ADDIS ABABA UNIVERSITY
FACULTY OF VETERINARY MEDICINE

EPIDEMIOLOGY OF GASTROINTESTINAL TRACT NEMATODIOSIS OF SMALL RUMINANTS IN THREE DIFFERENT AGRO-ECOLOGICAL ZONES OF SOUTHERN ETHIOPIA.

By

AMENU ASHA TOLKE

JULY 2005
DEBRE ZEIT, ETHIOPIA

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A thesis submitted to the School of Graduate Studies of Addis Ababa University in partial fulfillment of the requirements for the Degree of Master of Science in Tropical Veterinary Epidemiology

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LIST OF ABBREVIATIONS

AEZ: Agro-ecological zone

Buno: Bunostomum

B.phel: Bunostomum phlebotomum

BRD: Bureau of Rural Development

Chab :Chabertia

Epg: Egg per gram of faeces

FEC: Faecal egg counting

GIT: Gastrointestinal tract

GGZ: Gamo Gofa Zone

L_3: Third stage larvae

masl.: metres above sea level

Oesophago: Oesophagostomum

O.col: Oesophagostomum columbianum

PME: Post mortem examination

SNNPRS: Southern, Nations, Nationalities and People's Regional State

Spp.: Species

Tricho: Trichostrongylus

WZFEDD: Wolayta zone Finance Economic Development Department.

WZRDD: Wolayta Zone Rural Development Department

GGZRDD: Gamo-Gofa Zone Rural Development Department

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ABSTRACT

An epidemiological study on gastrointestinal tract nematodiosis of small ruminants in three different agro-ecological zones of southern Ethiopia was carried out from August 2004 to April 2005 on 180 gastrointestinal tracts and 2,828 faecal samples collected from sheep and goats to identify nematode species, determine the occurrence and factors related to the nematode infection. The study was carried out through post-mortem examination and coprological examinations using floatation and McMaster egg counting methods. Post mortem examination revealed the existence of ten (10) nematode species with different percent prevalence rates (*Oesophagostomum columbianum*, 92.2; *Trichostrongylus colubriformis*, 73.9; *Haemonchus contortus*, 68.9; *Trichostrongylus axei*, 61.7; *Tricuris ovis*, 42.8; *Bunostomum trigonocephalum*, 18.9; *Teladorsagia spp.*, 15.6; *Trichostrongylus probolurus*, 5.0; Strongyloides *papillosus*, 1.1 and *Cooperia curticei*, 0.5). The identification of *Teladorsagia spp.* and *Trichostrongylus probolurus* was new to the region and even to the country after Graber, (1975) and the identification of *Cooperia curticei* was for the first time in Ethiopia. The prevalence of gastrointestinal tract nematodiosis varies from 98.3% in lowland and midland agro-ecology to 100% in highlands, with an overall prevalence of 98.9% in all agro-ecological zones. The variation in the prevalence of individual nematode species on agro-ecological basis was significant ($P<0.05$) except for *Oesophagostomum columbianum* and *Strongyloides papillosus* ($p>0.05$). The seasonal point prevalence of *Haemonchus contortus*, *Trichostrongylus axei*, *Bunstomum trigonocephalum*, *Oesophagostomum columbianum*, *Trichuris ovis* and *Trichostrongylus colubriformis* were significantly varied ($p< 0.05$) between seasons of the year. Mean nematode burden of different seasons of the year have shown significant differences for seasonal variation ($p<0.05$). These variations were observed between seasons of late wet and early dry ($p<0.05$), late wet and mid dry ($p<0.05$), late wet and late dry ($p<0.05$), late wet and early wet ($p<0.05$) and between agro-ecological zone of highland and lowland ($p<0.05$). Sex difference and species variation did not show difference in the mean worm burden ($p> 0.05$).

Out of 98.9% of infected animals in the study area, 97.7% were infected by more than one nematode species. 64.0% of poly-parasitised animals in the study area were infected by 4 or more nematode species. 58.4% of the infected animals harboured light infestation, 40.5% were moderate and only 1.1% was severely infected by gastrointestinal tract nematode species. The mean total nematode burden and mean total epg count both from slaughtered animals in this study was positively correlated (Spearman's rho (r_s)=0.57, $p<0.001$) and the correlation of mean epg to individual nematode species burden was significant for three nematode species; *Trichostrongylus colubriformis*, (r_s=0.50); *Haemonchus contortus*, (r_s=0.45) and *Oesophagostomum columbianum*, (r_s=0.39) with $p<0.001$ for all correlations. Faecal examination results from population of sheep and goats during four sampling periods indicated significant seasonal variation ($p<0.05$) for all study sites. Majority of infected animals had a faecal egg count in the range of 50-800 epg and only few proportions of animals had faecal egg count over 1200.

The widespread existence of various nematodes in the form of polyparasitism both in sheep and goats in all agro-ecology of the study area, and the high nematode burden both at postmortem and coproscopic examination suggest the institution of various control measures including strategic anthelmintic treatment for efficient utilization of the available small ruminant resources at hand.

Key words: Epidemiology; GIT nematodes; Postmortem; Coproscopy, Small ruminant; Southern Ethiopia.

1. INTRODUCTION AND OBJECTIVES

1.1 Introduction

The contribution of livestock to the human being particularly in the developing countries is numerous and small ruminant production is an important component of livestock production in Africa (Rege, 1994). Small ruminants in Africa represent 21% of the world's small ruminant population (sheep, 17% and goats, 30% of the world's sheep and goats population respectively) (Ibrahim, 1998).

Highly adaptive nature to range of environments, ability to utilize wide variety of plant species, short generation cycle and high reproductive rates which lead to high production efficiency made sheep and goats complementary to cattle and camel (Rege, 1994; Ibrahim, 1998). Sheep and goat are a major source of income (cash) and food protein for rural farmers in most part of tropics including Ethiopia (Ibrahim, 1998), and skin, fiber, manure and as an investment (Devendra and Mcleory, 1982; Rege, 1994). However, the full exploitation of these resources is hindered in the tropical environment, and particularly in Africa due to a combination of factors such as drought, poor genetic potential of the animals, traditional system of husbandry and the presence of numerous prevalent diseases (Schillhorn van veen, 1985; Mboera and Kitalyi, 1994; Mtenga *et al.*, 1994; Ndamukong, 1994; Rege, 1994; Ibrahim, 1998).

Among the diseases that affect small ruminants; gastrointestinal tract (GI) nematode parasites impose severe economic impact on sheep and goat production in the world exerting deleterious effect on host, which may be manifested by lowered vitality, reduced rate of reproduction, slower growth rate or death of infected individuals (Wilford, 1974; Belschner, 1976; Smith and Sherman, 1994; Kaufmann, 1996; Ibrahim, 1998) and it is a serious problem of the developing nations of the world, particularly, where nutrition and sanitation are poor (Mostofa *et al.*, 1996).

The severity of the disease and effects it cause is prominent in young flocks (lambs) and yearlings (Belschner, 1976) and to those individuals that are stressed (Soulsby, 1982; Urquhart *et al.*, 1996; Radostits *et al.*, 2000). Hence the disease deserves special attention as it diminishes the capacity of sheep and goats to achieve their inherent potential level of production for any given feeding and management regimen (Morris, 1988).

Various epidemiological factors are affecting the distribution and importance of parasitic disease. One of the factors seriously affecting the pre-parasitic phase of nematode development is the presence of suitable climate, particularly of temperature and moisture. The requirements of the different free-living stages of nematodes in this regard vary from parasites to parasites. As a result some parasites are more adapted to temperate cool environment while others are adapted to warm tropical environment (Craig, 1998).

Some of the major nematodes responsible for GIT parasitosis in small ruminants under tropical environment are: *Haemonchus, Trichostrongylus, Nematodirus and Cooperia spp.* (Family: Trichostrongylidae); *Bunostomum trigonocephalum* and *Gaigeria pachyscelis* (Ancylostomatidae); *Chabertia ovina* and *Oesophagostomum spp* (Strongylidae); *and Trichuris and Strongyloides spp.* (Troncy, 1989). A number of published works indicate that these nematode species are infecting sheep and goat population of tropical environment, either singly or mixed in a host at a time. However, under natural field condition, polyparasitism predominates in most cases and the prevalence varies depending up on the area and the parasite species involved.

In Ethiopia, a number of attempts have been made so far to identify the different genera and species of nematodes in small ruminants and determine the prevalence both by coprology and post mortem examination. The report made by Graber (1975) was one of the earliest and extensive attempts in describing the different types of helminth parasites of domestic animals including that of small ruminants from different parts of Ethiopia. The existence of *H. contortus, Oe. columbianum, S. papillosus, Oe. venulosum, C. ovina, Skrjabinema ovis, B. trigonocephalum, Trichostrongylus spp., Teladorsagia spp.* and *Trichuris spp.* was reported

from Oromiya (Yabello, Debre Zeit, Bale); SNNPRS (Sidamo, Gamo Gofa); Amhara (Debre Berhan, Wollo, Kombolcha, Shoa) and Somale region (Ogaden) (Graber, 1973; Graber, 1975).

A valuable input in identifying parasites of small ruminants was also made through externship program by students of the Faculty of Veterinary Medicine of Addis Ababa University and by some research institutes and regional laboratories of the Ministry of Agriculture. In most cases, five genera of nematode parasites from different angles of the country were reported, and these include: *Haemonchus spp., Oesophagostomum spp., Bunostomum spp., Trichostrongylus spp. and Trichuris spp.. Longistrongylus elongata* was reported in sheep at Debre Berhan, ILRI research station (Tembely *et al.*, 1997). *Skrjabinema ovis* was reported in sheep at Debre Berhan(Tembely *et al.*, 1997) and from sheep and goats of eastern part of Ethiopia (Abebe and Esayas, 2001). *Chabertia ovina* was recovered from sheep bought from Arsi and Wollo areas and slaughtered at Addis Ababa abattoir (Bekele *et al.*, 1982). Details of findings and the specific areas so far studied are presented in Annex (4 & 5).

Although extensive studies are lacking in southern part of Ethiopia, two preliminary studies by the undergraduate students of the FVM of AAU at Wolayta and its surrounding indicated the importance of gastrointestinal tract nematodes as a major problem to sheep and goat production of the study sites (80 to 90% prevalence according to Dereje, 1992 and Haileleul, 2002). However, detail studies covering all agro-ecological zones and the important epidemiological factors that may have great role in the disease control are lacking. Therefore, the general purpose of this study is to identify GIT nematode species existing and to observe the major epidemiological factors that determine occurrence and magnitude of GIT nematodiosis of small ruminants in three different agro-ecological zones of Southern Ethiopia.

1.2 **Objectives of the study**

A. To identify the nematode species parasitising sheep and goats and determine their prevalence in three different agro-ecological zones of the study areas.

B. To observe the seasonal dynamics of GIT nematodiosis of small ruminants in the study areas and identify the involved epidemiological factors associated with the GIT nematodiosis.

2. LITERATURE REVIEW

2.1 Major GIT Nematodes Affecting Small Ruminant Production

Parasitic gastroenteritis is a worldwide problem and important cause of production losses in sheep and goat production (Eysker and Ploeger, 2000). These productivity losses due to nematode parasite infection of small ruminants could be due to changes in feed intake, impaired gastrointestinal tract function, competition for the host's essential nutrients and damages during parasite feeding; and these losses include the direct effects of severe clinical signs such as anaemia, oedema, diarrhoea, and anorexia; which can easily result in poor general performance and even mortality particularly in the young aged and immuno-suppressed (stressed) individuals (Wilford, 1974; Fox, 1997; Eysker and Ploeger, 2000).

The effect of parasitism on individual animal (host) is not distinctly manifested clinically for specific parasite species. In general, all intestinal nematodiosis lead to reduced feed intake which may be partly due to increased production of cholecystokinin by the intestinal cells, absorbed into blood system and act on neuro-endocrine control centre and suppress the appetite. However, based on the predominating clinical symptoms, we can group gastrointestinal tract nematodes as those that cause decreased feed utilization by the host, those that cause the destruction of host's tissues and those that cause loss of blood (Wilford, 1974; Soulsby, 1982; Troncy, 1989; Fox, 1997).

2.1.1 GIT nematodes that cause decreased feed utilization by the host

This group includes mainly *Teladorsagia spp.*, *Trichostrongylus spp.*, *Cooperia spp.*, *Strongyloides papillosis*, *Oesophagostomum spp* and *Nematodirus spp.*. The pathological changes observed due to these parasites include: tunnel under mucosal epithelium of abomasum (*Teladorsagia spp.*, *Trichostrongylus axei*) and small intestine, erosion of mucosal epithelium of abomasum and intestine, catarrhal enteritis, villous atrophy in anterior small intestine, hyperaemia and oedema. In extreme cases, diphtheritic enteritis and exudates hinder absorption (Dunn, 1978; Soulsby, 1982; Urquhart *et al.*, 1996; Radostits *et al.*, 2000).

The manifestation of these lesions is marked alteration in the influx and efflux of water and electrolytes (chlorine and sodium ions) in the bowel and morphological and biochemical changes in the epithelial cells and their microvilli (Soulsby, 1982) leading to protein losing enteropathy, accompanied by excessive mucus production, diarrhoea, weight loss, hypo proteinaemia (Smith and Sherman, 1994; Urquhart *et al.*, 1996), pica (Troncy, 1989) and in chronic cases this form is almost indistinguishable from malnutrition (Dunn, 1978).

2.1.2 GIT nematodes that remove the host's tissue and blood

This group of parasite includes *Haemonchus spp.*, *Chabertia ovina*, *Gaigeria pachyscelis*, *Bunostomum trigonocephalum* and *Trichuris spp.* In most cases, the predominating syndrome is said to be progressive debilitating anaemia (Smith and Sherman, 1994), but hyper acute and acute infection of *Haemonchus contortus* and acute infection of *Gaigeria pachyscelis* could lead to death without any more clinical manifestation than acute anemia (Belschner, 1976; Dunn, 1978; Soulsby, 1982; Troncy 1989; Smith and Sherman, 1994; Bowman, 1999; Radostits *et al.*, 2000).

The losses caused by *Haemonchus contortus* are more severe and important due to its extreme pathogenecity, wide geographical distribution in tropics and its high prevalence in small ruminants (Dunn, 1978; Troncy, 1989). *Gaigeria pachyscelis* is a highly virulent nematode that sucks blood and can cause death of a host even in small burden as few as 24 parasites (Soulsby, 1982). *Chabertia ovina* is a plug feeding parasite of large intestine which causes loss of blood when it draws plugs of mucosa by its wide mouth, and its blood sucking is said to be accidental, and loss due to haemorrhage at the biting site is voluminous (Soulsby, 1982; Troncy, 1989). *Bunostomum trigonocephalum* is a bloodsucker causing progressive anemia (Dunn, 1978; Soulsby, 1982) and blood-sucking habit of *Trichuris ovis* was stated by Troncy (1989).

The clinical manifestations due to these nematodes vary from sub-clinical to bleeding to death (Dunn, 1978; Soulsby, 1982; Troncy, 1989; Urquhart *et al.*, 1996) and could be generally

summarized as pale mucus membrane, oedema on the ventral aspect of the body, bottle jaw, weakness, wool falls out in patches, prostration and death.

