EFFICACY OF LEVAMISOLE, ALBENDAZOLE AND IVERMECTIN ON COMMON GASTROINTESTINAL NEMATODES IN COMMERCIAL GOAT FARMS IN GOMBA DISTRICT, CENTRAL UGANDA

By

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DECLARATION

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DEDICATION

I dedicate this dissertation to my dear wife Harriet Nsereko for the support and encouragement she has given me.

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LIST OF ABBREVIATIONS AND SYMBOLS

Alb	-	Albendazole
Day 0 -	-	day zero/ first day of experiment
Epg -	-	Eggs per gram
FECRT -	-	Fecal Egg Count Reduction Test
GIN	-	Gastrointestinal nematodes
H. contortus	-	Haemonchus contortus
Iver -	-	Ivermectin
L_3 -	-	Infective stage of nematode larvae on pasture
Lev -	-	Levamisole
Mepg -	-	Mean egg per gram
mg/kg body wt	-	milligram per kilogram body weight
n -	-	number of animals used in an experimental group
P -	-	P- value
PGE -		Parasitic gastro enteritis
$ -	-	United states dollar
SRVO	-	Small Ruminant Veterinarians of Ontario
t	-	t-statistic
UEPB	-	Uganda Export Promotion Board
UPTOP -	-	Uganda Program

ABSTRACT

In Uganda, anthelmintics are widely used in the control of gastrointestinal nematode (GIN) parasites. However, control is not based on knowledge of the parasite epidemiology and status of Anthelmintic efficacies. This has led to their indiscriminate use and spreading of resistant nematodes in the ecosystem. This study hence identified the common GIN parasites, risk factors to anthelmintic resistance and evaluated the efficacies of albendazole (Alb), Levamisole (Lev) and Ivermectin (Iver) against natural GIN infections in goats in Gomba district. Fecal samples were collected on day 0 (N=470) before treatment. Parasite eggs were identified using the floatation technique, while worm burden (epg) were determined using the McMaster technique. Fecal samples were pooled and cultured for 7 days at 27° C. L3 were extracted using Bearmann's technique and were identified using their morphological features. Goats with epg counts > 200epg were randomly set into 4 treatment groups: Alb, Lev, Iver and controls/placebo (n= 93). Fecal samples were collected on days 7, 14 and 21 post-treatment and fecal egg count reduction (FECR) test used to determine the efficacy for each treatment group. Risk factors for anthelmintic resistance were identified using questionnaire interviews on 62 farms (15- 300) goats/farm. Results: overall prevalence of GIN was 43%. Common GIN parasites were *Haemonchus* (56%), *Oesophagostomum* (33%) and *Stronyloides* (11%). Drug efficacies were; Alb: (82, 80 and 61) % at days 7, 14 and 21, Lev: (95, 91 and 69) % and Iver: (85, 84 and 81) % on the same days post treatment, respectively. Mean efficacies were; Lev (85%), Iver (83%) and Alb (77.3%). Only *Haemonchus* were recovered in copro-cultures in Alb treated goats at day 21. Major risk factors for reduced efficacy were; prolonged use of one drug type (97% Alb), weight determination by visual appraisal (94%), self medication (67%) and grazing animals on communal pastures (80%). In conclusion, level of GIN infections in goats in Gomba was low probably due to heavy anthelmintic application. *Haemonchus* was the predominant GIN parasite. Albendazole, levamisole and ivermectin were still effective against common GIN parasites in Gomba but, (<90% efficacies) post-treatments was suggestive of possible parasite resistance against these drugs. Prolonged use of one anthelmintic and visual estimation of animal weight during treatment were the major risk factors for anthelmintic resistance. Specific reasons for the low GIN parasite prevalence needed further investigation. Farmer education was recommended to ensure judicious use of these drugs so as to maintain their current efficacies while alternative approaches to complement chemotherapy are sought.

CHAPTER ONE

INTRODUCTION

1.0 Background

Goat production is a valuable component of the economy of most rural communities globally (Nsubuga, 1994). Goats provide valuable products (meat, milk and skins); and the often overlooked manure for improved crop and fish production (Onditi *et al,* 2007). In Uganda, the role of the goat is very much valued in terms of human nutrition, food security, family income and socio-cultural needs (Devendra and Burns, 1983; Okello *et al.*, 1994; and Reed *et al.*, 1988).

Goat production in Uganda today offers one of the most promising opportunities for farmers and investors (Bwire, 2008). According to economic indicators in the region, domestic and regional demand for meat products is exponentially increasing (Allan, 2002). The market demand for local consumption and export of goat meat is strong, with goat meat fetching a higher premium than beef, fish or chicken (UPTOP, 2006). According to UPTOP (2006) the annual rate of increase in meat consumption is expected to be at: 7% for beef; 7% for goat meat, 3% for pork and 3% for chicken; this is higher than the livestock growth rates. There is hence an immense potential for development of goat production into a leading component of the agricultural sub-sector in Uganda (Nsubuga, 1994 and UEPB, 2008).

Development of the goat industry in many poor countries like Uganda is however faced with a number of constraints (Kumba, 2003). One of the major constraints afflicting goat production is the widespread occurrence of gastro-intestinal nematodes (GIN). In goats, the *Trichostrongyloid* parasites; especially the stomach wire-worm, *Haemonchus contortus* are the commonest and most devastating cause of gastrointestinal infections (Kusiluka and Kambarage, 2006). Other nematodes such as, *Oesophagostomum* and *Cooperia* species are of lesser clinical and economic significance (Magona *et al.*, 2000). Mortality rates exceeding 40% and weight losses of 6-12Kg/year/animal in small ruminants have been reported (Nganga *et al.*, 2004).

Increased occurrence of gastrointestinal nematode infections in goat herds of many farming communities of the developing countries like Uganda has been attributed to a number of reasons

(Magona and Musisi, 1999). Some of the major reasons include grazing systems that allow for pasture contamination such as, high stocking density and intensive management with little or minimal rotational grazing. Pasture contamination has a direct effect on the population dynamics of nematodes like *Trichostrongylus colubriformis* (Barnes and Dobson, 1990). Concentration of animals at watering points particularly, during the dry season, tethering of goats during the wet season (common in many agro-pastoral societies), have a strong influence on the epidemiology of gastrointestinal nematodes (Kusiluka and Kambalrage, 2006). These practices result into increased environmental contamination with infective larvae and hence incidence of clinical helminthosis.

Overzealous anthelmintic use is another reason for the increased occurrence of helminths parasites in goat herds (Maingi *et al.* (1996). This is mainly due to weaknesses in the quality of training and low level of awareness of the personnel involved in healthcare of the flocks in the rural areas.

Introduction of less tolerant breeds such as the Boer goats from South Africa is also believed to be responsible for increased GIN occurrence on goat farms (Nsubuga, 1994). The Boer goats are highly productive but are highly susceptible to GIN as compared to the indigenous goat breeds (Nsubuga, 1994).

It is widely believed that local goat breeds are tolerant to many parasites and other infectious diseases. Anecdotally, this tolerance is being lost with the introduction of improved exotic breeds for cross-breeding or even replacement of the indigenous goats (Nsubuga, 1994). Also, haphazard parasite control strategies have been blamed for increased occurrence of GIN infections (Magona *et al.*, 2000). Additionally, anthelmintic choice is largely governed by price, and only drugs from the benzimidazole group and levamisole are widely available. This may in the long run contribute to the development of anthelmintic resistance (Magona *et al.*, 2000).

There is however, a general lack of current data based on systematic study of epidemiology of GIN parasite infections in Ugandan goats on which to base control measures. Furthermore, anthelmintic resistance profiles and the risk factors leading to development of resistance in goats

have not been extensively studied; especially in the pastoral communities of Gomba district, Central Uganda. This study therefore identified the common GIN infections in goats in the pastoral communities of Gomba district. It also assessed the resistance profiles of the GIN infections to common anthelmintics and evaluate the risk factors associated with development of anthelmintic resistance.

Knowledge of the parasite profiles, drug resistance patterns and key factors responsible for development of anthelmintic resistance would provide useful information to goat farmers, animal health workers and extension staff on optimum utilization of drugs for improved GIN control. This will in turn lead to improved goat production and productivity of the farming households.

1.1 Problem statement

There is lack of current information on the; common GIN parasites affecting different goat farms, the efficacy status of the anthelmintics on nematode populations and the risk factors that lead to reduced efficacy of anthelmintics in Uganda. This has often led to indiscriminate use of anthelmintics which leads to spreading of resistant nematodes in the ecosystem.

1.2. Hypothesis

Current common farming practices on goat farms that misuse anthelmintics have led to reduced efficacy of anthelmintics against common GIN parasites populations.

1.3. Research questions

What are the common GIN parasites on commercial goat farms in Gomba district?
What are the GIN parasites in goats that are resistant to levamisole, albendazole and ivermectin?
What are the risk factors /farming practices that lead to reduced efficacy of anthelmintics against the common GIN parasites?

1.4. Aim of the study

To assess the level of effectiveness of commonly used anthelmintics in the control of GIN on selected commercial goat farms in Gomba district.

1.5. Study objectives

1) Identify the common GIN parasites in selected commercial goat farms in Gomba district.
2) Assess the efficacy of levamisole, albendazole and ivermectin on common GIN parasites.
3) Identify the farming practices/ risk factors that reduce the efficacy of anthelmintics (anthelmintic resistance).

1.6. Justification

It was hoped that knowledge of parasite profiles, efficacy status of the common anthelmintics and key factors responsible for development of anthelmintic resistance would be useful in guiding goat farmers, animal health workers and extension staff on optimum utilization and choice of drugs for improved GIN control. This will in turn lead to improved goat production for better household livelihoods.

CHAPTER TWO
LITERATURE REVIEW

2.1 Goat production

The global goat population is over 674.1 million goats and of these Africa accounts for 26.2% (Tolera *et al.*, 2000). East Africa has 38.9% and 10.2% of the African and world goat population, respectively (Tolera *et al.*, 2000). Most of the goats are kept by smallholder farmers and pastoralists (Tolera *et al.*, 2000). The goat population in Ugandan has been increasing since 1935 (Nsubuga, 1994). In the last animal census of 2008, the goat population had reached 12.4 million (UBOS, 2008).

The Production systems and management practices differ in different households depending on the value attached to livestock products (MPED, 1991). Small ruminant meat production contributes greatly to people's livelihoods in many African countries (Kumba, 2003). In terms of total output, goat products are the most important in developing countries where, 93% of all goat meat, and 73% of all goat milk are produced (Gutierrez, 1985). Small ruminants are more suitable for family consumption of 5-10 people, compared to cattle because of their small carcasses (10-15 kg) (Nsubuga, 1994). Indeed, goat meat is the most consumed meat globally (Alford and Henry, 2009).

In Uganda about one million goats are slaughtered annually for meat. The skins are exported or used in the local tannery and leather craft industry (MPED, 1991). Goats contribute significantly to the economy and food security of the poor in Uganda. They provide about 23% of the total red meat produced in Uganda (Okello *et al.*, 1996) The Small East African (SEA), the Mubende goat and the Kigezi goat are the indigenous goat breeds in Uganda. Boer goats were introduced in 1993 and crossbred with the local goats to improve their performance. However, the exotic goats and their crosses with indigenous stock are more susceptible to helminth infections compared to the local breeds (Nsubuga, 1994).

2.2 Constraints to goat production

Goat production is constrained by three major problems; economical, cultural and biological. Some of the economic constraints include; changes in demand of goat products attributed to changes in incomes or preferences. This discourages producers from investing in the business (Gutierrez, 1985). Other economic constraints include, inadequate skilled labour, overvalued exchange rates, initial investment costs, phytosanitary restrictions (Gutierrez, 1985; Conroy, 2000) and high mortalities of kids due to diseases and abortions (Devendra, 1999).

One of the important economic factors limiting economic goat production is parasitic gastro-enteritis (PGE). PGE limits production through high control costs, high mortalities, clinical treatments, sub-optimal productivity and weight losses (Walkden-Brown, 1984; Shavulimo 1989; Blackburn *et al.,* 1991; Rahman and Collins, 1990; Bath and De Wet, 2000).

