	.	1
Male	-0.221	0.632	0.802	**Male**	-0.078	0.716	0.925
Female	0^a	.	1	**Female**	0^a	.	1

B= Beta, Exp. B = Exponential Beta, Sig.= Significant.

Appendix 3: Monthly FEC mean differences for Nematodes under General Linear Models for repeated measures

Maseru				Quthing			
			Nematodes				
(I) Months	**(J) Months**	**Mean Difference (I-J)**	**Sig.[b]**	**(I) Months**	**(J) Months**	**Mean Difference (I-J)**	**Sig.[b]**
July	August	195.385*	0.006	**July**	August	27.358	1.000
	September	85.385	1.000		September	-8.491	1.000
	October	-1027.692*	0.000		October	-693.396*	0.000
	November	-735.385*	0.050		November	-600.943*	0.000
	December	-79.231	1.000		December	-770.755*	0.000
Aug	July	-195.385*	0.006	**Aug**	July	-27.358	1.000
	September	-110.000	0.194		September	-35.849	1.000
	October	-1223.077*	0.000		October	-720.755*	0.000
	November	-930.769*	0.002		November	-628.302*	0.000
	December	-274.615	0.126		December	-798.113*	0.000
Sept	July	-85.385	1.000	**Sept**	July	8.491	1.000
	August	110.000	0.194		August	35.849	1.000
	October	-1113.077*	0.000		October	-684.906*	0.000
	November	-820.769*	0.011		November	-592.453*	0.000
	December	-164.615	1.000		December	-762.264*	0.000
Oct	July	1027.692*	0.000	**Oct**	July	693.396*	0.000
	August	1223.077*	0.000		August	720.755*	0.000
	September	1113.077*	0.000		September	684.906*	0.000
	November	292.308	1.000		November	92.453	1.000
	December	948.462*	0.004		December	-77.358	1.000
Nov	July	735.385*	0.050	**Nov**	July	600.943*	0.000

	August	930.769*	0.002		August	628.302*	0.000
	September	820.769*	0.011		September	592.453*	0.000
	October	-292.308	1.000		October	-92.453	1.000
	December	656.154*	0.004		December	-169.811	1.000
Dec	July	79.231	1.000	**Dec**	July	770.755*	0.000
	August	274.615	0.126		August	798.113*	0.000
	September	164.615	1.000		September	762.264*	0.000
	October	-948.462*	0.004		October	77.358	1.000
	November	-656.154*	0.004		November	169.811	1.000

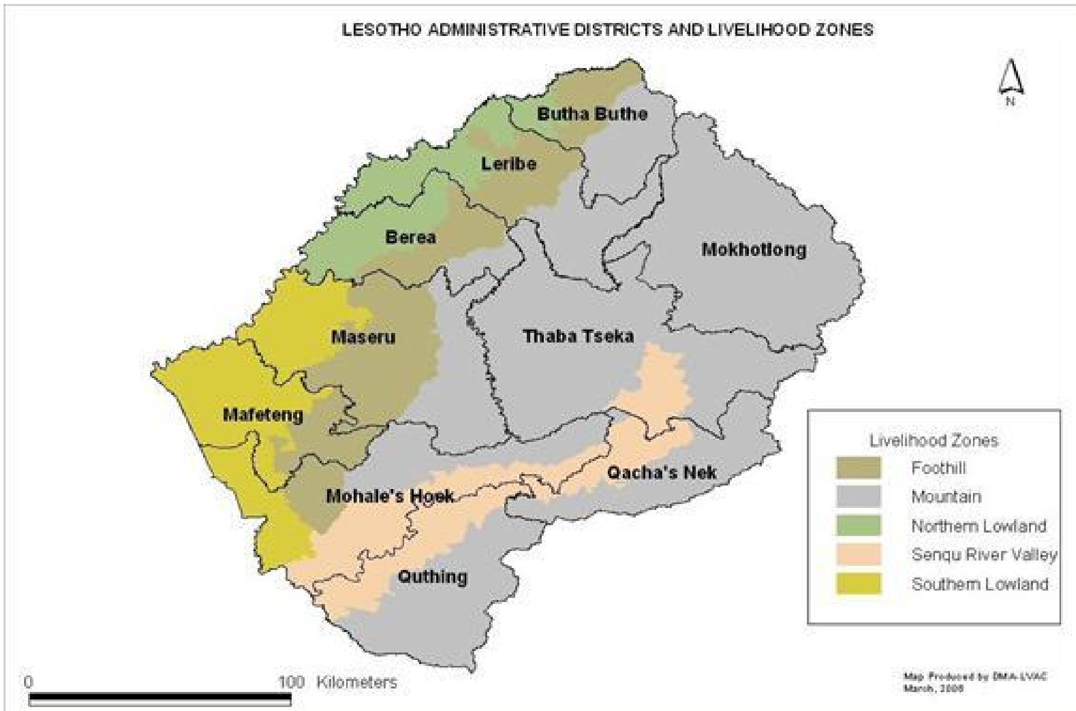
Sig.= Significance, Aug. = August, Sept. =September, Oct. =October, Nov. =November, Dec. =December