2.1.3 Nematodes that cause marked nodular reaction

Marked tissue reaction manifested by formation of nodules in the intestine of infected small ruminants is commonly observed in infestation by the 3rd stage larvae of *Oe. columbianum* (Soulsby, 1982; Troncy, 1989; Urquhart *et al.*, 1996). In previously exposed sheep and goats due to sensitisation, 3rd stage larvae of *Oe. columbianum* pass into sub mucosa of small intestine and some times under heavy infection to sub mucosa of large intestine and marked inflammatory reaction around each larva takes place. These nodules (inflammatory reaction) could be as big as 2.0 cm in diameter and containing greenish eosinophilic pus and fourth stage larvae (Urquhart *et al.*, 1996).

According to Soulsby (1982), these nodules are due to leucocytes, especially eosinophils and foreign body giant cells collected around the parasites and the focus becomes encapsulated by fibroblasts. Whenever there is massive infestation, the number of nodules will be numerous while the colon contains few adult worms. Extensive nodules on the intestinal walls and mucosa interfere with absorption, bowel movement, digestion and when these supurative nodules rapture to peritoneal surface causing supurative peritonitis and multiple adhesions (Soulsby, 1982; Smith and Sherman, 1994).

2.2 Basic Life Cycle of the Nematodes

Most GIT nematodes have the same basic life cycle. Majority are oviparous and the eggs are similar and very characteristic type, and immediate transfer of infection from one host to another does not occur (Troncy, 1989; Urquhart *et al.*, 1996; Craig, 1998; Hendrix, 1998).

After the eggs passed in faeces of the host, the first stage larva develops with in the egg and then hatches in the external environment. The first stage larvae feed on bacteria in the faecal pellet and moults to second stage larvae, during which the larvae shed complete cuticle, including the lining of mouth opening and the excretory pore. Once the moult is over, the larva is very active, it starts feeding vigorously on the bacteria with in faecal pellet and enters

to the second moulting period. The stoma closes and the larva is sealed off with in the separate cuticle, and this is ensheathed third stage larva (L_3), and it takes 6 to 14 days to reach to this stage in most cases (Dunn, 1978). This ensheathed L_3 can not feed and lives on its stored food. During this stage, the larvae leave faecal pellet and available on nearby pasture waiting for a host (Dunn, 1978; Soulsby, 1982; Troncy, 1989; Urquhart *et al.*, 1996; Craig, 1998; Hendrix, 1998; Bowman, 1999).

Though most GIT nematodes follow the above basic life cycle, some nematodes are showing exceptional circumstances. *Nematodirus* and *Trichuris* species produce egg with thick shelled. In *Nematodirus species*, the L_3 development takes place with in the egg shell, and the infection of the host is acquired by the ingestion of the L_3 with in the egg shell or hatched as L_3 and available on the pasture (Kaufmann, 1996; Urquhart *et al.*, 1996). While in *Trichuris species* the infective larvae develop after being passed in faeces with in the egg shell and the animal will be infected by ingesting the infective larvae inside the egg shell (Kaufmann, 1996). In *Strongyloides species*, the eggs when passed in the faeces contain fully developed larvae and have a possibility of developing either to free living adult or infective third stage larvae. In some parasites (*Bunostomum* and *Strongyloides*) these infective stages in the external environment may infect the host through skin penetration, i.e. they don't passively wait for ingestion (Troncy, 1989; Hendrix, 1998).

In vast majority of nematodes the parasitic phase starts after ingestion of third stage larva (L_3). The retained sheath of infective stage larvae is exsheathed through host and parasite stimuli (Soulsby, 1982). Then the exsheathed larva come in contact with the mucosa, penetrate deeply between the villi or into the glands. Most of the subsequent development occurs in, rather than on, the mucosa. In most cases these larvae emerge to the lumen at fifth stage (L_5) though some superficially developing genera emerge at the late fourth stage (Dunn, 1978; Troncy, 1989; Craig, 1998). In both cases these young adults feed, mature, copulate and become egg-laying adults. Then, eggs pass to external environment with faeces (Dunn, 1978). The prepatent period varies between 20 to 40 days in most cases (Troncy, 1989; Kaufmann, 1996; Urquhart *et al.*, 1996).

2.3 Factors affecting the epidemiology of GIT Nematodes

Many factors are known to influence the transmission and prevalence of nematode infections in grazing ruminants (Urquhart *et al.*, 1996) and the disease pattern is determined by factors influencing the susceptibility of the host, the number of infective larvae accumulating on the pasture and the number of larvae undergoing hypobiosis (Radostits *et al.*, 2000). Broadly the three influencing factors that can determine the occurrence of small ruminant gastrointestinal tract nematodiosis could be mentioned (Smith and Sherman, 1994; Stromberg, 1997).

2.3.1 Environment-Host Interaction

The environment-host interaction that can influence the occurrence and prevalence of gastrointestinal tract nematodiosis of small ruminants include:

2.3.1.1 Feed availability and quality

Nutrition plays great role in worm burden control. Poorly fed animals are more susceptible and carry more worm burden due to their failure to throw over of infection quickly (Radostits *et al.*, 2000), while adequately fed animals are better able to tolerate parasitism (Urquhart *et al.*, 1996). Protein supplementation to the young grazing sheep has reduced the need for survival drenching and increased the production (Van Houtert *et al.*, 1996).

In tropical Africa where small ruminants are kept under grazing management, the feed availability and quality mainly depends on the season of the year. Wet season being good both for feed availability and quality is also conducive for parasite larvae survival and development on pasture, while dry season is bad both to the host and parasite larvae. But during dry season, accumulation of flocks along water courses for the search of water and green grass favours disease transmission and spread between flocks (Troncy, 1989; Teklye, 1991; Radostits *et al.*, 2000).

2.3.1.2 Grazing behaviour of hosts

Grazing behaviour of the host is one of the influencing factors affecting the epidemiology of gastrointestinal tract nematodes. Sheep grazing close to ground are more exposed to massive numbers of infective larvae compared to free ranging goats that are less exposed to the infective larvae since their feeding behaviour includes a large component of browsing at levels well above the ground (Smith and Sherman, 1994). However, domesticated goats managed in areas where access to browse is restricted and pasture grazing is mandatory are equally or even have greater risk of nematode parasitism (Smith and Sherman, 1994; Radostits *et al.*, 2000).

2.3.1.3 Flock management

Overstocking and prolonged grazing on the same pasture leads to overgrazing (loss of available herbage per animal) and hence lower plane of nutrition. It also encourages large amount of faecal deposit on the grazing field and potentially to higher level of infectivity per unit area. Thus overstocking and prolonged grazing on a plot of land, besides affecting the growth rate of animals, it may exacerbate the pathogenic effect of acquired infections by lowering the protective immunity (Dunn, 1978; Troncy, 1989; Ndamukong *et al.*, 1994; Thamsborg *et al.*, 1996; Urquhart *et al.*, 1996).

Rotational grazing, alternate grazing, mixed grazing and zero grazing having knowledge on the epidemiology of a given nematode parasite, are some of important management techniques to control the nematode parasite with out chemical use (Dunn, 1978; Kaufman, 1996). But the use of rotational grazing to control ruminant GIT nematodiosis was said of little value because the infective larvae may resist long period on the grazing field (Soulsby, 1982; Radostits *et al.*, 2000).

2.3.2 Environment-Parasite Interactions

Fourth and fifth stage larvae and adult gastrointestinal tract nematodes of sheep and goats reside in the GIT, while eggs, first stage; second stage and third stage larvae exist on the external environment (Dunn, 1978). Having conducive temperature and moisture, nematode eggs deposited by carrier sheep and goats are able to develop to the third stage larvae (L_3) in the external environment. But external factors do influence the development from egg to infective larvae. These external factors to be included in environment-parasite interactions and thus affecting the epidemiology of GIT nematodes are mentioned as follows:

2.3.2.1 Climate and Season

In cool temperate climate free-living stage of parasite larvae could survive for longer period than arid tropical environment (Dunn, 1978; Chiejina *et al.*, 1989). In the cool tropical environment of Ethiopia, Tembely *et al.*, (1997) reported large number of nematode parasites from small ruminants during wet season. Similarly peak infection rate of gastrointestinal tract nematodes were reported during the rainy season and lower infection rate during dry season of the year in Southern Nigeria (Fritsche *et al.*, 1993) and in The Gambia (Anene *et al.*, 1994). This seasonal fluctuation may be due to a number of factors which are responsible for the numbers and availability of infective stages, and these may be conveniently be grouped as factors affecting contamination of the environment, and those controlling the development and survival of the free living stages of parasites (Anene, 1994; Urquhart *et al.*, 1996; Stromberg, 1997; Craig, 1998).

2.3.2.2 Biotic potential and survival capacity

The level of contamination of environment by the parasite is influenced by several factors. The biotic potential of a nematode may be one of the factors. Some nematodes such as *H. contortus* produce thousands of eggs (prolific egg layers up to 10,000 eggs per day for several months) while others like *Trichostrongylus spp.* produce only a few hundred (Urquhart *et al.*, 1996; Radostits *et al.*, 2000).

Some nematode eggs survive outside of their host for considerable period of time (ex. *Trichuris, Ascaris, Nematodirus*), which may be dependable on the thickness of their egg shell thus responsible for longer time contamination of the grazing field (Anene *et al.*, 1994).

2.3.2.3 Desiccation

Temperature and humidity are major determining factors among others for the development and survival of nematode egg and free-living stage of larva. Under favourable condition, the egg will be hatched to first stage larvae with in few hours after its passage through faeces. The consecutive first and second stage larvae are developed, and these egg and larvae are extremely susceptible to the desiccation (Craig, 1998). A study conducted in Awassa, southern Ethiopia, has indicated that there was significant difference in temperature and moisture content of sun exposed and under shade faecal masses (Demelash *et al.*, 2004). Higher temperature and low moisture were observed in sun exposed and lower in under shade. And also egg counts and larvae counts between sun exposed and under shade faecal masses was revealed that higher egg and larvae counts were encountered in those under shade and lower observed in sun exposed (Demelash *et al.*, 2004). But embryonated eggs of some nematode species and ensheathed third stage larvae are best equipped to survive the adverse conditions of the environment (Anene *et al.*, 1994). However, both direct sunlight and prolonged high ground temperature are fatal and hence no stronglylid life cycle can be completed in totally arid environment and desert region (Chiejina *et al.*, 1989; Bowman, 1999) unless microhabitats that provide enough moisture exist.

2.3.3 Host-Parasite Interaction

Analysis of nematode population in ruminants over a period of several years unveiled the presence of host and worm related factors affecting the survival of larval nematode inside a host (Craig, 1998).

2.3.3.1 The immune status of a host

Generally, the effect of a protective host immune response is to limit the parasite population with in certain limits acceptable to the well being of the host. This action is achieved by: elimination or expulsion of parasites; retardation or inhibition of development of newly acquired infection; reduction in the fecundity of female worms and reduction in the establishment rate of infections (Kelly, 1973). The defence status of a host naturally vary between species of host (sheep versus goats) and between individuals in a flock (Stear *et al.*, 1995; Radostits *et al.*, 2000); however, in many host parasite relationships where strong immunity develops, this is usually associated with previous exposure to the parasite (Bowman, 1999). Fluctuations in the immune status of grazing ruminants can also happen due to concurrent diseases, stress, steroid therapy and other physiologically related factors. Most commonly mentioned factors include:

2. 3.3.1.1 Peri parturient rise

This phenomenon is observed in pregnant and lactating ewes at the time of two weeks before lambing to four weeks post parturition (Dunn, 1978; Urquhart *et al.*, 1996; Bowman, 1999). The responsible factor for this rise of faecal egg count is said to be the release of lactogenic hormone, prolactine (Kelly, 1973; Urquhart *et al.*, 1996; Bowman, 1999) which suppress the immunity of the ewe and brings an apparent increase of the numbers of worms by the resumption of development of previously inhibited larval stages, increased rate of establishment of newly acquired larvae, failure in the elimination of existing infections, uninhibited development to maturity of newly acquired larvae, increase in the fecundity of egg

laying adult female nematodes. which were repressed in ordinary healthy non-lactating ewes (Kelly, 1973; Dunn, 1978). The condition in general brings increased worm egg out put which

is epidemiologically significant not only by contaminating the pasture but also its adjustment with the period of existence of new susceptible population of lambs (Kelly, 1973; Urquhart *et al.*, 1996).

2.3.3.1.2 Self cure phenomenon

In endemic area, after heavy rainfall; the faecal egg out put of certain nematodes (*Haemonchus contortus*) drop sharply to near zero level due to expulsion of adult worm burden. This situation is related to ingestion of massive third stage larvae that trigger an immediate type of hypersensitivity reaction due to ingested antigen (Soulsby, 1982; Urquhart *et al.*, 1996). Another explanation suggested was that self cure is due to ingestion of fresh growing grass that induces diarrhoea and thus resulting in expulsion of adult parasites. But whatever the cause, self-cure is probably of mutual benefit to both host and parasite. The host gets temporary relief from persistent blood loss while the aging parasite population is eventually replaced by a vigorous young generation (Urquhart *et al.*, 1996).

2.3.3.2 Age of the host

The existence of age related difference in susceptibility/resistance of sheep and goat flocks to nematode infections has been reported by several researchers. Soulsby, (1982) has indicated that young sheep and goat are susceptible to *Trichostrongylus* species than aged (older ones). Sheep aged 16 or 28 months showed better immunological response to nematode infection and suppressed nematode egg count in their faeces than 4-month-old lambs (Douch and Morum, 1993). Others relate age related susceptibility to various stresses they face, such as weaning stress and decreased milk production in ewes due to various reasons and hence reduced milk intake by suckling lambs and kids (Troncy, 1989; Silva *et al.*, 1998). Apparently, the immune response controlling the parasite populations in the host is readily impaired or deficient in young animals and, these are particularly susceptible to the pathogenic effects of infection (Kelly, 1973), which is best indicated by the persistent of infection by young animals is

DEDICATION:

This thesis paper is dedicated to my beloved brother Ato Jembere Zewde.

reflected by the continued passage of worm egg in their faeces for up to 60 days after infection (Kelly, 1973). However, Fritsche *et al.*, (1993) in their work have suggested that acquired immunity to be the major factor for susceptibility or resistance to nematode infection.

2.3.3.3 Genetic factor of the host

Sheep industries through out the world are seeking alternative approaches to parasite control because of production losses due to parasitism, increased frequency of drug resistance parasites and consumers demand for minimal chemical use in sheep and goat production (Owen & Axford, 1991; Kloosterman *et al.*, 1992). Variation in susceptibility between breeds and with in breeds due to genetic factor were reported by different researchers in the world (Soulsby, 1982; Owen and Axford, 1991; Gray *et al.*, 1992; Hohenhaus *et al.*, 1995; Gray, 1997; Amarante *et al.*, 1999). Research in sub humid coastal Kenya has clearly shown that indigenous Red Maasai sheep are more resistant to gastrointestinal nematodes (predominantly *Haemonchus contortus)* than exotic Droper sheep (cited by Woolaston, 1996). The study conducted on lambs of Suffolk and Gulf Coast Natives for naturally acquired strongyle infection, have shown that native lambs of the Gulf Coast developed resistance to *Haemonchus contortus* infection during their first exposure to infection at the age when they are considered immune incompetent and colostrally transferred anti *Haemonchus contortus* immunoglobulin did not appear to be involved in the resistance (Bahirathan *et al.*, 1996).