Biological constraints to goat production include heat stress which lowers feed conversion, meat production and milk production. Heat also causes growth retardation in kids because of the negative impacts of heat stress (Sezen *et al.*, 2009). It's important to alleviate the effects of heat stress in hot environments in order to maintain productivity and animal welfare (Sezen *et al.*, 2009). Also failure to improve the production potential of the indigenous breeds in their natural environment is a constraint to goat production (Devendra, 1999).

Another biological constraint is related to their small size and grazing habits. They are subject to theft, not useful for draft purposes, have low outputs relative to input costs and down grading the grazing land under uncontrolled grazing (Thomson and Thomson, 1987). The indigenous goat breeds which are predominant have low growth rates compared to the exotic meat breeds such as the Boer and the Boer crosses with the indigenous goats. The small East African (SEA) for example weighs between 20-25 Kg, the Mubende goat 30-35 Kg and the Kigezi goat 25-30 Kg mature live weight respectively. They produce comparatively small carcasses of between 10-15 Kg (Nsubuga, 1994).

The Boer goat on the other hand has superior traits for goat meat production. Heavier body weight and faster growing rate are the most notable. Birth weight of Boer kids ranges from 3 to 4

Kg with male kids weighing about 0.5 kg heavier than female. Kids at weaning can weigh from 20 to 25 Kg, depending on weaning methods and age (Lu and Potcoiba, 1988). At 7 months, bucks weigh between 40 to 50 Kg while does weigh between 35 to 45 Kg. At yearling, male Boers weigh between 50 to 70 Kg and females weigh between 45 to 65 Kg. Mature weights for bucks and does are 90-130 Kg and 80-100 Kg, respectively. These body weight measurements may vary depending on genetics, nutrition, health and disease and breeding age.

The cultural constraints in most African societies include farmers' high regard for keeping cattle as compared to keeping goats because cattle are regarded as a sign of wealth. Farmers with large cattle herds are accorded much respect and prestige than those with flocks of goats. A man without cattle is not respected in society because goats cannot be used in paying dowry (bride price), wedding ceremonies, funerals and customary rituals. Some other cultures prefer beef as opposed to goat meat. This is due to taste and an unfavorable odour of goat meat which dampen one's appetite (Singwane and Salam, 2007)

Other constraints are natural and they include droughts which cause water scarcity and feed shortages, and poor transport systems which results in poor delivery of veterinary services to farmers (Tesfaye, 2009).

2.3 Parasitic gastro-enteritis

Parasitic gastro-enteritis (PGE) causes severe losses in the livestock industry world-wide (Waller, 2006). *Trichostrongyles* like *Hemonchus contortus* which is the most pathogenic in small ruminants. Other less pathogenic *Trichostrongyles* include *Oesophagostomum species*, *Cooperia species* and *Trichostrongylus species* (Sani *et al.*, 2004).

PGE occur at different predilection sites and present with different clinical and pathogenic mechanisms. However, most common field infections of PGE present additive pathogenic effects of several nematodes. Haemonchosis is the most economically important disease of goats in Africa, particularly in kids. Its pathogenesis is related to the blood sucking habit of the parasite. Significant losses occur in form of high mortality, morbidity and high treatment costs (Miller, 1996).

The epidemiology of nematode infections is determined by several factors such as climatic factors, particularly rainfall and temperature. Rainfall or moisture facilitates survival, development and dissemination of free living helminth larvae on pastures. Optimum temperatures enhance development of parasite stages, while too low or too high temperatures inhibit development (Kusiluka and Kambarage, 2006).

Other factors influencing the epidemiology of PGE include; animal management systems, parasite factors (Kusiluka and Kambarage 2006) and age of the animal. Young animals are more susceptible to GIN infection compared to older ones and their resistance to infection increases with age (Nganga *et al.*, 2004).

2.4 Effects of gastrointestinal nematode infections in small ruminants

Profitable small ruminant production on pasture highly depends on proper control of nematode parasites (Miller *et al.*, 2005). The economic losses are in form of decreased production, high costs of prophylaxis and treatment and death of infected animals. Gastrointestinal nematode parasites damage the mucosa of the gastrointestinal lining causing indigestion and mal-absorption (Kumba, 2002). This leads to poor feed utilization and lowered growth rates in young animals. Reduced milk production, increased susceptibility to other diseases and poor quality products in the affected animals have also been reported (Kumba, 2002).

For small ruminant production world-wide, more money is spent in prevention of diseases from internal parasites than from all other diseases combined (Bath and De Wet, 2000). This is so because of the continuous presence of the parasites on pastures which are grazed by the animals. In the southern US for example, infection with GIN is the primary constraint to profitable production which threatens viability of the small ruminant industry in this region. In Columbia, there were cases where all goats died from *Haemonchus contortus* parasite infestations (Bath and De Wet, 2000).

In Kenya, it was observed that gastrointestinal helminths reduce production, weight and cause mortalities in goats. *Haemonchus contortus* was reported to be the main nematode involved in

the infections and has been estimated to cause losses of up to US $ 26 million each year (Anon. 1999).

Haemonchus contortus resistant strains that failed to respond to a single treatment of albendazole, which same single dose was effective against *Trichostrongylus axei, T. colubriformis, Cooperia curticei* and *Oesophagostomum columbianum* were reported in Kenya (Waruiru, 2000). When closantel and Closantel- albendazole combination were given at a dose of 10 mg Kg-1 and 5 mg Kg-1 respectively, high efficacy of up to 3 weeks against common GIN of goats including the resistant *H. contortus* was achieved.

It was recommended that closantel be used in full dose or in combination with other broad-spectrum anthelmintics in order to preserve its efficacy in control of mixed nematode infections (Waruiru, 2000). This would prevent establishment of larvae obtained from pasture and inturn would lead reduced pasture contamination and increased production. Reports of resistance in Kenya have been reported by Nginyi, *et al.* (2005). He reported resistance of *H. contortus* to Levamisole in smallholder and large scale goat farms, the problem being more significant on large scale farms.

In Uganda, research on the biological impact of helminth infections in goats showed that, low productivity of goats kept by many smallholder farmers in rural areas is mainly attributed to GIN infection (Lapenga and Rubaire, 2009). They were reported to limit productivity by decreasing weight gain (Githigia *et al.* 2001), suppressing milk production, destroying body tissues and systems resulting into condemnation of carcasses and organs (Coop 1982) and mortality among kids.

Goats acquire infection after picking infective larvae (L_3) on pasture which has been contaminated. The clinical disease manifests when susceptible animals are grazed heavily on infected pastures. The epidemiology of GIN infection is enhanced by the climatic conditions (rainfall and temperature 23-28°C) in Uganda, which favours survival of the free-living stages of parasites almost throughout the year (Lapenga and Rubaire, 2009).

Studies in dairy calves in Kenya revealed that *Haemonchus placei*, *Trichostrongylus axei*, *Cooperia species*. and *Oesophagostomum radiatum* were responsible for PGE and that *H. placei*

was found to be the predominant nematode in the young cattle (Waruiru *et al.*, 2001). Faecal egg per gram counts from cattle and necropsy worm counts showed that pasture larval levels were high during the rainy season (March-June and October-December) and low in the dry season (Jan-Feb and July-Sep) (Waruiru *et al.*, 2001). No recent reports of resistance to anthelmintics in Uganda have been reported in small ruminants and other livestock.

2.5 Control of gastrointestinal nematodes in goats

Several control methods that have been used include programmed management practices, such as rotational grazing, breeding resistant stock, immunization, use of anthelmintics and use of non-chemical methods (Kusiruka and Kambarage, 2006).

Rotational grazing involves subdividing the available pastures into small plots. Animals are then moved around these pastures in quick succession (3 - 4 days grazing only on each plot), being returned to their original plot after 30 - 40 days (Waller, 2006). This method is only possible for farmers with large pieces of land and not smallholder farmers who are constrained by land sizes. It may involve separation of animals according to age groups with young ones grazing a head of the mature animals. Mature animals get exposure to worm infestations in their early stages when they start grazing pastures and therefore their fecal droppings contaminate pastures with worm eggs or larvae as compared to the young ones which have no pre-exposure. So grazing young animals ahead of mature ones protects them from grazing pastures contaminated with infective nematode larvae (Waller, 2006).

Other management methods include alternate grazing by different species of hosts in which different species of worm larvae or eggs are deposited on the same pasture and taken up by different animal species. When the eggs or larvae of nematode parasites which have specific hosts are taken up by other animal species, their life cycles are interrupted and they fail to establish. Adjustment of stocking rates is also another management method which reduces the level of worm eggs that are deposited on pasture, hence minimizing contamination of the environment. Improvement of nutrition and better housing systems are also management strategies for GIN control. Improved nutrition boosts the animal immunity against worm infestation and other infections, while better housing makes it easy to maintain hygiene and

hence reduce worm build up from accumulated fecal droppings which act as source of worm infestation to the housed animals (Kusiruka and Kambarage, 2006).

Breeding resistant stocks based on genetic resistance of different breeds of goats to helminth infections also promotes control of gastrointestinal nematodes in ruminants. Indigenous goat breeds such as the small East African (SEA) breed in Kenya do not readily succumb to hemonchosis as compared to exotic breeds or their crosses with the Toggenburg and the Galla goats (Kusiruka and Kambarage, 2006). The phenomenon of indigenous small ruminant breeds being resistant to GIN infection is known to have developed over longer time in the host-parasite relationship (Gill *et al.*, 1993, 2000). These resistant breeds are capable of mounting effective immune response to GIN infection at an early age depending on the affected breed and nematode species (Barger, 1988). Two mechanisms of host responses to GIN infection have been reported to be operating in such cases and are mediated by the animal immune system. They include; the exclusion and the self-cure phenomenon. In the immune exclusion, larvae that are ingested fail to establish in animals that are heavily infected (Miller *et al.* 1983; Newlands *et al.* 1990), but when the animal is treated and larvae ingested then, the ingested larvae are able to establish. The second immune mechanism exhibited by resistant breeds is the self-cure phenomenon in which established adult nematodes are expelled spontaneously when massive larval invasion occurs over a very short period (Hong *et al.*, 1989). This normally happens after heavy rain releases large numbers of infective larvae from feces. This larval invasion causes rise in the abomasal pH, movement of serum protein especially albumin and sodium from circulating blood into the abomasal lumen. This leads to fluid dumping and diarrhea in which nematodes are expelled (Miller and Horohov, 2006). Immunoglobulin E (IgE)-mediated hypersensitivity is thought to be involved in this immune response. Characteristic immune response to nematode infection is majorly due to accumulation of mucosal mast cells and eosinophils in the gastrointestinal tract (Rothwell, 1989).

Inoculations of nematode parasite antigens/vaccine into healthy animals stimulates immune responses that confer protection against subsequent helminthes' infections. *Haemonchus contortus* larvae have been reported to confer immunity to subsequent challenge. Little work has been done using immunization in the sub-Saharan region (Kusiruka and Kambarage, 2006).

Exploring the use of natural products with anti-parasitic properties is also a GIN parasite control strategy. Some plants and their products world-wide are being explored to assess their possible anthelmintic effects against parasites including nematodes (Datsu Kalip *et al.*, 2011). A lot of research on plant extracts has been focused on searching for bioactive compounds from plants such as *Hagenia abyssinica* and *Glinus lotoides (Hirta)* as another approach to nematode parasite control. Emergence of multiple anthelmintic resistances in small ruminant GIN populations, and concerns over environmental effects of excreted anthelmintics, is what has led to development of these alternative parasite control methods (Abegaz and Dagne, 1978; Min and Hart, 2003). Other promising novel, non-chemical control methods for GIN currently being evaluated includes Copper oxide wire particles (COWP) (Kallu *et al.* 2005) and biological control agent *Duddingtonia flagrans* (Terrill *et al.*, 2004).

Chemotherapy is another nematode control method which is used world-wide. It involves use of drugs belonging to three anthelmintic classes and having different modes of action. The three anthelmintic classes that are commonly available on the market include:benzimidazoles such as albendazole, imidazothiazoles such as levamisole and macrocyclic lactones like ivermectin (SRVO, 2012).