Appendix 4: Monthly FEC mean differences for coccidia under General Linear Models for Repeated measures

Maseru				Quthing			
			Coccidia				
(I) Months	**(J) Months**	**Mean Difference (I-J)**	**Sig.[b]**	**(I) Months**	**(J) Months**	**Mean Difference (I-J)**	**Sig.[b]**
July	August	623.846	0.674	**July**	August	129.245	0.215
	September	336.923	1.000		September	2.830	1.000
	October	745.385	0.291		October	288.679*	0.000
	November	877.692	0.084		November	286.792*	0.000
	December	814.615	0.177		December	294.340*	0.000
Aug	July	-623.846	0.674	**Aug**	July	-129.245	0.215
	September	-286.923*	0.002		September	-126.415	1.000
	October	121.538	0.383		October	159.434*	0.000
	November	253.846*	0.000		November	157.547*	0.000
	December	190.769	0.444		December	165.094*	0.000
Sept	July	-336.923	1.000	**Sept**	July	-2.830	1.000
	August	286.923*	0.002		August	126.415	1.000
	October	408.462*	0.000		October	285.849*	0.007
	November	540.769*	0.000		November	283.962*	0.007
	December	477.692*	0.000		December	291.509*	0.004
Oct	July	-745.385	0.291	**Oct**	July	-288.679*	0.000
	August	-121.538	0.383		August	-159.434*	0.000
	September	-408.462*	0.000		September	-285.849*	0.007
	November	132.308*	0.000		November	-1.887	1.000
	December	69.231	1.000		December	5.660	1.000
Nov	July	-877.692	0.084	**Nov**	July	-286.792*	0.000

	August	-253.846*	0.000		August	-157.547*	0.000
	September	-540.769*	0.000		September	-283.962*	0.007
	October	-132.308*	0.000		October	1.887	1.000
	December	-63.077	1.000		December	7.547	1.000
Dec	July	-814.615	0.177	**Dec**	July	-294.340*	0.000
	August	-190.769	0.444		August	-165.094*	0.000
	September	-477.692*	0.000		September	-291.509*	0.004
	October	-69.231	1.000		October	-5.660	1.000
	November	63.077	1.000		November	-7.547	1.000

Sig= Significance, Aug= August, Sept=September, Oct.=October, Nov. =November, Dec. =December



Appendix 5: The map of Lesotho showing different agro-ecological zones

CHAPTER 5

5.1 GENERAL CONCLUSION

Farmers are aware of gastrointestinal parasites and the use of anthelmintics as a control measure against gastrointestinal parasites. Most of the farmers have lower education level and are very old to handle sheep farming effectively; therefore, this influence improper management of both animals against gastrointestinal parasites and grazing system to combat transmission of gastrointestinal parasites as it was found that grazing lands are the main source of transmission. In addition, lack of knowledge of farmers influence the manner in which medication is used against gastrointestinal parasites and these could lead to parasites being resistant to drugs.

The prevalence of gastrointestinal parasites correlates positively with faecal egg loads of gastrointestinal parasites. Agro-ecological zones and age of an animal have effect on the prevalence and faecal egg loads of gastrointestinal parasites; therefore, they should be considered when treatment is applied. Sex of an animal does not influence either the prevalence or faecal egg loads of gastrointestinal parasites. Nematodes accumulated when conditions and warm and moist while coccidia was found to be very opportunistic in that it increased when animals are exposed to cold stress in winter months.