Lines of Romany sheep, selected as lambs from consistently low or high faecal egg count (FEC) parents following periods of natural challenge in New Zealand, indicated significant difference between breeding lines for abomasal and intestinal nematode resistance (Bisset *et al.*, 1996). These lambs of resistant genotype had lower faecal worm egg counts, lower worm burden and higher level of resistance to larval establishment (Gray *et al.*, 1992). This genetic difference is moderately heritable, and could be effectively selected by using faecal worm egg count although many alternatives, such as DNA markers, host antibody and parasite antigen assays are being developed for use as selection criteria (Gray, 1997) and these genetically resistant individuals can be used for disease control (Barger, 1989; Stear and Murray, 1994).

2.3.3.4 Arrested development of the parasite in the host (Hypobiosis)

Hypobiosis, a temporary cessation of nematode larva development at a precise point in its parasitic development (Troncy, 1989), in a host population can be recognized by the presence of large number of larvae at the same stage of development in animals withheld from infection for a period of longer than that required reaching that particular larval stage (Smith and Sherman, 1994; Urquhart *et al.*, 1996). The fourth stage larva become metabolically inactive; they do not feed and remain with in the host in an inactive state until favourable conditions occur in the host or environment for their development and subsequent survival of their offspring.

The major factors that initiate hypobiosis are said to be acquired immunity of the host (pervious exposure) or the experience of climatic conditions during the free-living phase. In the tropical environment, reduced moisture and increased temperature are claimed to induce hypobiosis (Eysker, 1997; Gatongi *et al.*, 1998). The hypobiotic larva is not only able to evade unfavourable conditions but also evade the host's immunological surveillance system by being metabolically inactive (Fritsche *et al.*, 1992; Eysker, 1997; Gatongi *et al.*, 1998; Craig, 1998; Tembely *et al.*, 1997; Tembely, 1998).

2.3.3.5 Difference in the strain of parasite

The presence of strain differences in parasite species was stated in Urquhart (Urquhart *et al.*, 1996). The experiment done in two strains of *Haemonchus contortus;* Sheep Derived Strain (SDS) and Goat Derived Strain (GDS) indicated that, GDS appeared to affect goats more severely than SDS even though there was no difference in their establishment (Rahman and Collins, 1991).

2.4 Diagnosis

The problem of gastrointestinal tract nematodiosis is one of the major problems of small ruminant production and health. Due to this great impact imposed, early detection and correction is of paramount importance. Clinical diagnosis of gastrointestinal tract nematodes of sheep and goats needs history of the area, history of anthelmenthics treatment, grazing history, age of animal and clinical signs manifested by the disease (Troncy, 1989), but as GIT nematodiosis share common clinical manifestations with other diseases laboratory diagnosis is important.

2.4.1 Laboratory diagnosis

Although there is much current interest in the use of serology as an aid to the diagnosis of helminthosis, particularly with the introduction of enzyme linked immuno sorbent assay (ELISA) test, diagnosis of gastrointestinal parasitic infections still depends mostly on parasitological findings of eggs and/or parasites in faecal samples (Urquhart *et al.*, 1996).

2.4.1.1 Faecal examination

Faecal examination for the detection of worm eggs is most common and routine work in gastrointestinal tract nematode diagnosis (Urquhart *et al.*, 1996). Examination of faeces for nematode eggs may vary from a simple direct smear to more complex methods involving centrifugation and the use of floatation fluids (Hendrix, 1998). Various techniques were developed and used, but some are summarized as follows:

2.4.1.1.1 Qualitative methods

2.4.1.1.1.1 Direct faecal smear examination

The presence or absence of worm eggs in faecal sample by the use of direct smear of fresh faeces on a microscope slide and examination under low power objectives of the microscope is routine procedure. However, this technique is only useful to detect nematode eggs when it exists in high concentration in the faeces. Other disadvantages of direct techniques include difficulty to identify them since the eggs are partially covered by debris materials and quantitative results could not be obtained although it is fast and easy technique (Hendrix, 1998).

2.4.1.1.2 Concentration techniques

Light infections are not easily detected by the use of direct smear; therefore concentration technique was developed to over come the shortcomings of direct smear. The concentration techniques that are widely used include; the use of salt or sugar solution and centrifugal concentration techniques. In both cases the logic behind is to concentrate the nematode eggs in a given portion of sample or processed faecal material (Hendrix, 1998; Bowman, 1999). In flotation the type of egg recovered is related to specific gravity of solutions; half saturated sodium chloride (NaCl) with specific gravity of 1.125 is capable of floating trichostrongyloid and strongylid eggs while fully saturated sodium chloride solution with specific gravity of 1.204 is preferred as general purpose solution (Hendrix, 1998).

2.4.1.1.3 Quantitative methods/Egg counting techniques

The demonstration of a parasitic element in excreta indicates the presence of parasite. However, this information is not always sufficient. In the case of gastrointestinal strongylosis, the number rather than the presence of parasites is important (Troncy, 1989). A technique called McMaster method is commonly employed method that requires a special counting chamber called McMaster. This technique is said to be easily applicable low technology parameter to indicate the level of infestation and degree of worm burden in some instances. The method enables to determine the number of eggs per gram of faeces, although it is

difficult to relate directly with the burden of parasites in large ruminants (Hendrix, 1998), still it is widely used and best correlation was observed in small ruminants (Gray, 1997). And the method is also used to detect anthelmenthic resistance and to distinguish between susceptible and resistant breeds for genetic selection (Eysker and Ploeger, 2000).

2.4.1.2 Faecal culturing

Grazing sheep and goats usually have mixed nematode infections. Only few nematode parasites have characteristic eggs that enable us to differentiate them to genus level (*Nematodirus spp.*, *Trichuris spp.*, *Strongyloides spp.*), but those of tichostrongyle and strongyles are not easily differentiated, for this reason faecal culturing and larval identification based on the keys available is useful technique (Soulsby, 1982; Hendrix, 1998).

2.4.1.3 Sentinel worm counts

Representative animals are used (selected) and followed for longer period of time. This method is used to follow the dynamics of nematode population. In each selected period of time animals are necropsied and worm burden is counted (Eysker and Ploeger, 2000). Post-mortem examination of gastrointestinal tract for adult worm is a definitive diagnosis; worms recovered from specific sites could be identified by the use of morphological features based on keys (Hendrix, 1998; Urquhart *et al.*, 1996).

3. MATERIALS AND METHODS

3.1 Study area

The study was conducted in three selected agro-ecological zones of Southern Ethiopia (Southern Nations, Nationalities and Peoples' Regional State). The selected agro-ecological zones of the study sites were Bonke (highland agro-ecology) and Mirab-Abaya (lowland agro-ecology) from Gamo Gofa zone and Soddo-Zurya (midland agro-ecology) from Wolayta zone based on the altitude and weather condition.

1. Bonke (Highland)

Bonke is one of the 11 weredas of Gamo-Gofa zone, situated at 554 kilometres southwest to Addis Ababa. The wereda has three agro-ecological zones of which 46% is highland (>2400 masl), 24% midland (1600-2400 masl.) and 30% is lowland (600-1600 m.a.s.l.). The altitude range of the wereda is 600 to 4207 masl (top of mount Guge). The topography of the area is 18% is mountainous, 64%is sloppy and 18% is plain land. 10.8% of it was cultivated, 21.3% covered by forests and bushes, 10.8% was allocated for grazing and the rest 34.2% is for other purposes (Gamo-Gofa zone BRD, 2002/03).

The area receives mean maximum rainfall of 2200 mm and the mean minimum was 600 mm, with the mean average rainfall of 1500mm annually. The mean maximum temperature of the area was 30^0c and the mean minimum 4^0c and the average of 16^0c. In this wereda the study was based on the altitude range of 2430 to 3030 m.a.s.l. (Gamo-Gofa zone BRD, 2002/03).

2. Soddo-Zurya (Midland)

Soddo-Zurya is one of the seven weredas of Wolayta zone and located at about 390 kilometres southwest to Addis Ababa. The wereda has three different agro-ecological zones; 6.13% highland, 87.7% midland and 8.4% is lowland. The altitude range of the area is 1200 to 2950 m.a.s.l. (top of mount Damota). The area receives total annual rainfall of 1112.3 mm and the

annual average maximum temperature of 25.0 ^{0}c and annual average minimum temperature of 14.5^{0}c(W Z R D D, 2003).

3. Mirab-Abaya (lowland)

Mirab-Abaya wereda is one of the weredas of Gamo-Gofa zone located at about 465 kilometres south west of Addis Ababa. The total area of the wereda is 97, 975 hectare and 66.7% of it is lowland (1170 to 1600 masl), 10.5% is midland (1600 to 2400) and 21% is highland (>2400masl). Of the total land area, 55% is plain land, 15% is sloppy, 19% mountainous and 11% is valley. The annual rainfall of the area was 500 to 580 mm in lowland and 1000 to 1100 mm in highlands (Gamo-Gofa zone BRD, 2002/03).

Vegetation and wild life

The vegetation of the study areas is based on the respective agro-ecological zones. In the highlands coniferous trees, eucalyptus, bamboo plantation and intensively cropped fields with enset and other crops. The lowland part of the study areas are characterized by acacia trees, gully forests, bushes and grass lands. Various wild fauna are known to be hosted in these study areas, among which, lion, leopard, hyena, foxes, antelopes, large wild ruminants such as gazelle and buffaloes and zebras are predominantly exist.

Figure 1. Map of Ethiopia, SNNPRS and the Study areas

Legend

Southern region

Wolayta & Gamo-Gofa zones

Study weredas

Live stock population

In all study areas the predominant species of the livestock are cattle, sheep and goats (CSA, 2003). The details of livestock population of study zones and study weredas are indicated in tables 1 and 2 below.

Table 1. Livestock population of study zones

Study zones	Cattle	Sheep	Goats	Equine
Wolayta	658,886	87,525	96,215	24,262
Gamo-Gofa	850,290	381,533	227,278	38,931

Source: (CSA, 2003).

Table 2. Live stock population of the study weredas.

Study weredas	Cattle	Sheep	Goats	Equine
Bonke	91,418	92,183	16,349	8,554
Wolayta	96,746	17,405	4,761	2, 993
Mirab-Abaya	27,827	3,302	16,030	974

Source: (CSA, 2003).

Live stock management.

In all agro-ecological zones of the study areas sheep and goats were housed in rainproof houses either separately or together with large ruminants and human being. The livestock management of the different agro-ecological zones of the study areas have more or less based on grazing all year round on natural pastures. In all areas, communal type of grazing system predominates with mixed livestock grazing in the state owned grazing fields but occasionally sheep and goats were found tethered on pegs and trees.The goats of the lowland has free

access for browsing in wider permanent grazing lands (Annex 14, plates 1 & 2) that has bushes and forests while those of midlands and highlands were forced to graze together with other livestock classes (Annex 14, plates 4 - 9). Supplementation with crop residues, grass, and household left over, grains and root crops was common practice in midlands and highlands while occasional in lowlands during the night.

Health problem of the small ruminant in the study areas

In all cases there are well-equipped veterinary clinics in all weredas of the study area at the centre. The health problems of small ruminants that are frequently mentioned include: gastrointestinal tract helminth and lung worms in highlands, gastrointestinal tract helminth and ecto parasites in midlands and CCPP, mange mites and pasteurelosis in lowlands (GGZRDD, 2003; WZRDD, 2003).

3.2 Study Population

3.2.1 Study animals

The study animals are sheep and goat population raised in the highland areas of Bonke, midland areas of Soddo-Zurya, and lowland areas of the Mirab-Abaya. According to Bureau of Rural Development of Gamo-Gofa and Wolayta, the estimated figures are indicated in the table 3 below.

Table 3. Sheep & goat population of the study area

No.	Study area	Agro-ecology represented	Sheep population	Goat population
1	Bonke	Highland (Dega)	72,183	2,349
2	Soddo-Zurya	Midland (Weina dega)	10,405	3,761
3	Mirab-Abaya	Lowland (Kolla)	2,302	13,030
	Total		84,890	19,140

Source: (Gamo-Gofa and Wolayta Zonal Rural Development department, 2003)

Table 4. The age structure of the study animals

Age group	Percentage of Sheep		Percentage of Goats	
	Wolayta	Gamo-Gofa	Wolayta	Gamo-Gofa
<1 year	42.0	33.7	41.6	37.2
1-<2 years	13.0	16.6	18.0	17.0
≥ 2 years	45.0	49.7	41.3	45.6

Source: (CSA, 2003).

3.2.2 Sample size

The sample sizes for the post mortem and coprological examination of the study were as follows.

A. Post mortem examination

Post mortem examination for nematode species identification and worm burden determination was carried out starting from September 2004 up to April 2005. Samples were obtained by systematic random sampling method from sheep and goats slaughtered in three towns that belong to different agro-ecological zones. 12 sheep and goats were sampled per season per site from midland and lowland agro-ecological zone and 15 sheep and goats were sampled per season in highlands. A total of 180 GIT samples were obtained during the study period; 61 from highland, 60 from midland and 59 from lowland agro-ecological zones of which 101 were goats and 79 were sheep. 172 were obtained from local hotels and 8 were purchased.

B. Faecal sampling for prevalence study and quantification

For each wereda and both species of animals the sample size was determined by the use of the formula in Thrusfield, (1995) as indicated below:

$N = 1.96^2 \times PQ/D^2$

Where **N** is required sample size, **P** is expected prevalence based on previous preliminary surveys, **Q** is 1-**P** and **D** is the level of precision **(5%)**, **1.96** to indicate 95% confidence level. The study period was divided into four based on the seasonal condition of the area as late wet season (August and September), early dry (November and December), late dry (February and March) and early wet (April and May). Faecal samples for prevalence and epg determination were collected during these four seasons.

Therefore based on the formula our sample size for each wereda was 113 sheep and 138 goats by considering 92.0% prevalence of GIT nematodiosis in sheep population and 90.0% prevalence in goat population from previous surveys made in the surrounding areas (Dereje, 1992; Haileleul, 2002). This makes a total of 339 sheep and 414 goats, and a total of 753 faecal samples from three agro-ecological zones at a season but due to little goat population at high lands only 80 to 90 animals were sampled at a time and a total of 2,828 faecal samples were collected by systematic random sampling for prevalence determination and epg counting.

The samples of faeces for egg counting (epg) and worms recovered from GIT were preserved in 10% formaline and 70% alcohol, respectively for later examination in the laboratory.

3.3 Study methodology

3.3.1 Study type

Cross sectional study type for prevalence determination by post mortem and faecal examination and prospective longitudinal study type for studying the seasonal dynamics of nematodes was employed (Toma *et al.*, 1996)

3.3.2 Study procedures

A. Post mortem examination method

A day before slaughtering, ante mortem investigation was performed and properly recorded for each animal concerning its village of origin, age, sex, body condition score and its general health condition (Annex 1 and 2).

The body condition and age of the animals were determined using the body condition scoring and age determination method developed for respective species by Gatenby, 1991 and Mike, 1996(Annex 8 and 9).

Following slaughter the gastrointestinal tract was removed, and the abomasum, small intestine and large intestine were immediately isolated by three ligatures (between omasum and abomasum, abomasum and small intestine, ileum and caecum) to avoid mixing of the contents.

Collection of the contents of abomasum and intestines, and recovery of nematode species was according to, MAFF, (1977) and Urquhart *et al.* (1996). Identification and counting procedures was done according to MAFF, 1977; Soulsby, 1982; Jorgen, H. and Brian. P. 1994, Kaufmann, 1996 and Urquhart *et al.*, 1996(Annex 10, 11, 12)

In a mixed infection by nematode species, the intensity of nematode count was classified as low (< 2000 nematode), moderate (2000-10,000) and high (>10,000) as described in Radostits *et al.*, (2000).