2.6 Mode of action of albendazole, levamisole and ivermectin

2.6.1 Albendazole:

It is a broad spectrum anthelmintic belonging to the benzimidazole group of drugs. When the drug is taken up, it is slowly released into the gastrointestinal tract of the worms. The drug acts on the intestinal cells of the nematode, inhibiting uptake of glucose and causing starvation. It acts by binding to microtubules which are important organelles involved in the motility, division and secretion processes of cells in the worms. Blocking of microtubules inhibits the uptake of glucose and hence depleting the glycogen reserves. This leads to paralysis, death and expulsion of the worm in feces. Albendazole does not only kill adult forms but also the immature stages. It is also ovicidal – with activity against eggs being passed by the nematodes. This occurs by disturbance of the cell division process of the worm eggs. This causes worm egg production and development to be blocked by the drug (ovicidal effect). Albendazole also inhibits a helminth-

specific fumarate reductase, an enzyme involved in the energy management of the worm cells as well (SRVO, 2012).

2.6.2 Ivermectin:

Ivermectin is a broad spectrum anthelmintic and belongs to the macrocyclic lactone group. The mode of action of this drug is against neurotransmitter receptors which are specific to invertebrates. The drug blocks GABA receptors which are responsible for transmission of neuronal signals of the parasites. This results into either paralysis or expulsion of the worms out of the body, or starvation of the worm. The drug also diminishes oviposition or induces abnormal oogenesis of some GIN parasites. Ivermectin acts against most nematodes including the L4 stage, but it is not ovicidal. When administered to the animal, the drug is stored in fat tissue and is then slowly released into the body. This property makes it have prolonged activity in animal tissues for up to 35 day when given in injectable form (SRVO, 2012).

2.6.3 Levamisole:

Levamisole belongs to the imidazothiazole group of anthelmintics. When administered, it causes de-polarization of the ganglions and nervous cells of the worms. This paralyzes the parasites so that they are removed rapidly from the gut. Worms are paralyzed and die or expelled within 1 to 3 hours after administration of levamisole. The drug also interferes with the metabolism of carbohydrates (sugars) in the worm causing death. Levamisole works against a broad range of adult worms but is less active against the immature stages such as L4. It is not ovicidal and has a narrow safety margin. It is however effective against lungworm (SRVO, 2012).

These drugs generally eliminate the eggs or larvae of the parasites in the host preventing discharge of eggs and larvae into the environment. The epidemiology and biology of the parasites vary in different places, hence anthelmintic control strategies such as, the treatment frequency also vary between different agro-ecological zones within a country (Kusiruka and Kambarage, 2006). After many years of anthelmintic use, parasite resistance has emerged across the world (Maingi, 1991; Dorny *et al.*, 1993; DeVaney *et al.*, 1992).

.7 Challenges to Parasitic gastroenteritis control

Favourable environmental conditions for parasite proliferation such as the humid tropical climate hat is favourable for the survival, development and transmission of gastrointestinal nematodes hroughout the year (Barger *et al.*, 1994; Van Wyk, 2001).

Lack of awareness of proper nematode control strategies is also another challenge. For example ack of knowledge of the factors which influence the epidemiology of nematodosis such as the ole of rain fall distribution and temperature and knowledge of the life cycles of the GIN arasites will lead to poor nematode control by the veterinary extension staff. This is mainly due o poor extension education (Afaq, 2003).

Other challenges include poor surveillance and reporting systems, particularly in the traditional husbandry systems which makes information on worm control unavailable to the farmer. Limited financial and land resources amongst poor farmers also make control difficult because of irregular treatments and continuous grazing of animals on contaminated pastures which also promotes anthelmintic resistance (Kusiluka and Kambarage, 2006).

.8 Anthelmintic Resistance

Resistance is the ability of worms in a population to survive drug treatments that are generally ffective against the same species and stage of infection at the same dose rate (Kaplan, 2004). Resistance to all three broad-spectrum anthelmintic groups has been reported in many parts of he world including USA (Terrill *et al.*, 2001; Mortensen *et al.*, 2003), South America (Waller *et l.*, 1996), South Africa (Van Wyk *et al.*, 1999), Australia (Love and Coles, 2002) and the UK Sargison *et al.*, 2001) and Kenya (Maingi, *et al.*, 1993 and Wanyangu *et al.*, 1996). Resistance rises from selection when nematodes believed to be already possessing genes for resistance, are xposed to levels of drugs that kill the susceptible worms and spare the resistant ones. Rapid otation of different drugs is likely to cause multiple resistances (Scarfe, 1993).

2.8.1 Causes of anthelmintic resistance

Resistance is caused by several factors including genetic, biological or operational factors (Saeed, 2007). The major factors are operational factors which are due to farmer practices on the farm or due to activities of healthcare personnel operating with insufficient knowledge. These include; under-dosing, treatment frequency, healthcare supervision, type of anthelmintic used, selective and/or mass treatment, rotation of anthelmintics, nature of livestock farming, feeding practices and pasture rotation.

Underestimation of animal body weights during anthelmintic treatment, leads to administration of sub-lethal doses (Edwards *et al.,* 1986). This often results from measuring animal body weights using visual appraisal. Since drugs are given according to the weight of the animal, accuracy in estimating animal body weight measurements or a group of animals is required for appropriate dosing. Also poor quality/expired or adulterated drugs which sold on the general markets contribute to under-dosing and thus development of resistance. Under-dosing has been reported to affect the selection pressure exerted by the anthelmintics (Sykes *et al.,* 1992). It is the major cause of development of anthelmintic resistance (Warren *et al.,* 1993).

Drenching frequency (de-worming animals at short intervals between treatments) is another operational factor causing resistance. This is because it continuously exposes worms to the drug being used. This affects the selection pressure exerted by the anthelmintics (Martin, 1989; Sykes *et al.,* 1992). Reduction in the drenching frequency may prolong the useful life of some anthelmintic groups (Sangster, 1999). Hazelby *et al.* (1994), Conder and Campbell (1995), Scott *et al.* (1995), Anonymous (1998), Claxton *et al.* (1998), Geerts and Gryseels (2000) and Lloyd *et al.*(2000) all recommended for reduction in drenching frequency in order to prolong the effectiveness of the current drenches being used.

Lack of knowledge of the right anthelmintic type also leads to development of resistance (Waller, 1993). This calls for increased farmer awareness programs on worm control. Satyavati *et al.* (1976) and Lewis and Elvin Lewis (1977) recommended for use of plants that have anthelmintic properties as alternatives to synthetic drugs to slow down development of resistance.

Other causes of resistance include poor healthcare supervision by veterinary extension agents because they lack updated knowledge about endo-pasite control which they can disseminate to herd owners for effective GIN control and also leaving treatment of animals to farmers alone. Lack of experience in the control of GIN parasites (Maingi *et al.* 1996 and Lendal *et al.* 1998) and selective or mass treatments which exposes a majority of worms to selection pressure (Kaplan, 2004; Van Wyk *et al.* 2002, 2003) also causes resistance. Furthermore non-alternation of anthelmintic classes which leads to prolonged exposure of one drug to parasite population. This leads to propagation of nematode larvae that are resistant to the drug being used (Anonymous, 1998; Coles and Roush, 1992; Lloyd *et al.,* 2000). Mixing sheep and goats also promotes resistance since goats and sheep share some nematode parasites (Jackson, 1993). Poor animal nutrition (Saeed, 2007; Roberts and Adams, 1990) and non-pasture rotation (Afaq 2003) have also been blamed for speeding up development of resistance. Cases of anthelminthic resistance against levamisole in small holder sheep and goat farms in the coastal lowlands of Kenya have been reported (Wanyangu *et al.*, 1996 and Ngiyi *et al.*, 2004).

2.9 Conclusions from the literature reviewed

Literature above has shown that anthelmintic resistance exists in many countries in the world where anthelmintics have been used in the control of GIN infections. In all cases where it has occurred, it has been caused by almost similar factors. The occurrence of anthelmintic resistance in Kenyan small ruminant farms may indicate that Uganda could be having a similar problem. In Uganda the current status of anthelmintic resistance on commercial goat farms, particularly in Gomba district, where large volumes of drugs are being used is not clearly understood. This study therefore aimed at; finding the current efficacy status of the commonly used antlemintics against GIN, the resistance profiles of these parasites and to identify the farming practices that may predispose to development of anthelmintic resistance on commercial goat farms in Gomba district.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Identification of the common GIN parasites

3.1.1 Study area

The study was carried out on selected commercial goat farms in Maddu and Kabulasoke Subcounties, Gomba district in Central Uganda between June and July 2011. The district is made up of four Subcounties namely; Maddu, Kabulasoke, Kyegonza and Mpenja. It is bordered by districts; Mubende to the North, Mityana to the Northeast and Butambala to the East, Kalungu, Bukomansimbi and Sembabule to the South. The district is situated in the cattle corridor of Uganda and the major economic activity is livestock farming supplemented by subsistence crop cultivation. Anecdotally Gomba district is one of the major areas in Central Uganda known for commercial goat rearing. Communities in Maddu and Kabulasoke Subcounties are more of livestock keepers. The goat breeds kept include Boer, Boer crosses and indigenous breeds. Heavy reliance on anthemintics for worm control is common on these farms. The district receives little precipitation in two seasons; the relatively, long rains between March to May and short rains from October to December (Mpigi District Forest Department, 1997). Figure 1 is the map of Uganda showing Gomba district and an extract of the study Sub-counties.

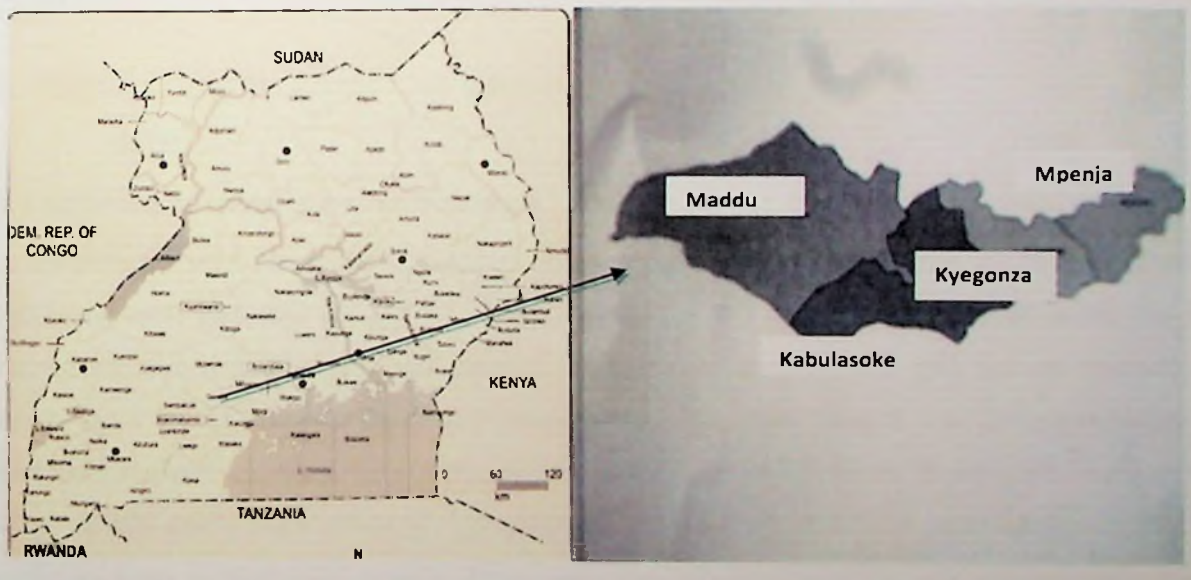


Figure 1: Map of Uganda indicating location of Gomba district (bold arrow) adopted from UCC. (2011)

3.2 Study animals

The study involved naturally infected goats in 3 commercial farms in Gomba District, Central Uganda. Both males and female goats aged between 3-12 months old were studied. Aging of the goats was based on farmers' records coupled with dental examination (Oltenacu, 1999). The goats were mainly indigenous Ugandan goats (the Small East African) or their crosses with the South African Boar goat grazed on natural and non-paddocked pastures in a predominantly woodland vegetation with shrubs for browsing. The average flock size in the 3 farms was 300 goats.