B. Coprological method

Faecal samples obtained from field (population) and from slaughtered animals were subjected to qualitative (flotation) and quantitative (modified McMaster) techniques (Annex 13). Faecal egg count was determined using modified McMaster technique, each nematode egg counted represents 50 eggs per gram of faeces, when the faecal samples became negative for nematode egg in modified McMaster technique, it was subjected to flotation technique for prevalence determination.

Classification of the intensity of infection was made based on faecal egg counts as light (50-800 epg), moderate (801-1200 epg) and heavy infections (>1200 epg) as described in Jorgen, H. and Brian, P. (1994) for the mixed infections in grazing small ruminants.

3.1.1 Statistical analysis methods

The data collected was recorded in Microsoft excel. The independent variables analysed were: agro-ecological zones (highland, midland and lowland), species of animals (Goat and sheep), sex of animals (male and female), age of animals (less than 1 year, 1-2 years, more than 2 years), body condition of animals (very thin, thin, moderate, fat) and season of the year (late wet, early dry, mid dry, late dry, early wet) but in the case of faecal samples obtained from the field mid dry was not used. The dependant variables analysed were faecal egg counts and nematode counts. Because of the skew ness in their distribution, faecal egg counts and nematode counts were subjected to a logarithmic transformation [log (x+1)] for analysis.

To compare the difference between means and proportions two soft wares were used. STATA 7.0 was used for univariate analysis of variance (ANOVA) to compare more than two means, t-test to compare the difference between two means, and chi-square to compare the difference between the proportions for faecal egg count (epg) and post mortem (nematode burden) results. SPSS version 11.5.0 was used to calculate means for egg counts and nematode counts and to detect significant differences between and with in subject effects and to correlate epg count to nematode burden of slaughtered animals.

Mean nematode egg counts and mean nematode burden were calculated and presented by using geometric means (antilogarithm).

4. RESULTS OF THE STUDY

4.1 Post mortem results

4.1.1 Nematode species identification and their prevalence

A total of ten different species of nematodes were recovered from the gastrointestinal tracts of 79 sheep and 101 goats during the study period (Table 5). The parasite species identified and their percent prevalence in decreasing order was as follows: *Oe. columbianum*, 92.2; *T. colubriformis*, 73.9; *H. contortus*, 68.9; *T. axei*, 61.7; *T. ovis*, 42.8; *B. trigonocephalum*, 18.9; *Teladorsagia spp.*,15.6; *T. probolurus*, 5.0; *S. papillosus*, 1.1 and *C. curticei*, 0.5. The *Teladorsagia spp.* and *C. curticei* were only encountered in the highland agro-ecological zones of the study site where as *Strongyloides papillosus* and *Trichostrongylus probolurus* were encountered in midlands and lowlands.

The over all prevalence of GIT nematodiosis of small ruminants in the three agro-ecological zones of the study sites was 98.9% and in the agro-ecological bases; 98.3, 98.3 and 100.0% in lowlands, midlands and highlands, respectively. There was significant individual nematode species prevalence variations ($p<0.05$) among different agro-ecological sites except for *Oe. columbianum* and *S. papillosus* as indicated in the table 5 below.

4.1.2 Post mortem findings based on season, agro-ecology, age, species & sex differences.

Differences in season of sampling, agro-ecology of the study sites, species of animals examined, age and sex were assessed to observe their influence on the post-mortem results and the findings are presented in the following order.

Table 5. Prevalence rates of GIT nematode species by agro-ecological zones

	Highland n=61	Midland n=60	Lowland n=59	Total n=180	χ^2	P value
Nematode species	% +ve	% +ve	% +ve	% +ve		
Oe. columbianum	91.8	90.0	94.6	92.2	1.8	0.4
T. colubriformis	65.6	71.7	84.7	73.9	9.9	0.042
H. contortus	42.6	85.0	79.7	68.9	49.5	0.0009
T. axei	73.8	51.7	59.3	61.7	10.7	0.046
T. ovis	32.8	46.7	49.1	42.8	6.2	0.0422
B. trigonocephalum	29.5	8.3	18.6	18.9	15.7	0.0009
Teladorsagia spp.	45.9	-	-	15.6		
T. probolurus	-	6.7	8.5	5.0	8.0	0.0345
S. papillosus	-	1.7	3.4	1.7	2.9	0.2
C. curticei	1.6	-	-	0.5		
Total nematode spp.	100.0	98.3	98.3	98.9	2.0	0.4

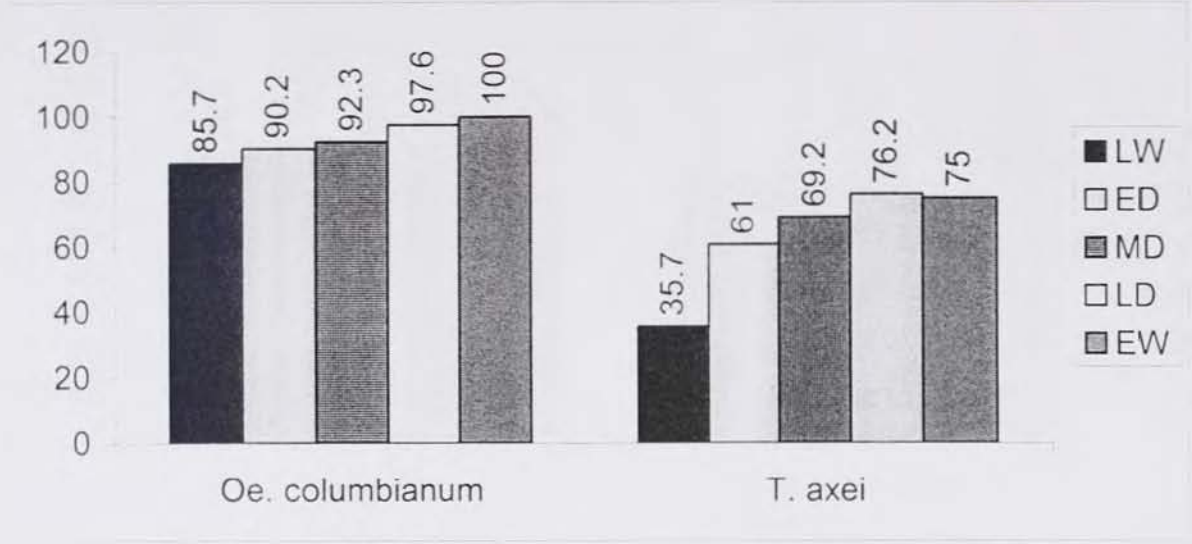
Table 6. Percent prevalence of GIT nematode species of small ruminant on age base

Nematode species	Age groups (180)		$\chi 2$	p
	1–2years(n=51)	>2 years(n=129)		
	% +ve	% +ve		
Oe. columbianum	94.1	91.5	0.3	0.6
T. colubriformis	80.4	71.3	8.2	0.1
H. contortus	80.4	64.3	6.4	0.01
T. axei	60.8	60.5	0	1
T. ovis	60.8	35.7	11.5	0.001
B. trigonocephalum	7.8	23.3	8.6	0.045
Teladorsagia spp.	7.8	18.6	5.2	0.0355
T. probolurus	7.8	3.9	1.4	0.2
S. papillosus	3.9	0.8	0.8	0.4
C .curticei	2.0	-		
Total nematode spp.	98.0	99.2	0	1

A significant variation in prevalence of *B. trigonocephalum, Trichuris ovis, H. contortus* and *Teladorsagia spp.* was observed between two age groups.

The identified nematode species from sheep and goats slaughtered during different seasons of the year (41in late wet, 40 in early dry, 39 during mid dry, 42 in late dry and 16 during early wet) have indicated significant seasonal variation. The seasonal point prevalence of *H. contortus, T. axei, B. trigonocephalum* and *Oe. columbianum* were varied highly significantly ($p<0.001$) between seasons of the year; while those of *T. ovis* and *T. colubriformis* point prevalence were significantly varied ($p< 0.05$) between different seasons but the over all point prevalence change for total nematode species was not significantly different between seasons of the year($p>0.05$). The seasonal point prevalence changes of six nematode species is indicated in the figures 2, 3 and 4 below.

Figure 2. *Oe. columbianum* and *T. axei* seasonal point prevalence



LW = Late wet season, ED = Early dry, MD = Mid dry, LD = Late dry, EW = Early wet

Figure 3. *B. trigonocephalum* and *T. ovis* seasonal point prevalence.

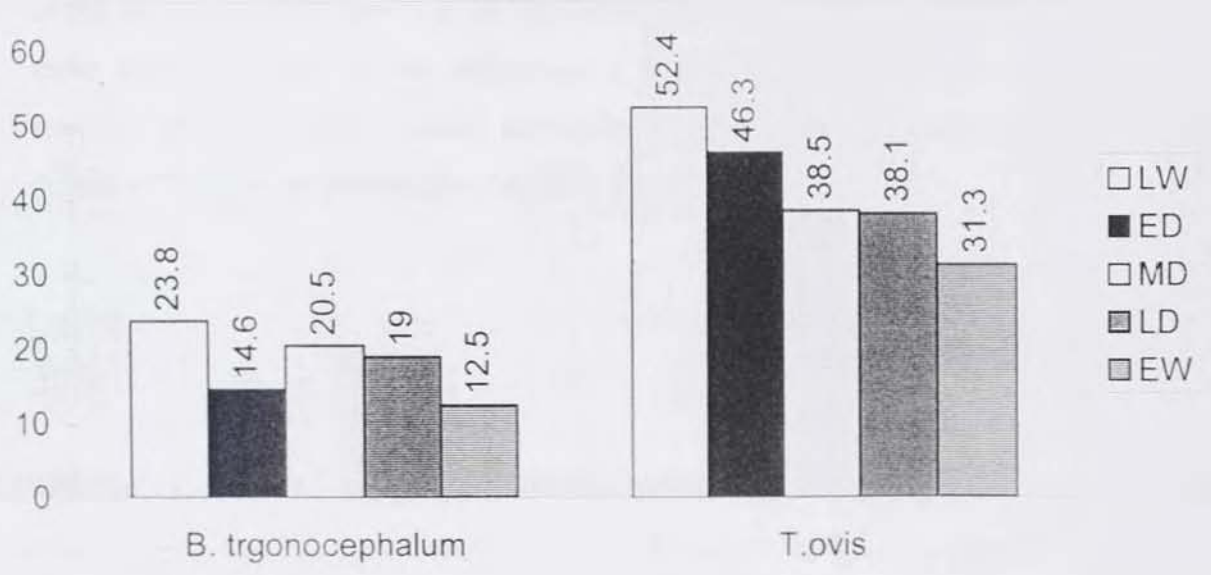
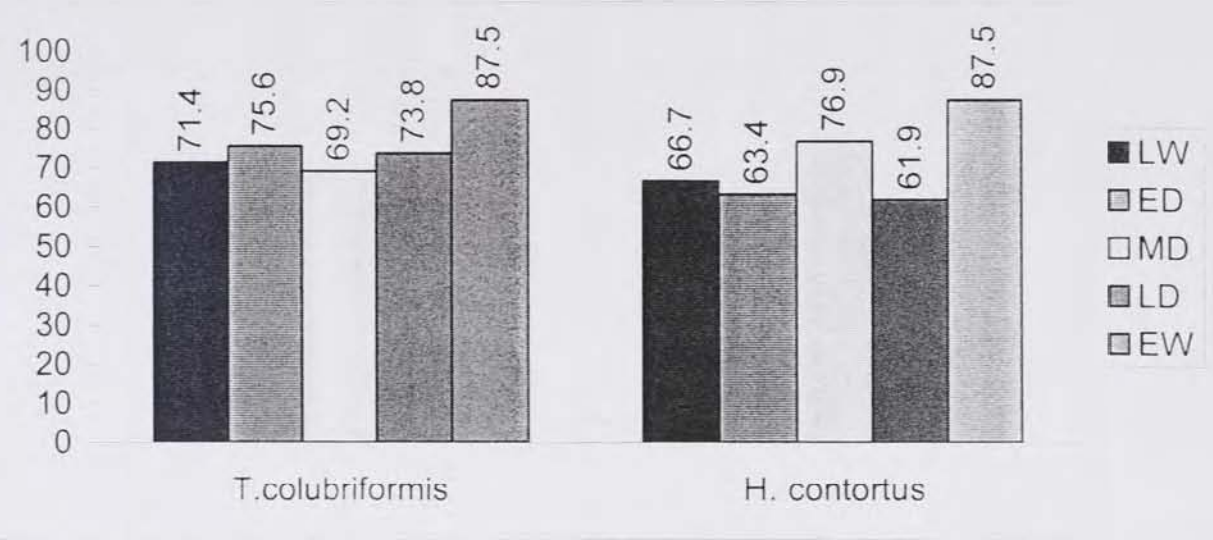


Figure 4. *T. colubriformis* and *H. contortus* seasonal point prevalence.



The total prevalence of GIT nematodiosis of small ruminants in this study was not significantly different between agro-ecology, between seasons of the year, between species of animals and between male and female. Significant differences were observed for mean total nematode burden and mean total epg count from slaughtered animals during different seasons of the year ($p<0.05$). There was no significant difference in the mean total worm burden and mean total epg count for sex difference of slaughtered animals ($p> 0.05$ in both cases) & species variation did not revealed significant difference in mean total nematode burden. The details of findings are indicated in the table 7 below.

Table 7. Prevalence, MTNB and MTEPG count by agro-ecology, season, species and sex of animals.

Variables	By agro ecological zone			By season					By species of animals.		By sex	
	Highland	Midland	Lowland	LW	ED	MD	LD	EW	Goats	Sheep	Male	Female
Total animals	61	59	58	41	40	39	42	16	101	77	49	129
Prevalence												
PM	100.0	98.3	98.3	97.6	97.6	100.0	100.0	100.0	100.0	97.5	96.1	100.0
Significance	χ^2=0.5, p=0.5			χ^2=0.9, p=0.9					χ^2=0.5, p=0.5		χ^2=0.5, p=0.5	
MTNB± SE	1522.0	1413.1	1046.6	860.4	1472.4	1519.7	1348.0	1927.1	1272.5	1371.6	1768.8	2149.9
	(324.5)	(251.0)	(190.2)	(140.6)	(340.9)	(415.4)	(334.3)	(359.9)	(181.6)	(263.4)	(252.7)	(189.3)
Significance	F=2.6, p=0.078			F=3.044, p=0.019					t=0.78, p>/t/=0.44		t=0.03, p>/t/=0.98	
MTEPG±SE	557.5	951.8	587.3	480.3	775.2	772.0	595.5	1411.0	791.0	556.9	688.8	690.0
	(201.8)	(339.5)	(242.8)	(192.2)	(211.5)	(466.9)	(159.1)	(996.3)	(239.3)	(168.8)	(238.8)	(205.3)
Significance	F= 10.44, p=0.0001			F=3.04, p=0.019					t=3.5, p>/t/=.0007		t=0.39, p>/t/=0.69	

PM = Post mortem, MTNB = mean total nematode burden, SE = standard error, MTEPG = mean total egg per gram of faeces,

HL = highland, ML = midland, LL = lowland, LW = late wet, ED = early dry, MD = mid dry, LD = late dry, EW = early wet

The results of mean nematode burden of different seasons of the year in three different agro ecological zones showed significant differences both for seasonal and agroecological variation ($p<0.05$). These significant variations were observed between seasons of late wet and early dry ($p<0.05$), late wet and mid dry ($p<0.05$), late wet and late dry ($p<0.05$), late wet and early wet ($p<0.05$) and between agro-ecological zone of highland and lowland during late wet season ($p<0.05$). The mean nematode burden in seasons of the year of three different agro-ecological zones is indicated in the table 8 below.

Table 8. Mean GIT nematode burden from sheep and goats by agro-ecology and season

Agro ecology	Season of the year				
	Late wet	Early dry	Mid dry	Late dry	Early wet
Highland	2089.2±749.9	2403.9±2793.0	3482.1±2625.0	2602.4±1158.2	-
Midland	1264.9±703.7	2155.8±1602.9	2271.3±3148.9	2160.4±2952.9	3443.0±1919.0
Lowland	388.7±298.3	2148.4±1820.0	2171.2±1662.2	2287.7±1095.5	2183.3±1043.9
Total	1249.7±900.6	2253.0±2156.1	2644.0±2594.1	2407.2±2166.5	2577.1± 2047.2

(Arithmetic mean and standard deviation)

The results of necropsied animals has shown that 58.4% of the infected animals harboured light infestation, 40.5% were moderate infection and only 1.1% were severely infected by gastrointestinal tract nematode species of small ruminants during the study period. The findings are presented by species of animals in the table 9 below.

Table 9. Intensity of nematode count from sheep and goats in the study area

Intensity (Level of infection)	Animal species				Total	
	Sheep		Goats			
	No.	%	No.	%	No.	%
Light (<2000 nematodes)	44	57.1	60	59.4	104	58.4
Moderate (2000-10000)	32	41.6	40	39.6	72	40.5
Severe (>10000)	1	1.3	1	1.0	2	1.1

The results of post mortem indicated that out of 98.9% of infected animals in the study area, 97.7% were infected by more than one nematode species. On agro-ecological bases; 96.6%, 98.3% and 98.4% of infected sheep and goats in midland, lowland and highland agro-ecological zones of the study sites respectively had mixed nematode infections and only 3.4%, 1.7% and 1.6% of infected individuals in respective agro-ecological areas harboured one nematode parasite species. The number and percentage of poly parasitised animals in different study sites are indicated in the table 10 below.

Table 10. Number and percentage of nematode species infecting parasitised sheep and goats

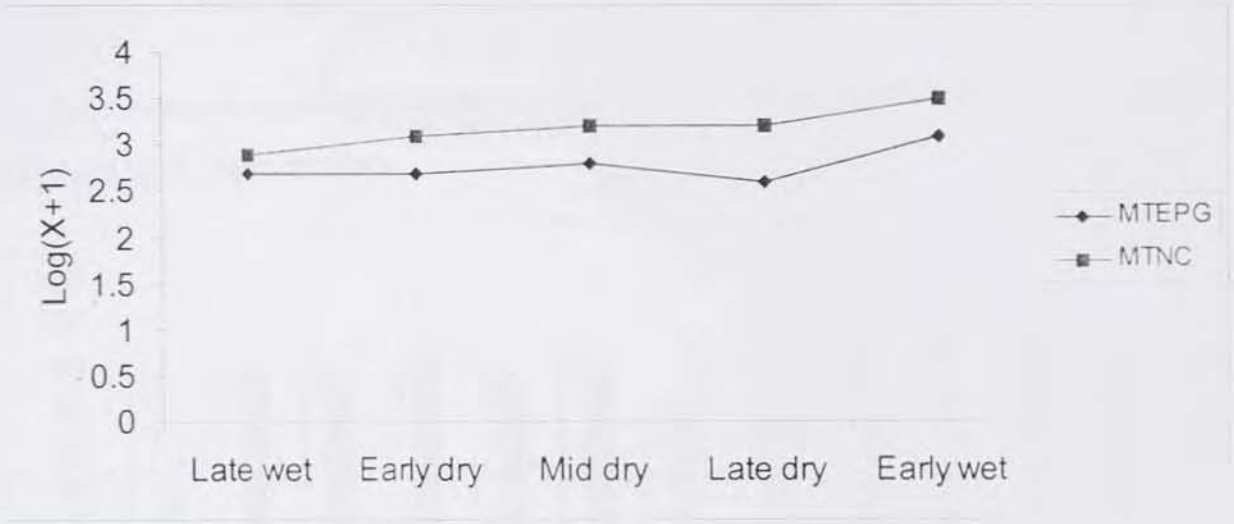
Number of nematode spp.	Highland (n=61)	Midland (n=59)	Lowland (n=58)	Total (n=178)
	% positive	% positive	% positive	% positive
1	1.6	3.4	1.7	2.2
2	19.7	10.2	8.6	12.9
3	21.3	25.4	15.5	20.9
4	27.9	39.0	39.7	35.4
5 and above	29.5	22.0	34.5	28.6

Poly parasitism of more than three nematode species in a single host predominates in all agro ecological areas and varies from 57.4% in highland to 74.2% in lowland. A total of 64% of poly-parasitised animals in all agro-ecological zones were infected by 4 or more nematode species.

4.1.3 Correlation of total nematode count to total epg counts from slaughtered sheep and goats.

The mean total nematode count and mean total epg count both from slaughtered animals in this study was positively correlated, and their correlation was significant (Spearman's rho (r_s)=0.57, p=0.000). The correlation of mean epg to individual nematode species burden in this study was found to be significant for three nematode species; *T. colubriformis*, r_s=0.50; *H. contortus*, r_s=0.45 and *Oe. columbianum*, r_s=0.39 with p=0.000 for all correlations. The correlation of mean total nematode burden to mean total epg is indicated in the figure 5 below.

Figure 5. MTNC & MTEPG both from slaughtered sheep & goats in different seasons.



MTNC = mean total nematode count.

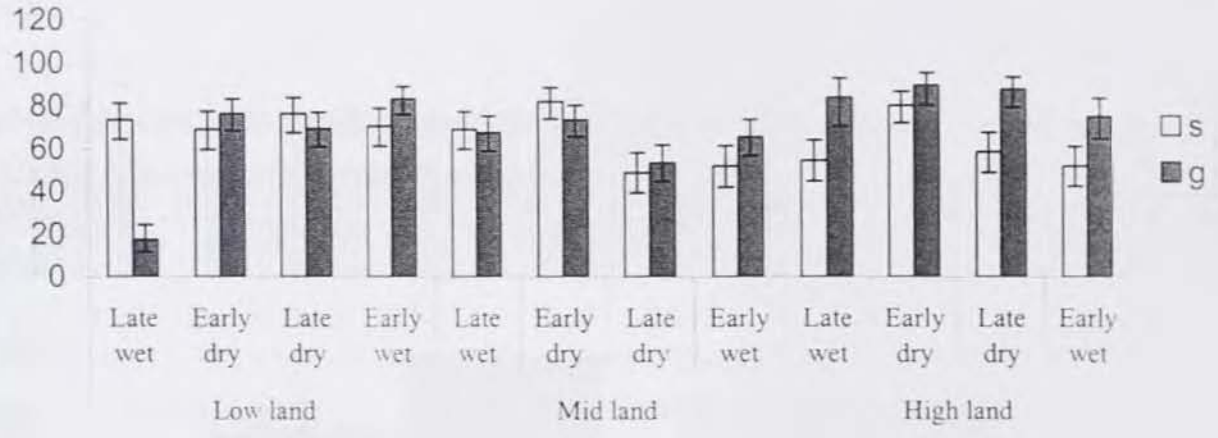
MTEPG = mean total egg per gram of faeces.

4.2 Coprological results

4.2.1 Prevalence of nematode infection from faecal examination.

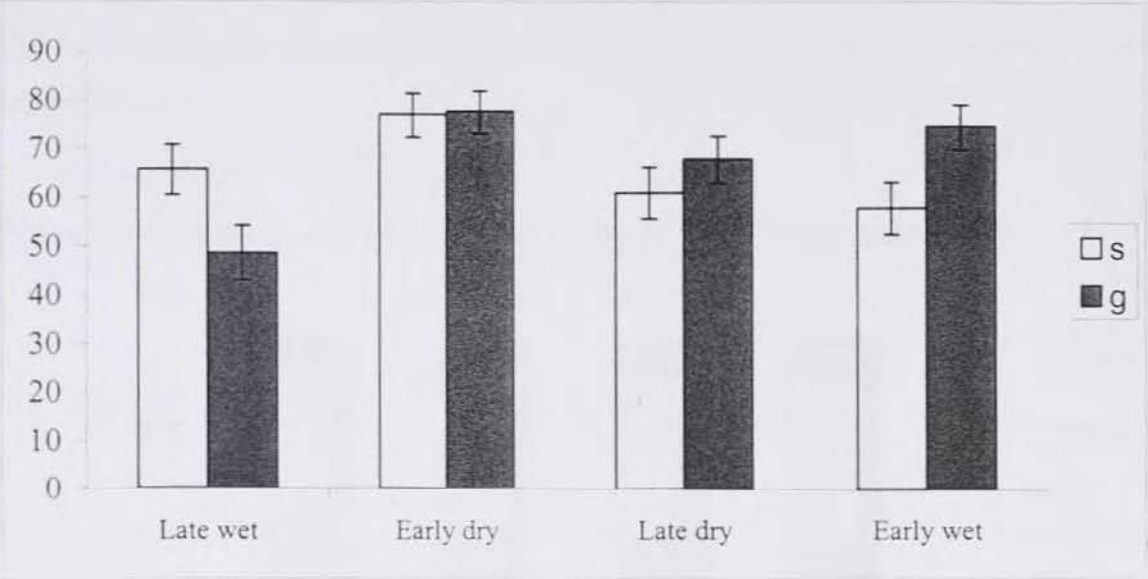
Faecal examination results in all study sites from population of sheep and goats during four sampling periods; late wet (August), early dry (November), late dry (February) and early wet (April) indicated significant seasonal variation ($p<0.05$) for all study sites. The coprological point prevalence and their 95% confidence interval indicated the significant difference in the prevalence of GIT nematodiosis between sheep and goats during late wet season in lowland and highland; and late dry and early wet seasons in highland. In all seasons of the year the point prevalence of GIT nematodiosis from coprology in highland indicated the higher prevalence in goats than in sheep. Detail findings of coprological examination are indicated in the figures 6, 7 and 8 below.

Figure 6. Seasonal coprological point prevalence(%) of GIT nematode infection of sheep (s) and goats (g) by agro-ecology.



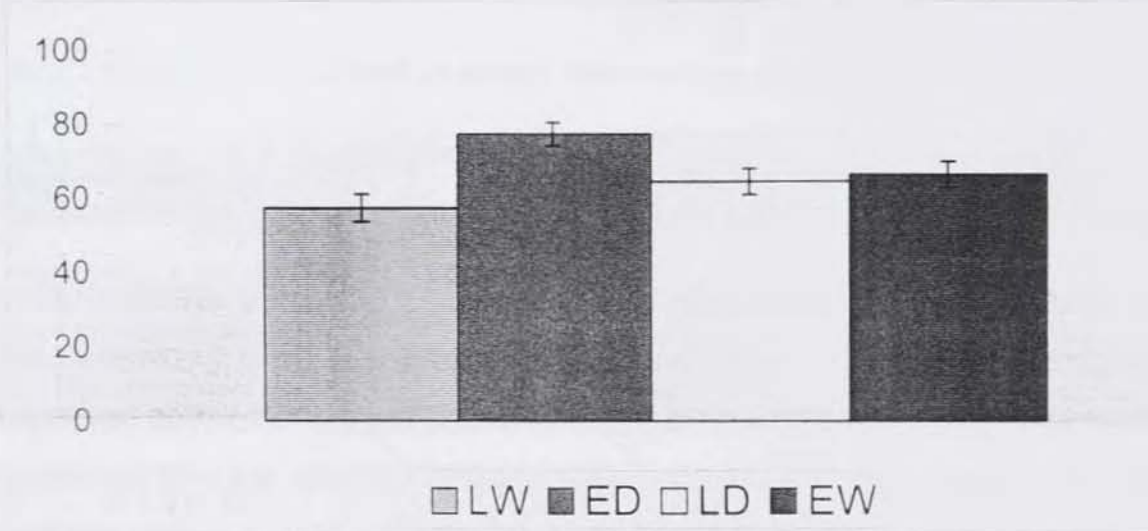
The coprological examinations of sheep and goats in the total study sites during different seasons of the year indicated the highest prevalence during early dry period than other seasons of the year. Significant difference in the point prevalence between sheep and goats was observed during late wet and early wet seasons of the year.

Figure 7. Seasonal coprological point prevalence (%) of GIT nematode infection of sheep (s) and goats (g) in all study sites



Total prevalence in small ruminants in general indicated significantly higher prevalence during early dry season of the year than other seasons in the study sites; the finding is indicated in the figure 8 below.

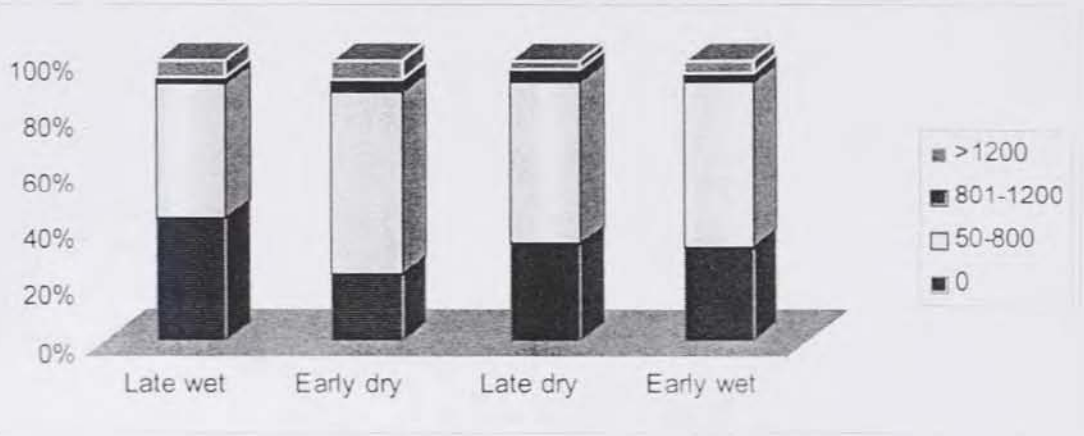
Figure 8. Seasonal point prevalence percentage of GIT nematode infection of small ruminants in all study area by coproscopic examination.



4.2.2 Results of faecal egg count

The majority of infected animals had a faecal egg count in the range of 50-800 epg and only few proportions of animals had faecal egg count over 1200. The results are indicated in the Figure 9 below.

Figure 9. Intensity of nematode infection based on coprological examination.



0= indicating zero faecal egg count (no nematode egg counted per gram of faeces)
50-800= 50 to 800 epg of faeces (light infection),
801-1200= 801 to 1200 epg of faeces (moderate infection) and
>1200= more than 1200 epg of faeces, indicating heavy infection with GIT nematodes.

4.2.2.1 Fecal egg counts based on season, agro-ecology, age, species and sex differences.

Mean epg count in agro-ecological zones have showed highly significant variation in different season of the year ($p<0.05$, $p< 0.05$ and $p< 0.001$ for early dry, late dry and early wet seasons respectively), but during late wet season mean epg counts of different agro-ecological zones was not significantly different ($p>0.05$).

Age differences of the animals had not shown significant difference in epg count in all seasons of the year ($p>0.05$). A species difference has revealed significant differences only during late wet and early wet seasons of the year ($p< 0.05$). Difference in body condition of sampled

animals has shown significant differences only during early wet season of the year ($p<0.05$). Detail results are presented in the table 11 below.