3.3 Sample size calculation

Sample size was calculated on the assumption that nematode prevalence was 50%, hence the sample size was calculated using the formula;

$$N = \frac{t^2 p(1-p)}{m^2}$$; (Kish and Leslie, 1965)

Where; N= required sample size, t = confidence level 95% (1.96), p = estimated prevalence for Gomba district (44.8%) according to Magona and Musisi (1999) and m = margin of error 5% (0.05)

$$N = \frac{(1.96)^2 \times 0.448 (1- 0.448)}{(0.05)^2} = 380 \text{ goats}$$

3.4 Selection of study farms and animals

A list of farms with flock sizes of 100 goats and above was obtained from the district veterinary extension staff and this formed the sampling frame. The farms chosen were under the same management system (under open grazing management system) and had not de-wormed their flocks for 6 weeks before commencement of the study. From the list, one farm was selected in each of the three parishes by simple random sampling. In all, three farms with average flock sizes of 300 goats were selected. For purposes of subsequent follow-ups, fecal samples were collected from at least 50% of only young animals (3-12months) which are not normally sold off by farmers.

3.5 Collection and handling of fecal samples

Fecal samples were collected from the rectum of each goat. Sampling was done in the morning between 9 and 12 noon. About 5g of fecal samples were collected. The samples were placed immediately in thin polythene bags, labeled by animal tag and farmer's name, placed in a cool box containing ice-blocks and transported for laboratory analysis.

Figure 2: showing labeled of collected fecal

3.6 Laboratory analysis

3.6.1 Identification of nematode eggs

The flotation technique was used in the identification of the nematode eggs (Hansen and Perry, 1994). The floatation solution was a saturated solution prepared by mixing 400g of common salt (Sodium chloride) in 1litre of water. The McMaster technique was used in the determination of fecal egg counts (Hansen and Perry, 1994). Fecal egg counts were done by mixing 3g of fecal sample in 42 ml of saturated salt solution and placing a drop of it in the chambers of the McMaster. The egg counts were done by counting all the floating nematode eggs in one field of the McMaster chambers and multiplied by 100.

3.6.2 Identification of nematode larvae

Fecal samples from all goats on all the farms were mixed in equal proportions (2 g from each animal). Little water and wood saw were added to provide for aeration and the mixture was incubated at 27° C for 7 days. The eggs hatched into larvae which were then extracted using Baermann technique (M.A.F.F., 1986). This technique involved wrapping incubated fecal samples in gauze placed in a wire mesh and then immersed in water in a funnel set on a stand. The Apparatus was left to stand for 24 hours overnight at room temperature, after which the larvae were extracted by releasing the clip at the tip of the funnel to let a few drops of

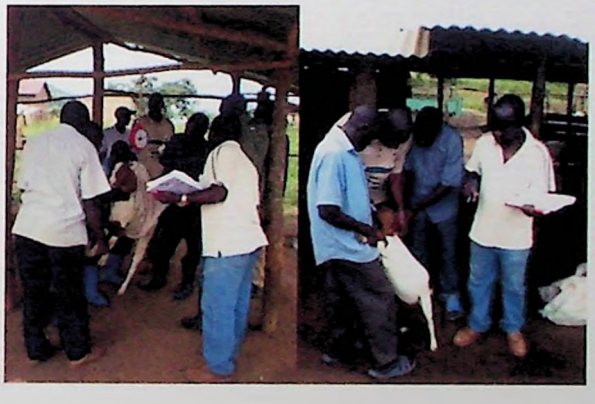
supernatant containing larvae. The extracted larvae were stained with lugol's iodine and then examined microscopically using x 5 objective. The larvae were differentiated according to their distinct characteristic morphological structures (MAFF, 1986).

3.7 Assessment of the efficacy of levamisole, albendazole and ivermectin on common GIN parasites

On-farm experiments were set on commercial goat farms in Gomba district. The Anthelmintic efficacy of Albendazole, Levamisole and Ivermectin against common goat gastrointestinal nematode infections was determined. The drugs used were purchased from local drug shops and were all broad spectrum drugs but had different modes of action.

3.7.1 Grouping and treatment of experimental goats

Fecal egg counts were done on samples from all goats within the age bracket of 3-12 months. Only goats with egg counts above 200 eggs per gram (epg) of fecal sample (n = 93) were chosen for experimental treatments as illustrated in Table 1. All goats in each study farm were treated but samples for analysis of drug efficacy were collected from only the tagged goats. Commercially available anthelmintic drugs from local pharmacies were used but for purpose of confidentiality, the brand labels are not indicated in this study.



(a) (b)

Figure 3: showing the weighing (a) and treatment (b) of experimental goats

Table 1: Experimental treatments

Group	Treatment	Dose (mg/kg of body wt)	Dosage route	No. of goats
1	Control (5% dextrose)	50	Oral	24
2	Albendazole (10%)	10	Oral	21
3	Levamisole (1.5%)	15	Oral	30
4	Ivermectin	0.2	Sub-cutis	18
TOTAL				**93**

3.7.2 Collection of fecal samples after treatment

After anthelmintic treatments, fecal samples were collected from each experimental goat on days 7, 14 and 21 post treatments. About 5 grams of feces was collected from the rectum using a gloved index finger. Each sample was put in a transparent plastic bag and the open end of the bag tied to keep the sample secure. The bags were put in a cool box containing ice packs before being transported to the laboratory at the National Livestock Resources Research Institute, Tororo Uganda within six hours from collection. All samples were collected between 9-10 am just before the goats were released for grazing each morning.

3.7.3 Fecal egg counting and determination of anthelmintic efficacy

In the lab, about 2 grams of each fecal sample was scooped and subjected to fecal egg counting using a modified McMaster technique (Kaplan and Miller, 2006). The McMaster has two chambers which are employed during fecal egg counting. The method of egg counting involves placing drops saturated solution of fecal material under the two calibrated chambers. The suspension is left for about 30 seconds to settle in which the worm eggs float on top of the chamber fields and are counted to determine the number of worm eggs per gram of fecal sample. Egg counts for each goat were noted before treatment and days 7, 14 and 21 after treatment. To determine anthelminthic efficacy (resistance), the geometric mean egg counts for each treatment group was computed and used to estimate fecal egg count reduction (FECR) using the formula described by described by Varady *et al.*(2004):

$$FECR = 1 - \frac{T_1}{T_2} \times 100$$

Where, T_1= post-treatment egg

T_2= pre-treatment epg

3.7.4. Identification of resistant nematodes

Each of the 3 gram samples that remained after scooping for McMaster analysis were pooled an incubated at 27°C for 10 days. The hatched larvae (L_3) were extracted using the Bearmann technique (Foreyt 2001) and examined under x 5 objective of a light microscope (Zeiss®, West Germany). The different nematode larvae were identified based on peculiar morphologic characteristics.

3.8 Identification of farming practices that lead to development of anthelmintic resistance.

This was done by carrying out farmer interviews using structured questionnaires. The study sought to obtain a general picture of people's goat husbandry practices, their knowledge of the anthelmintic drugs and drug administration. The study also sought to know how farmers' accessed information on worm control. The survey was done with the help of the district extension staff who provided a list of farms in Maddu and Kabulasoke Subcounties of Gomba district. The list of famers given had flocks of between 15 - 300 goats. From the two selected sub-counties, 27 goat farmers were randomly selected from Maddu, while 34 farms came from Kabulasoke Sub-counties respectively. A predetermined checklist of questions on husbandry practices, drug use and access to information on worm control was used (details are in the designed questionnaire in the appendix).

3.9 Statistical analysis

Data obtained from questionnaire interviews was subjected to a general linear model (GLM) analysis using SPSS. Descriptive statistics were generated using the frequency functions of excel. Association between egg counts and farm, breed, age, and sex of the goats were done using T-tests to compare mean values for fecal egg count reductions using SAS, Version 2010). The p-values less than 0.05 were considered significant.

CHAPTER FOUR
RESULTS

4.1 Common GIN parasites

The overall prevalence for Gomba district was 43%. Average prevalence on the two farms in Maddu subcounty (Farm 1 in Kyayi parish with 30% prevalence and Farm 2 in Maddu parish with 56% prevalence) was 43%. Prevalence for Farm 3 in Kabulasoke parish, Kabulasoke Subcounty was 43.4%. The prevalence results are summarized in the Table 2.

Table 2: Prevalence of GIN parasites in goats

Sub-county	No. of farms selected per Sub-county	Parish/farm name	Farm identification No.	Total number of goats examined	Number of goats infected	Prevalence (%)
Maddu	2	Kyayi	1	213	64	30
		Maddu	2	125	70	56
Kabulasoke	1	Kabulasoke	3	152	66	43.4
Total	**3**	**3**		**470**	**200**	**43**

4.1.2 Fecal egg counts amongst goats before treatment

The mean epg for the three farms were; farm 1 in Kyayi (epg = 377), farm 2 in Maddu (epg = 484) and farm 3 in Kabulasoke (epg = (358). The epg was significantly higher ($t = 2.3$, $p < 0.02$) in Maddu compared to Kabulasoke farm as shown in Figure 4 and Table 3.

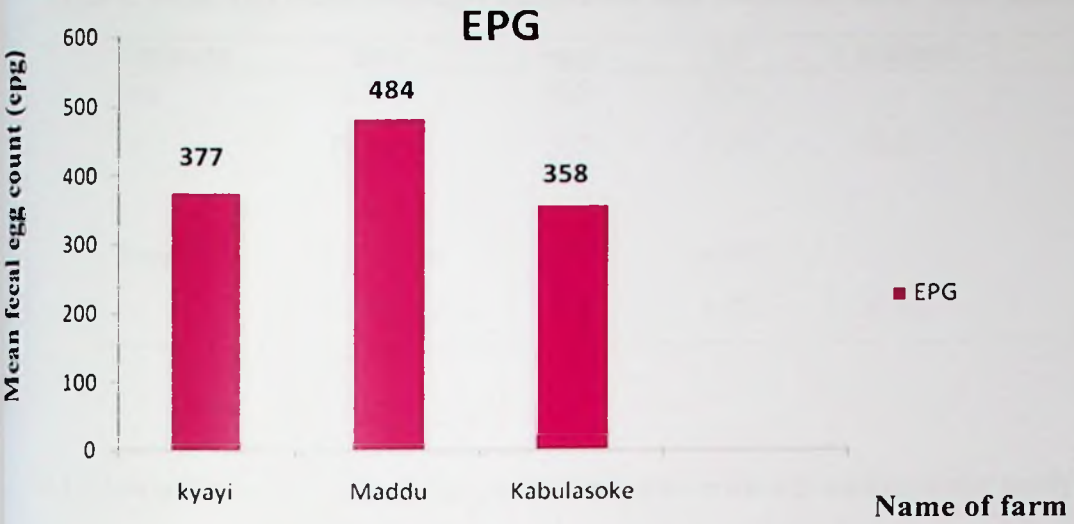


Figure 4: Comparison of mean egg per gram amongst goats on different farms before treatment

Table 3: Comparison of worm burden in goats on different goat farms before treatment

Farm name/code	egg per gram	Standard error	t- test	p- value
Kyayi (1)	377	± 45.0	-	-
Maddu (2)	484	± 50.0	1.68	0.097
Kabulasoke (3)	358	± 43.0	0.32	0.75
Maddu (2)	484	± 50.0	-	-
Kabulasoke (3)	358	± 43.0	2.3*	0.02*

Mean epg was significantly higher in farm 2 compared to farm 3 (t= 2.3* p= 0.02*)

4.1.3 Egg counts amongst indigenous and Boer cross bred male and female goats

The mean epg was higher in males (epg = 420 ± 51) than in females (epg = 392 ± 28). The difference was however not statistically significant (t= 0.51, p = 0.61).

The mean epg for indigenous goats was not significantly higher (414 ± 43) than in Boer cross bred goats (epg = 398 ± 37), (t = 0.32, p = 0.75).

The results of the mean epgs for the male and female indigenous and Boer cross bred goats are summarized in Table 4.

Table 4: Mean egg count amongst indigenous and Boercross bred male and female goats.

Attribute	Sex	epg	SE	t- statistic	P- value
Sex	Male	420	± 51	-	-
	Female	392	± 28	0.51	0.61
Breed	Boer cross	398	± 37	-	-
	indigenous	414	± 43	0.32	0.75

4.1.4 Variation in mean fecal egg per gram count with age amongst the study goats

The mean egg per gram counts of goats decreased with age up to six months but, the decrease at 6 months was very significant (from 353 to 254). Goats of 6, 7 and 8moths had mean egg per gram counts of (254), (326) and (302) respectively (Figure 5). These mean epgs at 6 and 8 months were significantly lower ($p = 0.008^*$ and 0.023^*) compared to those of goats between 3- 5 months and those above 8 months as summarized in Table 5.

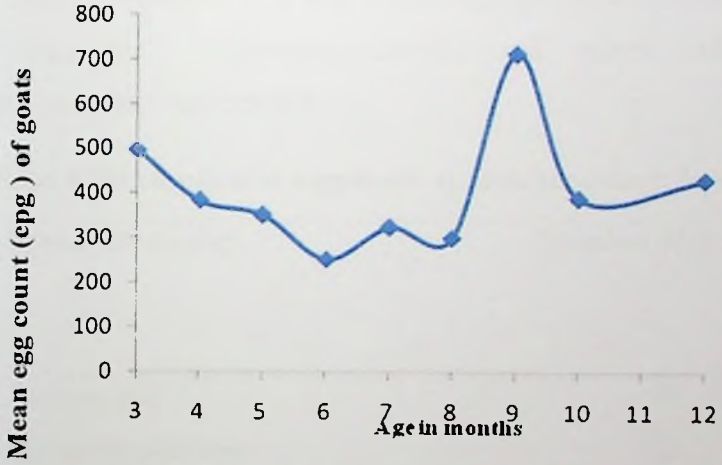


Figure 5: Variation in mean fecal egg per gram count with age amongst the study goats

The highest rise in epg occurred 9 months.

Table 5: Variation in mean fecal egg per gram count with amongst the study goats

Age (months)	Mean epg	Standard error (SE)	age comparison	t-statistic	p-value
3	498			-	-
4	385	± 60	3 verses 4	1.39	0.17
5	353	± 61	3 verses 5	1.69	0.09
6	254	± 61	3 verses 6	2.69	**0.008***
7	326	± 74	3 verses 7	1.85	0.068
8	302	± 67	3 verses 8	2.23	**0.023***
9	713	±109	3 verses 9	1.77	0.080
10	391	± 117	3 verses 10	0.82	0.41
12	431	± 56	3 verses 12	0.86	0.39

Mean egg counts was significantly lowest in 6 and 8 month old goats (**p = 0.008*** and **p = 0.023***) respectively.

4.1.5 Distribution of nematode species recovered from pooled coprocultures

A total of 72 nematode larvae were isolated from pooled fecal samples. Of these, 56%were *Haemonchus larvae*, 33% *Oesophagostomum* and 11% were *Strongyloides* (Table 6).

There are Figures 6, 7, 8 and 9 showing photomicrographs of nematode larvae of *Haemonchus, Strongyloides, Oesophagostomum* and mixed infection due to *Haemonchus* and *Oesophagostomum* respectively.

Table 6:Distribution of nematode species recovered from coprocultures before treatment

Nematode species	Number identified	Percentage composition (%)
Haemonchus	40	56
Oesophagostomum	22	30.6%
(Haemonchus +Oesophagostomum)	2	2.78
Strongyloides	8	11%
Total	**72**	**100**

Figure 6: Photomicrograph showing a typical Haemonchus larva.

Note the characteristic kinked tail (short arrow) with a sheath (long arrow) typical of *haemonchus species*.

Figure 7: Photomicrograph showing *Strongyloides larva*.

Note the characteristic short tapering unsheathed tail (**bold arrow**) typical of *Strongyloides species*

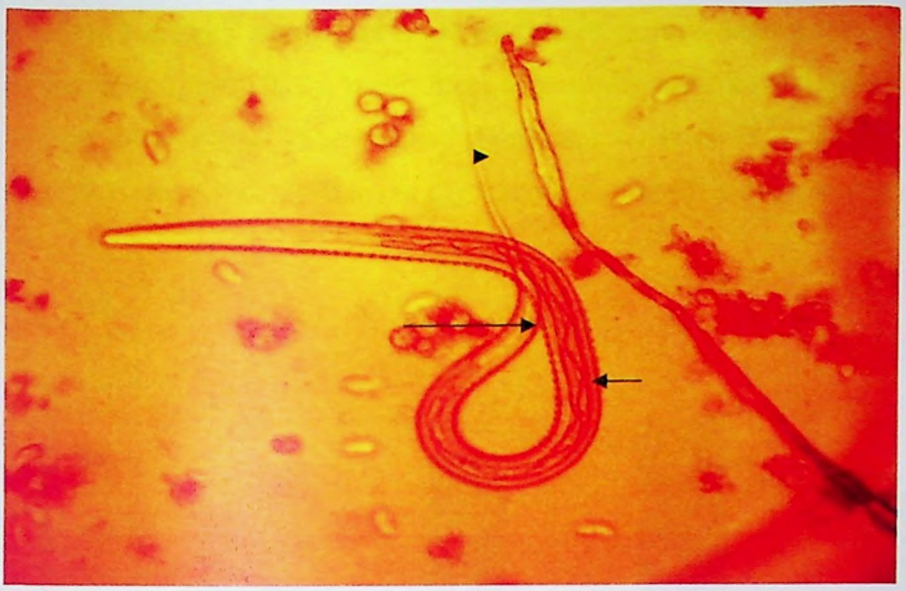


Figure 8: Photomicrograph showing *Oesophagostomum larva*.

Note the characteristic pentagonal gut cells (**bold short arrow**) and the long tail (**bold arrow head**) with a sheath (**bold long arrow**).

Figure 9: Photomicrograph showing mixed infection with *Haemonchus* (▸) and *Oesophagostomum species* (→)

4.2 Mean fecal egg counts amongst treatment groups before treatment

As shown in figure 10, the mean fecal egg counts amongst the groups before treatments ranged between 350-418 epg. There was no significant variation ($R^2 = 0.60$, $p > 0.05$). Alb. $p = 0.8$, Lev $p = 0.59$, iverm $p = 0.32$) in mean egg counts amongst the treatment groups before treatments.

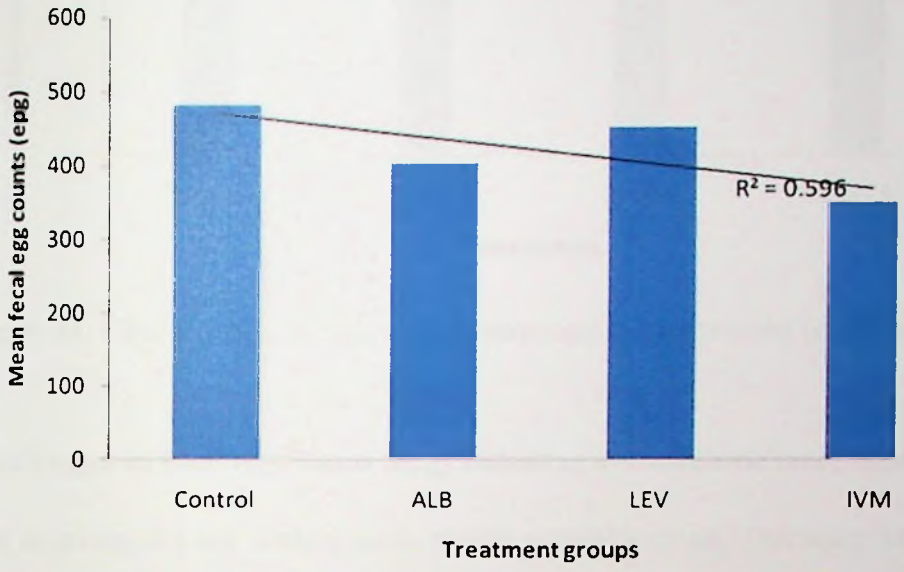


Figure 10: Mean fecal egg counts amongst treatment groups before treatment

4.3 Changes in mean fecal egg counts amongst the untreated (control) goats

The mean fecal egg counts amongst the untreated (control) goats ranged between 381-532 epg over the 21 day study period. There was variation in egg counts amongst the untreated goats during the period (Figure 11). This variation was however not statistically significant ($R^2 = 0.003$, $p > 0.05$).

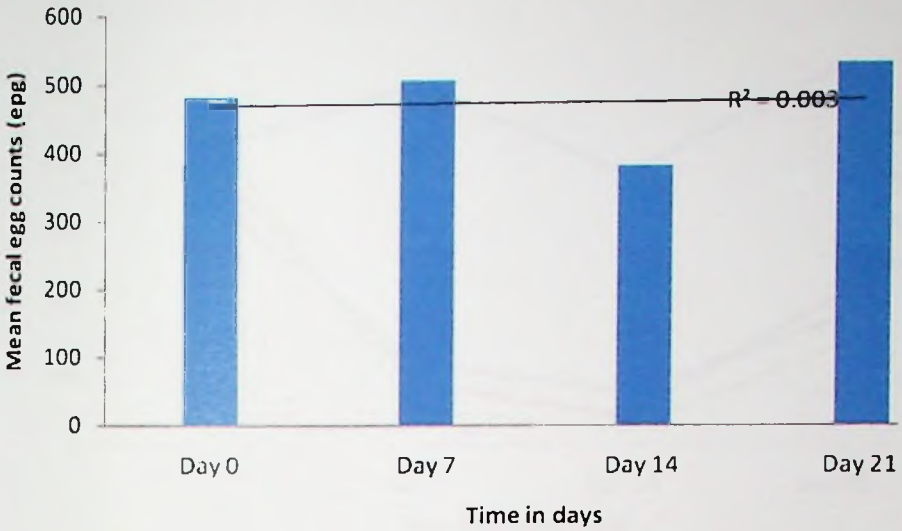


Figure 11: Changes in fecal egg counts amongst the untreated (control) goats

4.4 Changes in fecal egg counts (epg) following anthelmintic treatment

The mean epg for the control goats stayed generally steady (between 381-532 epg) throughout the study period. However, mean epg in all treated goats sharply declined from above 380 epg to mean epg of 23, 40 and 73 for levamisole, albendazole and ivermectin treated goats respectively, by day 14 (Figure 12). After day 14, the mean epg for all treatment groups started rising but remained below 200 epg except for the albendazole treated goats.

Throughout, the 21 days, mean epg (range 23-209) in all treatment groups remained significantly ($P = 0.02$) below the mean epg range (350-418) for the control group (Table 7)

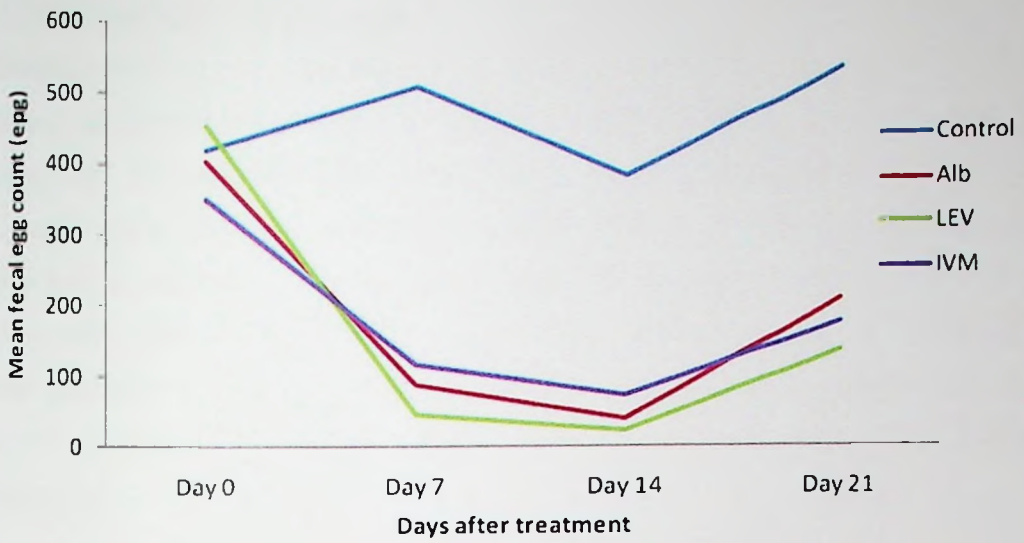


Figure 12: Variation in mean fecal egg counts following anthelmintic treatment

Table 7: Variation in mean fecal egg counts following anthelmintic treatment

Agent	Time after treatment	Mean egg counts (epg)	t-statistic	P-Value
Albendazole	Day 0	418		
	Day 0 Vs. Day 7	88	4.68	0.001
	Day 0 Vs. Day 14	40	3.83	0.003
	Day 0 Vs. Day 21	209	3.16	0.002
Levamisole	Day 0	452		
	Day 0 Vs. Day 7	45	6.30	0.001
	Day 0 Vs. Day 14	23	4.80	0.001
	Day 0 Vs. Day 21	136	3.90	0.002
Ivermectin	Day 0	350		
	Day 0 Vs. Day 7	116	3.95	0.002
	Day 0 Vs. Day 14	73	2.93	0.004
	Day 0 Vs. Day 21	176	3.20	0.002

4.5 Efficacy of anthelmintic agents

Percentage efficacy of Albendazole, levamisole and ivermectin is shown in Table 8. The efficacy of albendazole was 82%, 80% and 61% at days 7, 14 and 21 days post treatment, respectively. The efficacy of levamisole on the other hand was 95%, 91% and 69% on the same respective days. That of ivermectin was 85%, 84% and 81% over the same treatment days, respectively. Generally, efficacy was highest for levamisole (85%), followed by ivermectin (83%) while albendazole (77.3%) was the least efficacious over the entire treatment period. There was however, a shaper decline in efficacy of levamisole and albendazole between days 14 and 21 compared to ivermectin which relatively steady in efficacy throughout the 21 days (Figure 12).