Table 11. Mean epg count by agro-ecology, age group, body condition, animal species and season.

Variable	Season of the year							
	Late wet season		Early dry season		Late dry season		Early wet season	
	No.	Mean ± se	No	Mean ± se	No.	Mean ± se	No	Mean ± se
AEZ								
Highland	102	305.0±58	165	304.0±49.0	147	321.6±40.4	130	251.9±48.3
Midland	170	302.0±101	204	336.5±96.6	136	210.8±57.8	146	158.0±16.1
Lowland	110	296.3±72	182	257.5±60.5	185	270.8±31.9	197	272.0±61.5
Significance		F=0.02, p=0.98		F=3.7, p=0.02		F=8.6, p=.0002		F=15.2, p=0.000
Age								
< 1 year	84	349.8±175.5	107	348.8±78.9	89	313.2±15.1	98	205.2±101.8
1-2years	92	316.1± 85.4	132	332.6±143.1	134	246.8±31.0	141	224.9±40.2
≥2 years	206	275.9±52.2	313	271.7±38.9	245	260.7±39.0	234	235.0±35.1
Significance		F=1.2, p=0.3		F=2.5, p=0.058		F=2.1, p=0.1		F=0.7, p=0.5
BCS								
Very thin	19	540.4±437.4	-	-	4	244.9±62.9	2	916.5±2000
Thin	75	322.5±115.3	190	277.2±98.5	79	260.4±105.4	61	187.0±33.7
Moderate	255	288.5±60.7	253	329.4±53.4	138	299.8±32.7	90	263.0±55.2
Fat	26	269.5±44.7	68	269.0±74.9	63	249.3±41.3	47	292.7±225.6
Significance		F=2.17, p=0.06		F=2.2, p=0.1		F=0.8, p=0.5		F=2.8, p=0.04
Species.								
Goats	158	261.8±55.4	285	291.1±43.8	253	264.9±38.0	274	252.3±46.6
Sheep	224	331.9±79.5	268	307.2±76.7	215	266.9±29.0	199	192.6±29.1
Signifiance	t=-2.26, p>/t/=0.02			t=0.65, p>/t/=0.5		t=-0.09, p>/t/=0.9		t=-3.0, p>/t/=0.002
Total								
Season	382	300.9±52.2	551	298.8±43.6	468	265.8±24.6	474	225.2±29.8
Signifiance				F=21.4, p=0.000				

5. DISCUSSION

5.1 Identification of nematode species

The post mortem examination of 180 sheep and goats during the study period enabled the identification of ten (10) nematode species parasitising the small ruminants in three agro-ecological zones. The existence of nematode species such as *Oe. columbianum, T. colubriformis, H. contortus* and *T. axei* in higher percentage through out the study period in all agro-ecological zones of the study sites agrees to the findings of other workers in other parts of the country (Bayou, 1992; Dereje, 1992; Esayas, 1999; Kasambara, 1999). But the identification of *Teladorsagia spp.* and *C. curticei* from highlands and *T. probolurus* from midland and lowlands in this study was new to the region and even to the country after Graber, (1975) in which he reported *Teladorsagia spp.* from sheep at Debre-Berhan area and *T. probolurus* from camels in Harrar.

5.2 Nematode prevalence

The prevalence of GIT nematodiosis of small ruminants from necropsied animals indicated 98.9% (97.5% in sheep and 100.0%in goats). This high prevalence of GIT nematodiosis of the present study agrees with previous findings in different corners of the country and other parts of the tropical countries (Gebreyesus, 1986; Esayas, 1988; Tesfa-alem, 1989; Melkamu, 1991; Dereje, 1992; Genene, 1994; Bonfoh *et al.*, 1995(in Togo); Esayas 1999; but higher than the reports of Jacquiet *et al.*, 1995 (in Mauritania); Abdala and Elmalik, 1997(in Sudan); Achnef, 1997; Berrag and Cabaret, 1998 (in Morocco) and Haileleul, 2002(in southern Ethiopia)).

The moderate prevalence rate of *Teladorsagia spp.* in highland (45.9%) is indicative of its economic and pathogenic importance to small ruminant production of the area since it is pathogenic especially during its immature stage (Dunn, 1978; Jorgen and Brian, 1994; Urquhart *et al.*, 1996). The higher prevalence rate of *Oe. columbianum* (90.0% in midland, 91.8% in highland and 94.9% in lowland) agrees with the previous findings of Dereje (1992); Kasambara (1999) but higher than the findings of Ahmed (1988); Esayas (1988); Tesfa-alem

(1989); Melkamu, (1991); Bayou (1992); Yoseph (1993); Getachew (1998); Abebe and Esayas (2001); Haile-leul (2002) in different parts of Ethiopia and Bonfoh *et al.* (1995) in Togo; Nwosu *et al.* (1996) in Nigeria. *Oe. columbianum* is known for its ability to form numerous nodules in small and large intestines of previously exposed animals thus causing enormous economic loss by damaging the mucosa of intestines and hampering the digestive and absorptive function of gastrointestinal tract of infected sheep and goats (Graber, 1975; Soulsby, 1982; Smith and Sherman, 1994; Urquhart *et al.*, 1996).

The magnitude and distribution of some of the identified nematode species seems to be related with the agro-ecological zone of the study area: *Teladorsagia spp.* was identified only in the highland from sheep and *Haemonchus contortus* prevalence was significantly higher in lowlands than highlands ($p<0.001$). This difference in their prevalence might be related to their geographical origin; since *Teladorsagia* is a temperate parasite and therefore it is adapted to cool environment, while *Haemonchus a*s tropical or sub-tropical parasite is well adapted to warm climate (Craig, 1998; Radostits *et al.*, 2000).

The significantly higher ($p<0.05$) prevalence of *B. trigonocephalum* observed in animals aged over two years than animals less than two years (23.3% versus 7.8%) could partly be related to the length of the period of exposure to the parasite in which older animals are exposed to a longer period of infection than young animals with out having major difference in susceptibility or resistance to this worms. Parasites belonging to the family Ancylostomatidae are not very immunogenic and thus adults are equally susceptible to infection as those of young groups (Troncy, 1989). Contrary to this, *T. ovis* and *H. contortus* infestation exist at higher prevalence in younger than adult age groups and is supposed to be related to the immunity developed after exposure in adult groups (Urquhart *et al.*, 1996).

The findings of the overall high nematode prevalence together with high nematode burden in all study sites is suggestive of the importance of the infection in small ruminants all over the region, irrespective of the variations in climate and vegetations that exist, and this finding differs from the work of Anene *et al.* (1994) in Southern Nigeria, who reported significant variations in prevalence and worm load in various agro-ecological zones.

The finding of significantly higher nematode prevalence by coprological examination in goats than sheep in highlands during most of the seasons of the study period agrees with the finding of Jacquiet *et al.* (1992) in south-west Mauritania and this might be related to the more susceptibility of goats than sheep when they are equally challenged (Smith, 1994).

5.3 Seasonal dynamics in prevalence

The seasonal dynamics in prevalence of most individual nematode species indicated significant variation ($p<0.05$) between seasons of the year (figure2, 3 and 4) but the over all nematode point prevalence in different seasons of the year did not reveal seasonal change ($p>0.05$). This present finding differs from the findings of Nwosu *et al.* (1996) in Nigeria; Tembely *et al.* (1997) at Debre-Berhan of Ethiopia and Magona & Musisi (1999) in Uganda; who indicated clear seasonal differences in over all nematode prevalence. This difference might originate from the variation in the changing pattern of individual nematode species prevalence during different seasons of the year in the study sites.

The coproscopic finding of a significant increase ($p<0.05$) in early dry season prevalence of nematodes (77.4%) compared with 57.5% prevalence in late wet season is in agreement with the results of Yoseph (1993) and Achenef (1997). The increase in coprological point prevalence during the early dry season might be related to the lowered host immunity because of the decline in feed quality and quantity as dry season starts. As the temperature and moisture during such period are, however, conducive to free living stages of parasite, there will be increased establishment with continued challenge and increased fecundity of the existing adult nematodes (Troncy, 1989; Agyei, 1996).

The prevalence of *Oe. columbianum* and *Trichostrongylus spp.* infestation has shown increased seasonal pattern, September through April, while those of *Trichuris ovis* and *B. trigonocephalum* were decreasing starting from September to April. An increasing trend in prevalence of *Trichostrongylus spp.* in relation to season was observed by Bekele *et al.*, (1982). This variation in prevalence with changes in the season might be related to nematodes specific behaviour. The release of inhibited larvae from nodules during dry season when there was feed shortage (stress) in case of *Oe. columbianum* and the resistance of *Trichostrongylus spp.* larvae to desiccation of dry season than others might favoured its increasing trend (Dunn,

1978; Troncy, 1989). The decreasing pattern in point prevalence of *B. trigonocephalum* might be due to the unfavourable condition of dry season for skin penetration and that of *Trichuris ovis* might be due to the ingestion of the infective larvae within the eggshell by the host usually at the end of dry season, when the grass biomass diminishes and the animals are forced to graze near to the ground (Graber, 1975; Radostits *et al.*, 2000).

5.4 Intensity and type of infection

The increased mean nematode burden obtained during the early wet season (1927.12±359.9) compared with late dry season (1348.0±334.3) is in agreement with other findings in different parts of the world (Agyei, 1996; Nwosu *et al.*, 1996; Abdalla and Elmalik, 1997; Egbe, 1999; Nginyi *et al.*, 2001; Etana, 2002) and is probably attributed to the highest number of infective larvae present on the pasture at early wet season and exposure to a high larval challenge in an already weakened animal due to previous drought (Troncy, 1989).

The increment in mean nematode burden recorded during mid dry season than early dry season, when the weather was harsh to free living stage of nematodes, might be due to the previously established larvae in the host during early dry season and the reduced efficiency of the host immune system due to decreased quality and quantity of feed (Troncy, 1989; Urquhart *et al.*, 1996).

The nematode egg out put (epg) variation obtained during the different seasons of the year was significant particularly between late wet and late dry ($p<0.05$); between late wet and early wet ($p<0.05$); between early dry & late dry ($p<0.01$) and between early dry & early wet ($p<0.05$). This finding of present work agrees with the results of Jacquiet *et al.* (1995), Fritsche *et al.* (1993), Assefa & Sissay (1998), Etana (2002) and Agyei, (2003) who indicated the highest FEC during the rainy season and the lowest during the extreme dry season.

The lowest epg count obtained during the early wet season of this work could be explained by the fact that, those larvae which get access to the host after first rain might have not been reached to egg laying adults during the time of sampling, therefore their existence in high number was not indicated by the presence of proportionally high number of eggs in the faeces (Troncy, 1989; Jorgen and Brian, 1994).

The relatively low faecal egg count obtained in the lowland study site (Mirab-Abaya) during the early dry period could be explained by the better opportunity goats have for browsing during early dry season, therefore less challenge by the infective larvae and less nematode burden during previous wet season (Smith, 1994).

The significantly higher ($p<0.05$) mean nematode egg count observed in sheep than goats in late wet season (331.9±79.5 versus 261.8 ± 55.4) and the significantly higher epg out put ($p<0.05$) of goats than sheep during early wet season (252.3 ± 46.6 in goats versus 192.6 ± 29.1 in sheep), might probably be due to the variations in feeding habit of the two species and partly also due to the seasonal influence. Goats are browsers and they prefer browsing than grazing in late wet season when the plant leaves are plenty, so that the challenge by the infective stage of larva is less than that of sheep, which prefer to graze than browse at any season. During the early wet season, however, due to the scarcity of plants for browsing and as most of the plant leaves shaded out during the late dry season until few days after the rain; the goats are equally exposed to the infective larvae present on newly emerged grass. Nonetheless, as the immune status of goats is weaker than sheep (Craig, 1998; Radostits *et al.*, 2000), the establishment rate of infective larvae and the fecundity of adult female nematodes in goats might be higher than those of sheep so that higher burden together with higher fecundity of nematodes in goats revealed it self by higher nematode egg out put.

The significant variation ($p<0.05$) obtained in mean faecal egg out put of male animals (293.4±43.4) than females (262.6±21.0) differs from the findings of previous works (Esayas, 1988; Achenef, 1997; Getachew, 1998) who indicated absence of difference in sex variation; and from that of Assefa and Sissay (1998) who reported female animals to have higher faecal egg out put than male animals. The difference of present finding might be related to the fact that male animals in the study areas are sold with good market price as they have greater demand for export to Arab countries and only few were allowed to remain in the flocks mainly for the purpose of breeding service. The action and process of serving numerous breeding females by few male animals in a flock, wastes their grazing time and energy and could lead to stress unless they are supplemented, leading to increased establishment of infection and higher nematode faecal egg out put in male animals of the study site.

The intensity of nematode infection, 58.4% light; 40.5% moderate and 1.1% heavy in necropsied small ruminants of the present study differs from other findings in different regions of the country (Melkamu, 1991; Dereje, 1992; Yoseph, 1993; Achenef, 1997; Haile-leul, 2002). The difference of present finding might be due to different categorization systems used.

The percent of poly parasitism from necropsied animals in this study (97.7%) agrees with the work of Yoseph, (1993). The existence of more than one nematode species in a single host has an additive pathogenic effect on the host and the pathogenecity is usually high when *Haemonchus, Trichostrongylus* and *Oesophagostomum* are present together (Jorgen and Brian, 1994) and epidemiologically important as it creates a year round task for small ruminant breeders.

5.5 Correlation of epg to nematode burden

A strong positive correlation ($r_s = 0.57$, $p<0.001$) of mean total nematode burden to mean total epg count both from slaughtered sheep and goats of the study area was observed during the study period. A similar positive correlation was found in sheep of Debre Brehan (Tembley *et al.*, 1997) with a correlation coefficient of $r_s= 0.52$. Silvestre *et al.* (2000) also found positive correlation ($r_s=0.47$; $p= 0.02$) in dairy goats and a higher positive correlation of $r=0.74$ was found in young sheep (McKenna, 1981)

The correlation of mean epg to individual nematode species burden in this study was found to be significant for three nematode species, *T. colubriformis,* ($r_s=0.50$); *H. contortus,* ($r_s=0.45$); and *Oe. columbianum*, ($r_s=0.39$) and $p <0.001$ for all correlations. This finding also agrees with the findings of Tembley *et al.*, (1997); Silvestre *et al.*, (2000) and Craig, (1998) who stated the positive correlation between faecal egg count and the worm burden of economically important parasites such as *Haemonchus contortus*, *T. colubriformis* and *Oe. columbianum.*

6. CONCLUSION AND RECOMMENDATIONS

The study carried out in three different agro-ecological zones of southern Ethiopia during the last nine months has revealed the wide spread existence of six nematode species *(Oe. columbianum, T. colubriformis, H. contortus, T. axei, T. ovis, B. trigonocephalum)* and four previously non-reported nematode species (*Teladorsagia spp., T. probolurus, S. papillosus* and *C. curticei*) infecting sheep and goats in the area.

The over all high prevalence of GIT nematodiosis of small ruminants in all agro-ecology suggests the importance of the problem in the study area in hampering the productivity and health of small ruminants.

The assessment of seasonal dynamics in prevalence of total GIT nematodiosis in post mortem has shown lack of significant changes over time, which indicates that in all the seasons of the year, there was high prevalence in all agro-ecological zones of the study area. However, the economically important nematode species such as *H. contortus*, *T. colubriformis*, *T. axei* and *Oe. columbianum* have indicated significant differences in their prevalence in different seasons of the year especially during the beginning of dry season and the beginning of wet season. This seasonal difference was also shown in coprological examination.