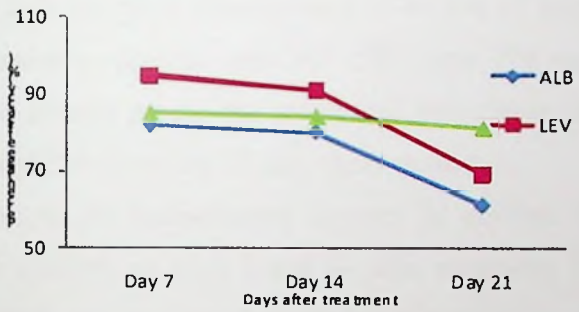


Figure 13: Mean efficacy of albendazole, levamisole and ivermectin over the treatment period

Table 8: variation in % efficacy following treatment with albendazole, levamisole and ivermectin

Agent	Percentage efficacy (FECR %)			Mean percentage efficacy (%) over the study period
	Day 7	Day 14	Day 21	
Albendazole	82	80	61	77.30
Levamisole	95	91	69	85.00
Ivermectin	85	84	81	83.03

4.6 Prevalence of GIN parasites recovered from fecal cultures after treatments

Following culturing, nematodes belonging to the genera *haemonchus* and *oesophagostomum* were recovered (Table 9). Amongst the control goats, the prevalence of *haemonchus species* was 75, 50 and 25% on experimental days 7, 14 and 21 respectively. Conversely, the prevalence of *Oesophagostomum species* was 42, 58% and 0% respectively on the same days. Overall, amongst the control goats, the respective prevalence for *Haemonchus* and *Oesophagostomum* were 50% and 33% over the 21 day study period.

The prevalence of *Haemonchus species* in pooled fecal samples from goats treated with albendazole was 0% on days 7 and 14 after treatment. However, on day 21, the prevalence was 9.5%. No (0%) was recovered in pooled samples from levamisole and ivermectin treated goats within 21 days.

Table 9: prevalence of nematode larvae in fecal cultures following anthelmintic treatment

Anthelmintic Agent	Nematode species	Prevalence (%)			Mean Prevalence (%)
		Day 7	Day 14	Day 21	
Control (n = 24)	*Haemonchus*	18 (75%)	12(50%)	6(25%)	50.0%
	Oesophagostomun	10(42%)	14(58.3%)	0 (0%)	33.3%
Albendazole (n = 21)	*Haemonchus*	0	0	2(9.5%)	3.2%
	Oesophagostomun	0	0	0	0.0%
Levamisole (n = 30)	*Haemonchus*	0	0	0	0.0%
	Oesophagostomun	0	0	0	0.0%
Ivermectin (n = 18)	*Haemonchus*	0	0	0	0.0%
	Oesophagostomun	0	0	0	0.0%

4.7. Drugs and drug administration practices

Albendazole was the most commonly used anthelmintic (97%). Only 3% of the farmers used levamisole and none used ivermectin. Majority of the farmers (71%) began treatment at 3months and above, while 19% commenced treatment at 2 months and only 10% at 1month. The drenching gun was used by most of the farmers (84%) in administering the anthelmintics, while very few farmers (13%) used syringes and only 3% used bottles. Sixty seven percent (67%) of the farmers did self treatment of their herds and only 33% called upon veterinary extension staff to do it for them. Dose determination in majority of the farmers (94%) was done using the weight of the animal, while only 6% of the farmers used age of the animal. The weight of the animal to be treated was estimated using visual appraisal in 97% of the farmers surveyed, while 3% of the farmers used weighing scale or tape-measure. Majority of the farmers (48%) de-wormed their animals every 3months, 16% every after 2 and 6 months, while 13% and 7% did it every 4 and 6months respectively. Few farmers (32%) altered anthelmintics, while the majority (68%) did not. Of the farmers who altered the drugs, 39% did it every month, 36% every 6 months and only 6% did it every year. On the issue of whether the drugs were working or not, most of the farmers (87%) said the drugs were working, while 13% said drugs were not working. The summery of

the perceived risk factors associated with drugs and drug use that could lead to reduction in anthelmintic efficacy is given in Table 10

Table 10: Drug use practices that may lead reduction in anthelmintic efficacy

Common drugs used	Albendazole (97%)	Levamisole (3%)	Ivermectin (0%)
Commencement of treatment	3 months (71%)	2 months (19%)	1 month (10%)
Method of drug administration	Drenching gun (84%)	Syringes (13%)	Bottles (3%)
Who does treatment	Farmer (67%)	Extension staff (33%)	-
Dose determination depended on	Animal weight (94%)	Animal age (6%)	-
Method of wt determination	Visual (97%)	Weighing scale (3%)	-
Frequency of de-worming	Every 3 to 4 months (61%)	Every 2 months (16%)	Every 6 months (23%)
Alternation of drugs	Alternated (32%)	Not alternated (68%)	-
Whether drugs work or not	Drugs work (87%)	Drugs don't work (13%)	-

4.8 Access information on worm control

Most farmers (97%) had access to information on worm control. Only 3% had no access to information on worm control. Of those who had access to information on worm control, 42% obtained information from extension staff, 32% from media, 23% from farmer groups and 3% from friends. For those who had access to information, 39% could access it all the time, 32% once in 3 months and 29%, every month. Of the farmers that accessed information on worm control, 74% said the information was relevant while 26% of them thought the information obtained was not important (summery in Figure 14).

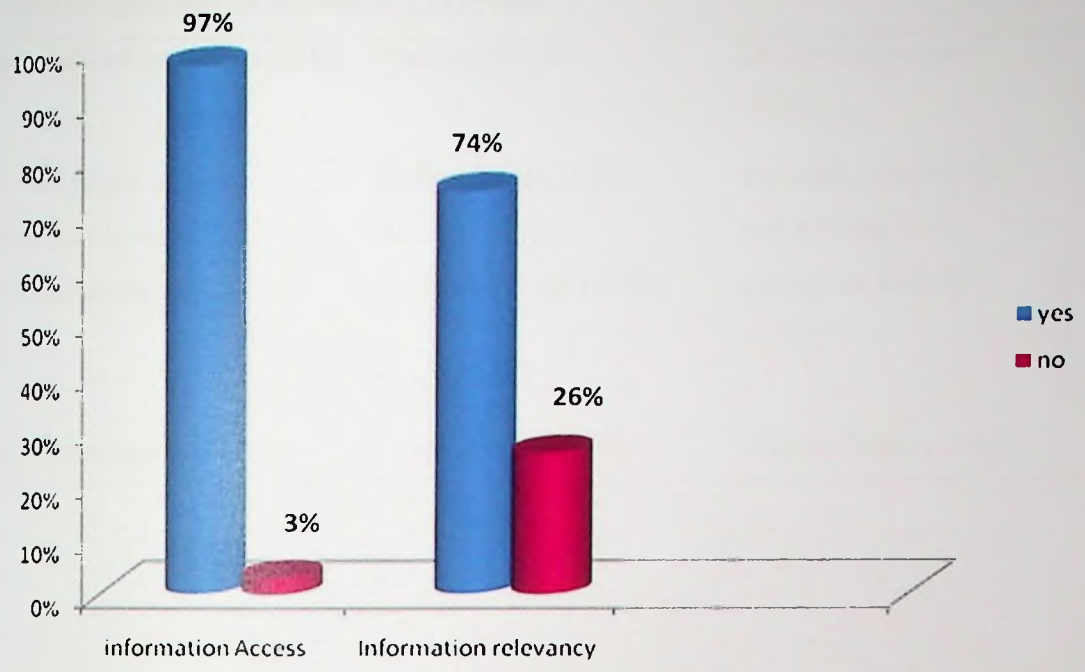


Figure 14: Showing access to information on worm control

4.9.0 Husbandry practices

Sixty eight (68) percent of the farmers segregated goats from cattle, while 32% did not. Regarding the time of release of goats, 58 % of all the farmers surveyed released their goats before 10 am, while 42% did it after 10 am. On the issue of housing, only 29% of the farmers had raised goat houses, while the majority (71%) had non-raised goat houses. On litter management, majority of the farmers (48%) removed litter from goat houses on daily basis, 32% weekly, while 13% did it occasionally and 7% never removed litter from their goat houses at all. Of those farmers that removed litter from goat houses, 48% of them disposed it directly into the grazing pasture, while the rest (52%) disposed it outside the grazing pasture. On grazing management, majority of the farmers (80%) grazed their animals on open grazing land, while only 20 % confined their animals on fenced farms (The results are summarized in Figure14)

Table 11: Summery of husbandry practices

Segregation of animals species	Segregated (68)	Did not segregate (32%)	-
Time of release of goats	Before 10 am (58%)	Beyond 10am (42%)	-
Raised goat houses	Raised (29%)	Not raised (71%)	-
Litter management	Removed daily (48%)	Removed weekly (32%)	Removed occasionary (13%)
Grazing management	Open grazing (80%)	Fenced farms (20%)	-

CHAPTER FIVE

DISCUSSION

Common GIN in goats

A mean prevalence of 43% GIN infection was recorded in the current study. This was low compared to the mean prevalence of 53.7% reported by Magona and Musisi (1999) in their experiment on the small East African village goats in Mbale district, Eastern Uganda. Prevalence of 95% GIN infection rates was reported among goat flocks in the tropics and 62% prevalence in Kenya (Nganga *et al.*, 2004 and Meingi *et al.*, 2001). The difference in the prevalence between the study by Magona and Musisi (1999) in Mbale district and the current one could be due to the differences in the vegetation nature and the worm control practices. The Eastern region of Uganda where Mbale district is located is covered by savannah grassland type of vegetation. In Eastern Uganda, farmers are limited by land size because of the high human population. So, most of the farmers keep goats by tethering and the goats used by Magona and Musisi (1999) were also tethered. Tethered goats graze on the same grass with possibility of continuous picking of worm larvae from the contaminated grass where the goat was confined. This is opposed to Gomba district which had large open grazing land covered by woody vegetation which is not contaminated by worm larvae. Browsing is reported to lower GIN burdens in goats by reducing the intake of infective larvae from pastures close to the ground (Kabasa *et al.*, 2000). Some browse plants were also reported to contain substantial amounts of crude protein and condensed tannins that enhance the goats' nutrition and their ability to resist development of or the effects of helminthes infections (Kabasa *et al.*, 2000). Condensed tannins in some plants had nematocidal properties against free-living nematodes (Chandel and Mehta 1990), and grazing goats on such forages (Niezen *et al.* 1995) will control GIN or improve the nutritional status of GIN-infected animals. It is therefore important that farmers preserve the browse plants in their goat farms as a strategy for controlling of helminthosis.