Some nematode species such as *H. contortus* has significant variation on agro-ecological basis (42.6% in highland versus 85.0% in midland) while *Teladorsagia spp.* and *C. curticei* were identified only in highland agro-ecological zone. Others such as *B. trigonocephalum* and *T. ovis* were of secondary importance in all agro-ecological zones of the study areas. Nematode species such as *T. probolurus, S. papillosus* and *C. curticei* were existed with lower prevalence. Most of the examined infections (97.7%) were of mixed type and of light and moderate intensity (58.4% were light, 40.5% were moderate).

Mean nematode burden and mean nematode faecal egg count was varied seasonally; nematode burden was significantly high during early dry and early wet seasons

From the results of the present study, GIT nematodiosis of sheep and goats in the study areas was found to be one of the major problems that hampered efficient utilization of the available small ruminant resources at hand and thus requires serious attention by all concerned bodies or

institution to properly address and give solutions to the problem. Therefore the following few points are recommended based on the findings.

1. Strategic treatment using broad-spectrum anthelmenthics should be practiced in all agro-ecological zones: at the end of wet season and end of dry season during which the nematode prevalence and burden starts increasing.

2. Supplementation of important nutrients (protein) especially during the dry season should be exercised to avoid nutritional related stresses that affect host immunity and susceptibility to parasitic infections.

3. Further studies covering all agro-ecological zones should be done in all regions of the country, as there could be unidentified nematode species that could cause significant economic losses.

7. REFERENCES

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8. ANNEXES

Annex 1. Ante mortem information-recording format

No.	Date	Site(origin)	Spp.	sex	Age	BCS	Qualitative result	epg	Other parasites observed
1									
2									
.									

BSC=Body condition scoring, epg=egg per gram of faeces.

Annex 2. Post mortem examination result recording format

No.	Date	Organ (site)	Ttotal worm count	Individual worm count									Others
				H.c.	T.a	T.p	T.c	T.o	O.c.	B.t.	Str.	Tel.	

H.c= H.contortus, T.a. = *T.axei*, T.p= *T.probolurus*, T.c= *T.colubriformis* O.c. = *O.columbianum*, B.t=*B.trigonocephalum* T.o=*Trichuris ovis*, Str. = *Strongyloides*, Tel.= *Teladorsagia spp.*

Annex 3. Chemicals and reagents used in the study

- Fixatives and Preservatives of nematodes

  70% alcohol: 70 parts ethyl alcohol, Distilled water,30 parts

- Clearing agents (lacto phenol)

  20% phenol crystals in mixture of 20% distilled water, 8ml. Glycerine, 16.5ml lactic acid

  Keep the solution in dark glass bottle in dark place.

- Preservative for nematode eggs

  10% formaline: 10 parts of concentrated formaline, 90 parts distilled water.

Annex 4. Prevalence (%) of GIT helminthes of sheep and goats in Ethiopia based on coprological and post mortem examination.

Region	Sheep		Goat		Source	Remark
	Copro.	PME	Copro.	PME		
1.Tigray	88.1	95.6	84.3	90.5	Getachew (1998)	
2. Amahra						
Gondar	94.9	100.0	90.0	100.0	Gebreyesus (1986)	
Kombolcha	91.0	100.0	-	-	Genene (1994)	
D/Berhan	79.1	89.6	-	-	Achenef (1997)	
3. Oromiya						
E/ Showa	93.2	96.4	92.2	94.5	Melkamu (1991)	
Wolega	-	-	15* & 96.5**	-	Ahmed (1988)	*:during February
Illubabor	90.2	-	81.3	-	Bayou (1992)	**:during October
Bale	92.3	97.4	93.0	94.2	Tesfalem (1985)	
Asela	86.0	93.3	-	-	Yosef (1993)	
4. Somale						
Ogaden	96.0	-	-	-	Solomon (1987)	
Ogaden	93.6	-	96.3	96.5	Esayas (1988)	
Jijiga	-	-	76.9	-	Graber (1973)	
5.SNNPRS						
Wolayta	91.0	90.0	86.0	98.0	Dereje (1992)	
Wolayta	90.4	100.0	82.1	95.2	Haileleul (2002)	
Eastern Ethiopia	92.0	95.6	91.0	100.0	Abebe and Esayas (2001)	

Annex 5. Major nematode species and their prevalence in different regions of Ethiopia based on post mortem findings.

Region	*Haemonchus spp.*		*Trichostrongylus spp.*		*Bunostomum spp.*		*Oesophagostomum spp.*		*Trichuris spp.*		*Chabertia ovina*	Source
	Sheep	**Goat**	**Sheep**	**Goat**	**Sheep**	**Goat**	**Sheep**	**Goat**	**Sheep**	**Goat**	**Sheep**	
Tigray	95.5	90.4	28.9	68.7	-	18.1	82.2	24.1	6.7	81.9	-	Getachew (1998)
Amhara: Gondar	36.4	45.8	6.8	20.8	34.1	81.3	77.3	68.8	54.6	60.4		Gebreyesus (1986)
Kombolcha	83.8		63.4		40.7		79.6		63.4			Genene (1994)
D/Berhan	62.1		51.7				13.8		65.5		3.5	Achenef (1997)
Arsi&Wollo	66.8		89.4		34.4		57		83.2		4.0	Bekele etal.(1982)
Somale: Ogaden	93.6	83.8	36.1	16.6	32.0	59.4	53.0	61.1		34.1		Solomon (1987) &Esayas (1988)
Oromia: E.Shoa	65.5	72.6	39.3	41.1	50.0	82.1	72.6	67.1	60.7	69.9		Melkamu (1991)
Asela	63.1		54.8		44.5		85.7		59.5			Yosef (1993)
Bale	59.2	44.1	38.2	19.1	55.3	85.3	76.3	67.7	61.8	60.3		Tesfalem (1985)
Wollega		88.2		29.4		35.0		53.0		76.5		Ahmed (1988)
Illubabor	58.0	43.9	26.0	22.0	44.0	34.0	86.0	63.0	24.0	26.0		Bayou (1992)
SNNPRS:	80.0	81.0	10.0	13.6	10.0	17.2	90.0	88.2	50.0	27.8		Dereje (1992)
Wolayta	61.6	54.8	22.1	21.4	41.9	35.7	74.4	66.8	36.0	28.6		Haileleul (2002)
E/Shoa, Harar,	98.8		49.6 (*T. a*), 88.4(*T. colu.*)		42.4 (*B. phle.*)		92.0 (*O. col.*)		67.6 (*T. ovis*)			Kasambara (1999)
Afar, Sidamo.												
East shoa	89.5		78.1(*T. colu.*)				77.1 (*O. col*)		54.0 (*T. ovis*)			Dessalegn(1999)

Annex 6. Determining the age of the goat (Mike Steel, 1996)

Age group	Teeth condition
Kid under 1 year	Eight sharp incisors
Yearling (1 – 2 years)	Central pair of baby teeth replaced by permanent ones
Young adult (3 - 4 years)	4 permanent teeth
Adult (4 – 5 years)	8 permanent teeth
Older adults >5 years	Worn teeth and some missing

Annex 7. Estimation of the age of the sheep (Gatenby, 1991)

Permanent incisors	Age of the sheep
None	Less than 1 year and 3 months
1 pair	1 year & 3 months up to < 1 year & 10 months
2 pairs	1 year 10 months up to <2 years 4 months
3 pairs	2 years 4 months up to 3 years
4 pairs	More than 3 years

Annex 8. Body condition scoring of the goat (Mike Steel, 1996)

Condition score	Body condition
0	Extremely thin; nearly dead; no muscle between skin and bone
1	SP sharp and stick up. TP are sharp and your fingers easily push under thin ends. There is hollow between the ends of each process, loin muscle are shallow.
2	SP process feel less sharp; your fingers can be pushed under the TP with the little pressure, loin muscles are of moderate depth.
3	SP only stick up very slightly; they are smooth and rounded. Firm pressure is needed to detect each one separately. TP are smooth and well covered; firm pressure is required to push your fingers under the ends, loin muscles are full.
4	SP can just be felt with firm pressure as a hard line and & level with the flesh on either side. The ends of the TP cannot be felt, loin muscles are full.
5	SP cannot be felt at all, TP can be felt; loin muscles are very fully developed.

Annex 9. Body condition scoring of the sheep (Gatenby, 1991)

Condition	Score	Description
Starving	0	Extremely emaciated & on point of death, not possible to detect any muscle or fatty tissue between the skin and the bone.
Very thin	1	SP are prominent & sharp. TP are also sharp, the fingers pass easily under the ends, & it is possible to feel between each process. The eye muscle areas are shallow and no fat cover
Thin	2	SP feel prominent but smooth and the individual process can be felt only as fine corrugations. TP is smooth & rounded and it is possible to pass the fingers under the end with a little pressure. Eye muscle areas are full, and have a moderate depth, but have a little fat cover.
Moderate	3	SP are detected only as small elevations; they are smooth and rounded, and individual bones can be felt only with pressure. The TP are smooth and well covered, and firm pressure is required to feel over the ends. Eye muscle areas are full, and have a moderate degree of fat cover.
Fat	4	The SP can just be detected with pressure as a hard line between the fat covered eye muscles areas. The ends of TP can not be felt. The eye muscle areas are full and have a thick covering of fat.
Very fat	5	The SP can not be detected even with firm pressure and there is a depression between the layers of fat in the position where the SP would normally be felt. The TP can not be detected; the eye muscles areas are very full with thick fat cover. There may be large deposits of fat over the rump and tail.

SP : Spinous processes, TP : Transverse processes

Eye muscles: is the muscle along each side of the backbone.

Annex 10. Post-mortem examination procedures

Recovery of Alimentary tract Nematodes (Urquhart *et al.*, 1996)

Details of collection, counting and identification of alimentary nematodes of ruminants are:

1. As soon as possible after removing the alimentary tract from the body cavity, the abomasal-duodenal junction should be ligatured to prevent transfer of parasites from one site to the other.
2. Separate the abomasum, small intestine and large intestine.
3. Open the abomasum along the side of the greater curvature wash the contents in to the bucket under the running water and make the total volume up to 4 litres, and then the mucus membrane will be carefully rubbed with fingers to remove any worms adhering to the mucus membrane.
4. After thorough mixing transfer duplicate 400ml. samples to suitably labelled containers and preserve in 70% alcohol.
5. The small intestine is run off the mesentery, open it along its entire length and wash the contents in the bucket. Treat as for the abomasal content.
6. The contents of large intestine are washed in to a bucket, passed through a coarse mesh sieve (aperture of 2 – 3 mm) and any parasite present collected and preserved in 70% alcohol.

Parasites collected and preserved are counted and identified based on the morphological features described in MAFF, 1977; Soulsby, 1982; Jorgen, H. & Brian, P. 1994; Urquhart, 1996 and Bowman, 1999.

Annex 11. Worm counting procedure (Urquhart et al., 1996)

1. After thorough mixing, transfer 4 ml of suspension to a Petri dish, scored with lines to facilitate counting.
2. Examine the presence of worms using a stereoscopic microscope (12 x objectives), identify and count worms.
3. Preserve worms with 70% ethanol.

Annex 12. Guide to differentiate adult alimentary nematodes

A. Gross characteristics

Abomasum

	Description	Nematode genus
1	2 cm. Long, bursa visible with naked eye, females have "barbers pole" appearance; reddish when fresh	*Haemonchus*
2	1cm. long; slender; reddish brown when fresh	*Teladorsagia spp.*
3	Less than 0.5 cm. long; the smallest trichostrongyloid of ruminants; can not be easily seen on abomasal wall or in contents; greyish when fresh	*Trichostrongylus axei*

Small intestine

	Description	Nematode genus
1	0.5 cm. long; slender; greyish when fresh	*Trichostrongylus or Strongyloides*
2	2 cm. long; slender; much twisted often tangled like cotton wool	*Nematodirus*
3	2 cm. long; stout white worms; head bent slightly	*Bunostomum*

Large intestine

	Description	Nematode genus
1	Up to 8 cm. long; whip like; with long filamentous anterior part twice as long as posterior part	*Trichuris*
2	1.5 to 2 cm. long; large bell shaped bucal capsule	*Chabertia*
3	Up to 2 cm. long; bucal capsule tapered & not obvious as in *Chabertia*	*Oesophagostomum*

B. Microscopic confirmation

Abomasum

Haemonchus

Male: Dorsal ray of bursa asymmetric; spicules barbed near the tip.

Female: Vulval flap, usually linguiform, present; gravid worm contains several hundred eggs; ovary coiled around intestine.

Teladorsagia

Male: spicules slender, rod like (*T. circumcincta*) or stout with branch near middle (*T. trifurcata*)

Trichostrongylus axei

Both sexes: execratory notch visible in oesophageal region.

Male: spicules un equal in length.

Female: vuval flap absent; gravid worm contains 4 – 5 eggs pole to pole.

Small intestine

Trichostrongylus

Both sexes: execratory notch visible in oesophageal region.

Male: spicules leaf shaped (*T. vitrinus*) or spicules with "stap" near tip (*T. colubriformis*)

Female: vuval flap absent; ovejectors present

Strongyloides

Only females present; long oesophagus, ovary and uterus show twisted thread appearance behind oesophagus; objectors absent.

Cooperia

Both sexes: small cephalic vesicles present, giving anterior end a cylindrical appearance; prominent cuticular striations in oesophageal region.

Male: spicules have "wing" at middle region, bearing striations.

Nematodirus

Both sexes: cephalic vesicles present.

Male: Spicule long; slender and fused; with extended tip which is heart- shaped (*N.battus*); lanceolate (*N.filicollis*); bluntly rounded (*N.spathiger*).

Bursa shows two sets of parallel rays (*N. battus*) or four sets (other species)

Female: large egg present; tip of tail is pointed (*N. battus*) or truncated with small spine (other species)

Bunostomum: Large bucal capsule present.

Large intestine

Trichuris

Characteristic whip shaped, microscopic confirmation is unnecessary.

Tail of female is bow shaped and that of male is spirally coiled with one spicule.

Chabertia

Large bell shaped bucal capsule with out teeth and rudimentary leaf crowns.

Oesophagostomum

Relatively small bucal capsule; cephalic vesicle is with cervical groove behind. Leaf crowns and cervical alae often present.

Annex 13. Faecal Egg Counting Techniques

MODIFIED MC MASTER METHOD (Urquhart *et al.*, 1996; Hendrix, 1998)

The method involves the use of a Mc Master egg counting chamber as described below.

1. Weigh 3.0 gm. of faeces or if faeces is diarrheic 3 spoon full.

2. Break up thoroughly in 42 ml. of water in a plastic container.

3. Pour through a fine mesh sieve (aperture of 250 micrometer).

4. Collect filtrate, agitate and fill a 15ml. test tube.

5. Centrifuge at 2000 rpm (revolution per minute) for 2 minutes.

6. Pour off supernatant, agitate sediment and fill tube to previous level with floatation solution.

7. Invert tube six times and remove fluid with pipette to fill both chambers of McMaster slide.

8. Examine the two chambers and multiply the number of eggs by 50 to arrive at number of eggs per gram of faeces (epg).

- If 3 gram of faeces are dissolved in 42 ml.
- Total volume is 45 ml.
- Therefore 1 gram is 15 ml.
- The volume under etched area is 0.15ml.