Magona and Musisi (1999) also reported that, very few farmers (6%) dewormed their goats. This was also reported by Kusiluka and Kambarage (2006) that small farmers were unlikely to spend their small income to purchase drugs for regular treatment as opposed to the rich farmers who

had the resources. This partly explains the higher prevalence of the worm burden in the study that was done in the poor communities of Mbale as compared to the present study area, with big average flock sizes of 300 goats on open pastures with less contamination. Nwosu *et al.* (2007) also observed that the economic status of the farmers and the management standard affects the prevalence of GIN infections on a farm. Large scale farmers are very cautious about the health of their flocks and it was likely that these farmers with big herds did treat their flocks quite more often than the smallholder poor farmers. In fact the very low prevalence of 30% was suggestive that the farmers had treated their flocks and told lies that, they had not treated the previous 6weeks before our intervention just to get our attention to their goat herds. The study revealed that farmers in the current study area often treated their flocks. It was advisable that the veterinary extension staff increase awareness among the farmers on the strategic use of these drugs to preserve their effectiveness.

In this study the GIN infection prevalence was relatively higher in young goats compared to the older ones. The results of this study were supported by studies done by Nganga *et al.* (2004), in Dorper lambs in the semi arid area of Kajiado district. They observed higher infections among young lambs compared to the older ones. They attributed low prevalence of GIN in older animals due to development of significant immunity. Similar findings were also reported by Tasawar *et al.* (2010). They also observed that young animals were more susceptible to nematode parasite infections. The reason for the similarity was due to young animals having defective protective immunity against worm infections. However, in this study, peak prevalence was observed at 9 months. This differed from observations made by Nganga *et al.* (2004) that, resistance against GIN infections in lambs increased up to 12 months. There could be difference in the age at which maximum immunity to helminths infection was developed between goats and sheep, but this needed further investigations. For this study it could be deduced that goats at puberty were susceptible to helminths infection as the young ones. This may be explained by the fact that sex hormones which are released when the animal reaches puberty lower the immunity of the animal. It was therefore advisable that farmers pay more attention in terms of health care on the young stages (3-5) months and the juveniles (8-10) month old goats. This is because of their increased vulnerability to GIN infections compared to other stages.

The breed of the animal had no significant effect on the prevalence of GIN infections in the goats in the current study. This however contradicted with what was reported by Barker *et al.* (2003), that the indigenous animals (Red Maasai sheep) were more resistant and resilient to *H. contortus* than Dorper and other exotic sheep breeds. There was a belief that indigenous animal breeds had genetic resistance to helminth infections as compared to the exotics or their crosses with the indigenous (Kusiluka and Kambarage, 2006). The difference in the results of the present study could be due to the less number of indigenous animals used. Further studies need to be carried out to verify these findings.

Sex-wise, the results of the present study differed from what was observed by Lashari and Tasawar (2011) that prevalence of GIN infections was more in males than females. The difference in the observations could be due to the smaller number of male goats used in the present study. From these findings, it was advisable that farmers treated all animals in their flocks irrespective of their sexes and breeds so that, the whole flock could be kept under controlled levels of worm infestations.

Common GIN worm species

Haemonchus larvae were the most predominant species in the pooled fecal cultures followed by *Oesophagostomum* and *Strongyloides* as the least (Table 5). This was in agreement with Akhter *et al.* (2011) study on prevalence of GIN in goats in Hyderabad, Pakistan and adjoining areas where they found that *Haemonchus* was the most predominant nematode species while *Strongyloides* was the least prevalent. Similar observations were made in Kenya by Nganga *et al.*, (2004). They observed that in most gastrointestinal infections in small ruminant in the tropics were predominated by *Haemonchus* and *Trichostrongylus.* The possible explanation for the predominance of *Haemonchus* nematode parasites lay in the fact that they have a high biotic potential such that they can establishment very rapidly as long as the temperature and moisture conditions that favour their survival are present. Other nematode *Trichostrongylus species* have a lower biotic potential and hence, their establishment is slower. Even in mixed infections, *Haemonchus* easily out-competes other nematode species and becomes predominant. This is so because its multiplication rate determines the rate of establishment and hence the size of the nematode burden in the host. The rate at which multiplication of the parasite occurs in the host

and is determined by the reproductive capacity (fecundity) of the adult worms, the incubation period, the survival and the rate of development of the parasite in the environment.

Mixed infections with *Haemochus* and *Oesophagostomum* were observed in the current study. Similar findings were reported by Magona and Musisi (1999) where mixed infections involved *Haemonchus, Oesophagostomum, Bunostomum, Cooperia, Trichostrongylus species* and *Nematodirus specie*. Akhter *et al*. (2011) also found mixed infections involving *Haemonchus* and other nematode parasites in goats. Similar reports were recorded by Kusiluka and Kambarage (2006) that, most common field infections of gastro-enteritis in small ruminants were due to additive pathogenic effects of several nematodes, with differences in predilection sites and pathogenetic mechanisms. Hence, in many instances, GIN infections present with differing clinical and pathological features. The similarity in the findings of the present study and those of others may be due to similarities in the environmental conditions that enhance survival of *Haemonchus*. In the tropics and subtropics, rainfall is the only limiting environmental variable for *Haemonchus* and other nematode parasite development, since temperatures are always high enough to facilitate their development process and survival on pastures. Consequently, the humid tropical environment of Gomba district enhances the survival of *Haemonchus* on pasture all year round. It is important therefore to consider control measures targeting *Haemonchus* so as to reduce its effects on goat herds.

Worm burden in goats

The mean square epg for the three farms ranged between 358-484 epg and among the different farms and the worm burdens were significantly higher ($t= 2.3$, $p = 0.02$) in Maddu compared to Kabulasoke farm. These were very low compared to the mean fecal egg counts of between 870 and 3563eggs per gram reported by Magona and Musisi (1999) among the small East African goats in the villages of Mbale district, Uganda. The possible explanation for this difference could be attributed mainly due to goats browsing than grazing, low stocking density and differences in hygiene management. In the current study, vegetation was woody shrubs which had very low levels of nematode larvae that may be picked by goats during browsing. Max *et al*. (2007), made similar observations that browsing goats on plants with anthelmintic properties reduced parasitic nematode burdens in goats. He also reported that poorly fed animals cannot tolerate as much

worm load as those that are well nourished. It is therefore important that farmers preserve such shrubs both for improvement of animal nutrition and for reducing worm burdens in the goats.

The current study also revealed low stocking densities and this was in agreement with findings of Bakht *et al.*, (2003). They identified one of the major causes for variation in worm burden in goats on different goat farms as differences in stocking densities. They observed that when small numbers of infected animals are kept on a given area, they will deposit less worm eggs than a large number on the same area. Overstocking also causes them to graze the grass more close to the ground, ingesting more larvae to increase their worm load. Also, rotating animals from one pasture to another, can allow time for worm larvae to die from age and heat exposure. The difference in worm burden in the present study compared to studies by others could be attributed to either the vegetation nature of Gomba or the season during which the study took place.

Considering vegetation, Gomba district is agro-pastoral with vast open range lands. Animals can therefore graze extensively on less contaminated pasture as opposed to areas with high stocking densities where contamination is high. It was therefore advisable that farmers maintain sufficient numbers to avoid overstocking which increases worm burden in their flock. If the season when the study was carried out is the cause of the differences in egg per gram count, then the dry season is the reason for the low egg per gram counts that were recorded in Gomba district.

The significant difference in the worm burden between Farm 2 and the other two farms was due to their relatively low standard of hygiene as compared the other two. This agrees with Bakht *et al.* (2003) that better sanitation was important for nematode parasite control as some GIN parasite gain access into the animal by skin penetration from the accumulated animal feces. It was advisable for farmers to do regular cleaning of goat houses and properly disposing goat manure to avoid contamination in the goat house. Famers should also ensure that manure does not contaminate water sources for the animals.

Anthelmintic efficacy of Albendazole, Levamisole and ivermectin

In the current study, the mean fecal egg counts amongst the control (untreated) goats ranged between 350-481 epg. The variation in egg counts among the untreated goats may be attributed

to the phenomenon of self-cure, which is an immune mechanism exhibited by resistant animal breeds against GIN infections, whereby established adult nematodes are expelled spontaneously when massive larval invasion occurs over a very short period, especially after rain (Hong *et al.*, 1989). These egg counts in this study were however much lower compared to mean egg counts of 2350 epg reported by Nalule (2011) in an experiment with the Small East African goats in Kampala, Uganda. Similarly, Waruiru (2002) reported worm counts of above 1500 epg in small East African goats in Kenya. A plausible explanation for the low egg counts for goats in the current study was that they were grazed on natural pastures with woody vegetation for browsing.

Conversely, in the experiments by Waruiru (2002) and Nalule (2011) the goats were grazed strictly on grass pastures. It has long been postulated that browsing influences the gastro-enteric nematode burdens in goats simply by reducing the intake of infective larvae from the ground herbage (Kabasa *et al.*, 2000). Additionally, browsed leaves tend to contain significant amounts of condensed tannins that enhance the goats' nutrition and thereby their ability to resist development of or the effects of helminthes infections (Kabasa *et al.*, 2000). It was therefore advisable that farmers should ensure that there were browse plants in their goat farms as a strategy against helminthosis.

In this study, the egg counts amongst treated goats ranged between 23-209 epg throughout the 21 day study period. No group showed total absence (zero egg count) of nematode eggs after anthelminthic treatment. Nalule *et al.* (2011) also observed continued shading of nematode eggs at counts of 603, 23 and 11 epg on days 7, 14 and 21 respectively, after treatment with albendazole. In a related study in Kenya, Munyua *et al.* (2010) demonstrated continued egg shading in groups of goats treated with levamisole or albendazole with mean egg counts of 750 and 33 epg respectively, 14 days after treatment.

They however observed that the goats treated with ivermectin had no counts (0 epg) by the 14^{th} day after treatment. A similar observation was made by Bersissa *et al.* (2010) in southern Ethiopia. It may therefore be deduced from this study that much as albendazole, levamisole and ivermectin do significantly reduce nematode egg counts, continued shading of eggs in feces

following treatments was indicative of a possible parasite resistance against these drugs. This should be confirmed by a suitable genetic exploration (Gilleard and Beech, 2007).

It should however be noted that fecal egg counts were so significantly ($p<0.05$) reduced in all treatment groups compared to the control goats, hence the 3 drugs could still be considered effective against common GIN parasites in the study farms. According to Love and Hutchinson (2003), routine monitoring of fecal egg counts following de-worming was important in monitoring success of treatment regimes. In goats, if the mean egg count of a group was much above 100-150 epg 10-14 days following a de-worming, either the drug was not as effective as it should be or the egg count was very high when the animals were treated and was often a signal that further information about de-wormer effectiveness is needed. It may also indicate that the pasture on which treated goats were grazed could be heavily contaminated (Love and Hutchinson, 2003).

Amongst the treated goats, the mean percentage efficacies were: 85%, 83% and 77.3% for levamisole, ivermectin and albendazole respectively, over the study period. These were similar to reports made by Keyyu *et al.* (2002) who in a study with goats and sheep in Kenya, reported efficacies of 97% and 59.4% for levamisole and albendazole respectively. Conversely, Bersissa *et al.* (2011) reported albendazole and ivermectin efficacies of 100% against strongyle worms in southern Ethiopia.

The observed efficacies in this study were indicating a probable anthelmintic resistance against commonly used anthelmintic agents and the need to re-examine nematode control practices in commercial goat farms in Uganda and Gomba district in particular. It was generally accepted that failure of an anthelmintic agent to reduce the arithmetic mean egg counts by at least 90%, from the pre-treatment levels or from those of untreated controls 5-10 days later, was suggesting development of parasite resistance (McKenna, 1990; Jackson and Coop, 2000). Most cases of reduced efficacies of anthelminthic agents were often seen on commercial farms as opposed to smallholder units. This is usually attributed to heavy reliance on chemotherapy in the commercial farms (Vatta and Lindberg, 2006). The farms involved in this study were indeed commercial goat farms though the extent of prior drug usage was not considered. It was also

Worth noting that flock sizes matter in the development of reduced anthelminthic efficacy (Wanyangu *et al.*, 1996). Large herd size has been reported as a risk factor for the presence of resistance. Farmers with large flocks were more likely to be able to buy anthelmintic drugs (Wanyangu *et al.*, 1996). In the present study, the average flock size for each of the 3 farms was 300 goats, which in deed were considerably large.

Albendazole exhibited an efficacy of (77.3%) compared to levamisole (85%) and Ivermectin (83%). This is suggestive that albendazole was probably the most frequently or longest used anthelmintic in the study farms. Albendazole also acts against both adult and young stages of nematodes compared to levamisole and ivermectin which only act on mature stages (Handbook for the Control of Internal Parasites of Sheep and Goats – 2012). Appearance of larvae in Coprocultures 21 days post treatment was also suggestive of resistance developing against this drug. The general principal is that, effective chemotherapeutic control of parasites and preservation of drug efficacy were unfortunately mutually exclusive objectives (Vatta and Lindberg, 2006). This was because drug resistant nematodes were present in small proportions within a population even before introduction of an anthelmintic agent. Prolonged or too frequent use of a particular drug increases selection pressure for resistant individuals within a population (Vatta and Lindberg, 2006). In the absence of genetic confirmation, one needs to be cautious in interpreting efficacy data involving commercially available drugs given in poor countries, drug outlets often stock poor quality or even fake drugs (Wanyangu *et al.*, 1996; Monteiro *et al.*, 1998). However, at their current efficacies, judicious application of albendazole, levamisole and ivermectin in commercial farms in Uganda could still be sustainable. The farmers needed to be making the best use of these drugs so that their current efficacies were maintained for as long as possible while seeking alternative approaches that complement chemotherapy in their quest to control nematodes in goat flocks.

Nematodes larvae belonging to the genera *Haemonchus* (75%) and *Oesophagostomum* (42%) were recovered from fecal cultures of untreated goats. This finding relates to a recent report from Ethiopia that in goats, haemonchus species were recovered in significantly higher proportions than oesophagostomum and strongylus species (Bersissa *et al.*, 2011). Earlier, Okeyo *et al.*, (1996), reported that *Haemonchus contortus* was the major intestinal parasite responsible for

helminthiasis in Kenya. This was also observed by Okwee-Acai *et al.* (2010) in a commercial breeder goat farm in Uganda. A control strategy that specifically targets *Haemonchosis* would therefore be very useful in improving goat production in Gomba or Uganda in general. Such could include vaccination (Bakker *et al.* 2004; Ruiz *et al.* 2004) or selection for *Haemonchus* tolerance (Okeyo *et al.*, 1996).

Amongst the treated goats, *Haemonchus larvae* were recovered only from those treated with albendazole 21 days after treatment. This may be partly explained by the fact that albendazole had the least efficacy level compared to levamisole and ivermectin. Ivermectin is also generally known to be more persistent in mammalian tissues than levamisole or albendazole, hence more long acting (Chiu *et al.*, 1987). Ivermectin has been reported to persist in mammalian tissues for up to 35 days after treatment (SRVO, 2012)

Besides, studies have shown that fecal samples from animals treated with ivermectin supports a significantly reduced invertebrate diversity (Iglesias *et al.*, 2006). Additionally, better and sustained performance by levamisole may also be attributed to the fact that levamisole treatments tend to improve non-specific immunity of treated subject (Mitchell and Armour, 1981). This makes the treated animals more resistant even to helminths (Mitchell and Armour., 1981). It may be implied from this study that goats treated with albendazole may resume pasture contamination with infective nematode larvae sooner than those treated with levamisole or ivermectin.

Nematode control practices in Gomba district

Survey results from farmer interviews on whether they changed the type of Anthelmintic used on the farm or not revealed that, 68% of them did not change. However, when farmers were asked which anthelmintic they were using on their farms, 97% of them mentioned albendazole as the drug they most frequently used. This was followed by levamisole (3%). Ivermectin was not used by both the veterinary officers and farmers because of its high cost of administering it. The present study results were similar to Bersissa *et al.* (2010) findings when studying on comparative efficacy of albendazole, tetramisole and ivermectin against gastrointestinal nematodes in naturally infected goats in Southern Ethiopia. They reported benzimidazoles and avermectins as the most and least frequently used anthelmintics. Ngiyi *et al.* (2005) also reported that benzimidazoles and levamisoles were the most commonly used drugs in the coastal

lowlands of Kenya. They also noted that ivermectin had not been used among the smallholder farms. There was a low level of awareness of the veterinary extension staff and goat herd owners of the consequences of prolonged use one type of anthelmintic. This was also reported by Maingi *et al.* (1996) and Lendal *et al.* (1998) in Kenya where, there was a lack of exact knowledge among herd owners and veterinary healthcare personnel about the proper control of endo-parasites so as to preserve the efficacy of these drugs. Non-alternation of anthelmintic classes lowers the efficacy of the drugs thus leading to drug resistance (Anonymous, 1998; Coles and Roush 1992; Lloyd *et al.*, 2000). This could be the reason for the low efficacy of albendazole as compared to ivermectin and levamisole in the field efficacy evaluation study (chapter 4). It was advisable that farmers in a particular area used one drug type for a given period for example one year and then change over to another class so as to preserve their effectiveness for a longer time. Despite the presence of the government veterinary extension services in the study area, very few farmers (33%) called for a husbandry officer during the de-worming of their flocks. Majority (67%) of the farmers did flock treatment themselves and they did it with a drenching gun (84%). A big number of the farmers (94%) determine the dose to be administered basing the animal weight. This was determined using visual appraisal in 97% of the farmers interviewed. Only 3% of the farmers used a weighing scale or weighing tape in determining the weights of animals prior to treatment. De-worming of herds by the farmers themselves, coupled by weight determination using visual appraisal was consistent with that of Magona and Musisi (1999) and Waller (2006). Live weight determination using visual appraisal was likely to lead to under-dosing. Giving sub-optimal doses exposes worms to drug resistance (Edwards *et al.*, (1986). It was therefore important that farmers weigh at least a proportion of their flocks during anthelmintic treatment so as to give accurate doses.

The present study showed that most farmers (48%) de-worm their animals every 3months, 16% every after 2 and 6 months, while 13% and 7% do it every 4 and 6months respectively. Too frequent administration of drugs to animals exposes GIN populations to continuous presence of drugs, thus leading to development of resistance. This finding has been reported by (Martin, 1989 and Sykes *et al.*1992). The results presented in this survey indicate that, majority of the farmers (64%) treat their animals 3-4 times which was the recommended treatment frequency. Only 36% treat two times a year.

access to information on worm control, most farmers (97%) claimed to have access to information on worm control and only 3% had no access. Of those who had access to information on worm control, 42% obtained information from extension staff, 32% from media, 3% from farmer groups and 3% from friends. Despite the farmers' access to information on worm control, very few farmers (3%) changed anthelmintic used on their farms and called up on extension staff during treatment. This has two implications; either the cost for the extension services is high or the extension staff never had clear knowledge on the problems associated with self treatment of their herds and over use of one drug type on the farm. Therefore farmers were never advised on the importance of herd treatment under professional care and periodic change of anthelmintic in the preservation of the efficacy of the drugs. This may be due to Poor knowledge of endo-parasite control and lack of experience among herd owners and the healthcare personnel as was reported by Maingi *et al.,* (1996) and Lendal *et al.*, (1998). Reason for the lack of adequate knowledge on parasite control is lack of training in the updated information on parasite control. Extension staffs are advised to acquire updated information on parasite control so that they can equip farmers with the current information.

On grazing management system, 80% of the farmers grazed their animals on open grazing land, where different herds interacted on same pastures. This was also reported by (Magona and Musisi (1999) and Waller (2006), that communal grazing systems on open pastures and tethering animals from different herds on same pastures, is a common husbandry practice in many tropical countries. This may lead to transmission of residual anthelminntic resistant gastrointestinal nematodes amongst goats in different flocks. Reason for the similarity is that most farmers in the developing countries are poor and lack the finances to fence off their farms. So, they resort to communal grazing on open land on which herds from different herds interact. Control measures that involve many farmers sharing a given communal grazing land and using one class of anthelmintic are necessary for avoidance of continuous contamination of pastures.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

ONCLUSIONS

he following conclusions were made:

1. The relatively low prevalence of GIN infection and low worm burdens (epg) in this study show that; the natural infection with GIN parasites in commercial goat farms in Gomba is low compared to earlier studies elsewhere in the region; probably because of heavy application of anthelmintic drugs on these farms. However, specific reason/s for this apparent low prevalence needs to be established.

2. *Haemonchus, Oesophagostomum and Strongyloides* are the common gastrointestinal nematode parasites on commercial goat farms in Gomba District and *Haemonchus* was the most predominant of the three probably because of its high biotic potential.

3. Prevalence of gastrointestinal nematode parasites in the goats in Gomba is more in young goats (3-5) months and in juveniles 9 month old goats attributed to defective development of immunity against helminths in the young ones and the effect of sex hormones at puberty in the juvenile goats respectively.

4. Albendazole, levamisole and ivermectin are still effective against common GIN parasites in Gomba, Uganda, but the continued shading of eggs in feces (<90% efficacies) after treatments is suggestive of a possible parasite resistance against these drugs.

5. Albendazole was the least efficacious of the three drugs and resistant strains of Haemonchus appeared in fecal cultures at day 21 post treatment. This was a sign of its prolonged use on farms.

6. Possible farming practices (risk factors) responsible for reduced anthelmintic efficacy include; prolonged use of one anthelmintic class, self-medication of goat herds and visual estimation of animal weight during anthelmintic treatments.

Recommendations

s study recommended the following;

1. Farmer education on judicious use of anthelmintic is necessary in order to preserve their efficacy.

2. Control strategies targeting *Haemonchus* nematode parasites such as vaccination, need to be sought in order to reduce its effect on goat herds.

3. There is need for farmers grazing animals on same communal pastures to treat their herds around the same time using one anthelmintic class and then do change over to another class periodically.

4. Farmers need to weigh a proportion of their goat flocks in the different age groups during treatment so as to give accurate dosages depending on the heaviest animal in each group.

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APPENDIX

Sample structured questionnaire

Date ..... Farm/Farmer.....

flock size .....

A) Drugs and drug administration

a) What drug types do you use?

i) Albendazole (Yes, No) ii) Levamisole (Yes, No) iii) Ivermectin (Yes, No)

b) What age do you start treatment of goats?

i) 1month (Yes, No) ii) 1.5months (Yes, No), iii) 2months (Yes, No), iv) 3 months and above (Yes, No)

c) How do you administer the drug?

i) Use: bottle (Yes, No), ii) syringe (Yes, No), iii) Drenching gun (Yes, No)

d) Who does the treatment?

e) How do you determine the dose?

i) weight (Yes, No), ii) Age (yes, No), iii) sex (Yes, No)

e) If you use weight in 3) above, how do you determine it?

i) Visual estimation (Yes, No), ii) use weighing scale or tape (yes, No)

f) How often do you de-worm your goats?

i) Every month (Yes, No), ii) every after 2months (Yes, No) iii) every after 3months (Yes, No) iv) Every after 4months (Yes, No), above 6months (Yes No)

g) Do you alter the drugs you use? (Yes, No)

h) How often do you do that? I) every month (Yes, No), ii) every 6months (Yes, No), iii) every year (Yes, No) iv) Never (Yes, No)

i) Are the drugs working? (Yes, No)

B) Advice from extension

a) Do you access information on worm control? Yes, No)

b) What is your source of information? i) Media (Yes, No) ii) extension (Yes, No), iii) Friends (Yes, No) iv) farmer's groups (Yes, No)

c) How often do you get the advice? i) every month (Yes, No), ii) once in 3months (Yes, No), iii) all the time (Yes, No)

d) Is the information relevant? (Yes, No) ii) not sure (Yes, No)

C) Husbandry practices

a) Grazing system: Do you segregate your goats according to their age groups? (Yes, No)

b) Do you graze your animals on your fenced personal grazing land or open shared grazing land?

c) What time do you release your goats? I) Before 10 am (Yes, No) ii) after 10 am (Yes, No)

d) Housing: Is the goat house raised? (Yes, No)

e) Litter disposal: How often do you remove the litter?

i) Daily (Yes, No), ii) weekly (Yes, No) iii) occasionally (Yes, No), iv) Never (Yes, No)

e) Do you dispose litter directly in the grazing pasture? (Yes, No)

f) Where is your source of water?

i) Communal source with neighboring farms (Yes, No),

ii) Personal well/ valley dam (Yes, No)