Annex 14. Field pictures from sheep and goats grazing and browsing during different seasons of the year

Plates 1 and 2, goats browsing during late wet season of the year in lowland AEZ of the study area during the study period.

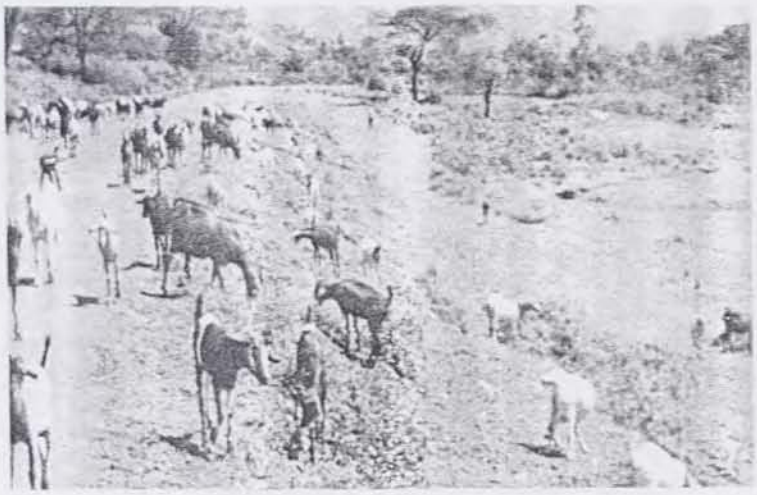


Plate 3. Goats grazing during early wet season of the year in lowland AEZ of the study site during the study period

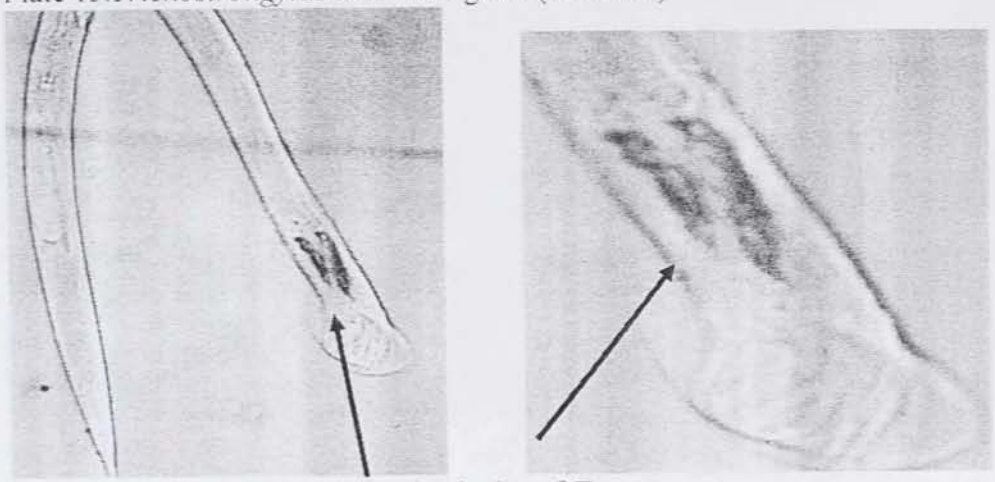
Plates 4 and 5. Sheep grazing in highland AEZ of the study site during late wet and mid dry season of the study period.

Plate 6. Goats grazing in highland AEZ of the study site during late wet season of the study period

Plates 12 and 13. *Teladorsagia spp.* from sheep (High land).

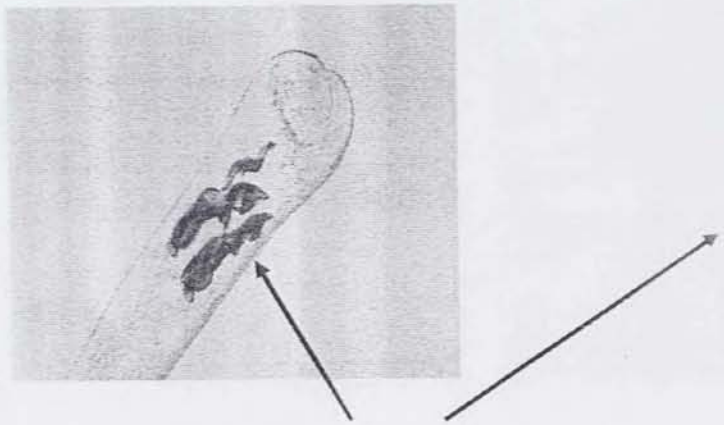
Branched spicules of *Teladorsagia spp.*

Plate 15.*Trichostrongylus axei* from goats (mid land)



Unequal spicules of *T. axei*

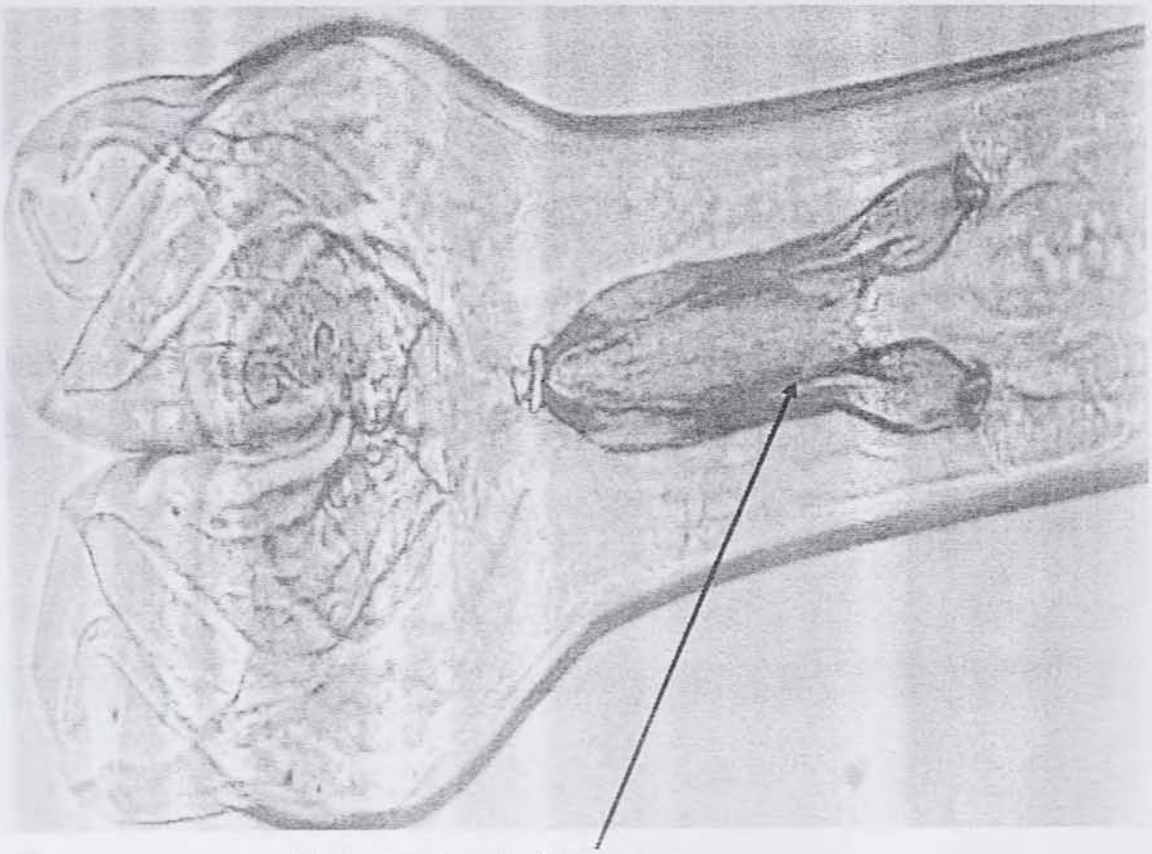
Plates 16 and 17. *T. probolurus* from sheep (low land)



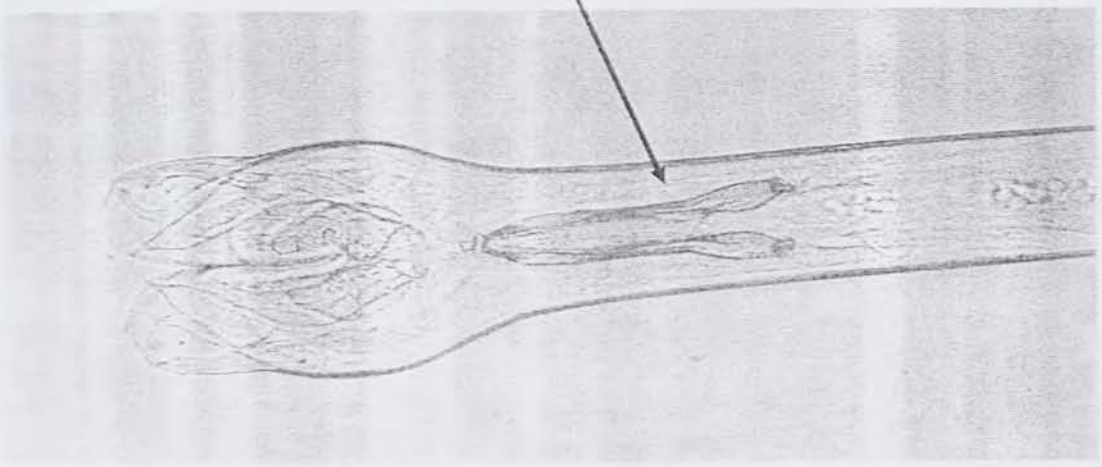
Arrows pointing at typical spicules of *T. probolurus.*

Annex 15. Microscopic pictures of male bursa and spicules of *C.curtiei*, *Teladorsagia spp.*, *T. axei* and *T. probolurus* identified from the study sites during the study period.

Plates 10 and 11. *C. curtcei* from sheep (High land)



Groves on the spicules



Plates 7 and 8. Goats grazing during early dry and late dry seasons of the year in midland AEZ of the study sites during the study period.

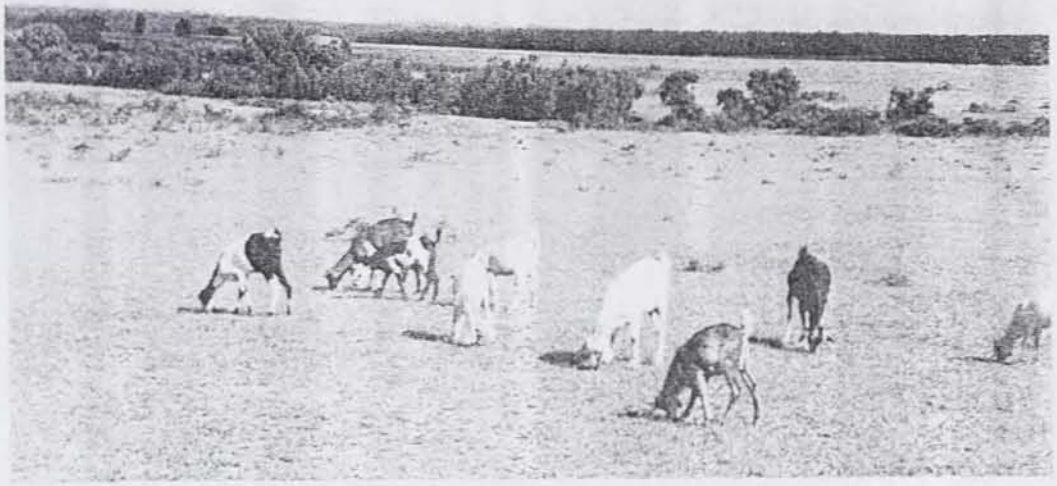
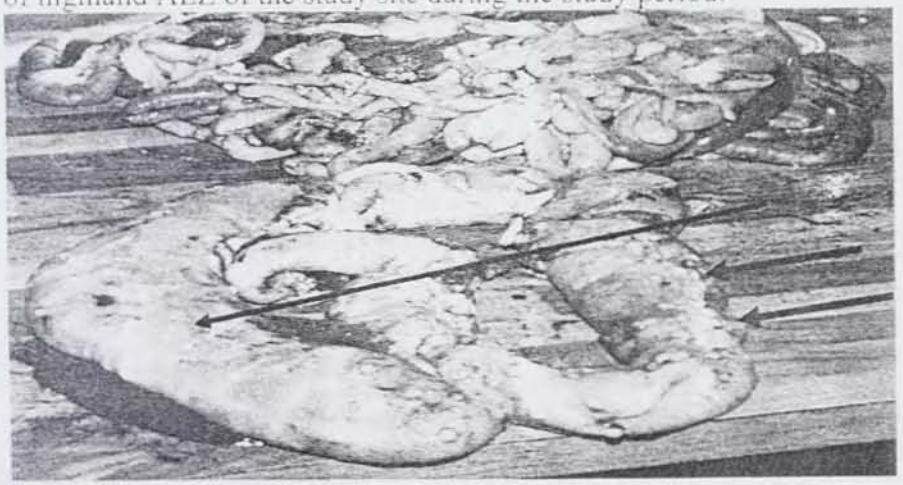


Plate 9. Numerous nodules on the large intestine of sheep slaughtered at a local hotel of highland AEZ of the study site during the study period.



Arrows pointing at nodules on large intestine due to arrested *Oe. columbianum* larva.

9. CURRICULUM VITAE

I. Personal Data

Full name: Amenu Asha Tolke

Birth date: March, 7/1969

Place of birth: Humbo, Wolayta, Southern Ethiopia

Marital status: Married

Nationality: Ethiopian

Membership: Ethiopian Veterinary Association

II. Educational Background

Primary education at Humbo Tebela primary school from1975-1979.

Junior secondary education at Ottona Junior secondaryschool from 1980-1981.

High school at Soddo comprehensive high school from 1982-1985.

University (undergraduate) at A.A.U. F. V. M., Debre Zeit 1986 to 1991.

Postgraduate studies at A.A.U, F. V. M., Debre-Zeit from 2004 to 2005.

III. Work Experience

1992-1993: As field veterinarian in pastoral area of southern Ethiopia.

1994: As field veterinarian at Wolayta, southern Ethiopia.

1995-1996: In Soddo Reg. Vet. Lab. in department of microbiology.

1997-2003: As researcher in Soddo Reg. vet. Lab. in department of Parasitology.

IV. Language ability

Wolaytigna: Spoken and written

Amharic: Spoken and written

English: Spoken and written

V. Papers and publications

Productive and Reproductive Performance of Jersey cattle under grazing management system in Wolayta Soddo State Dairy farm (DVM Thesis).

Field efficacy trial on commonly used trypanocidal drugs in six trypanosomosis problem areas of southern Ethiopia (Unpublished).

Epidemiology and seasonal dynamics of major GIT nematodiosis of small ruminants under tropical environment (Seminar on current problems of livestock).

Epidemiology of GIT nematodiosis of small ruminants in three different agro ecological zones of southern Ethiopia (MSc thesis).

VI. Work shops and Trainings

Laboratory techniques from October 1 to December 12/2003 in Pretoria University, South Africa.

VII. Referrences

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10. SIGNED DECLARATION SHEET

I the under signed, declare that the thesis is my original work and has not been presented for a degree in any university.

Name Amenu Asha

Signature _____

Date of submission _____

This thesis has been submitted for examination with my approval as University Advisor.

Dr. Abebe Wossene _____

Epidemiology of Gastrointestinal TractNematodiosis of smal_ Ruminants in three Differnt Agro-Eclogical Zones of southern Ethiopia.

Amenu Asha