A COMPARISON OF THE EFFICACY OF THREE ANTHELMINTIC DRUGS AGAINST MIXED NATURAL GASTROINTESTINAL NEMATODE INFECTIONS IN CAMELS (*Camelus dromedarius*) IN KENYA

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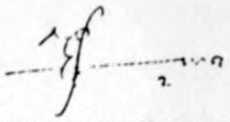
DECLARATION

This thesis is my original work and has not been presented for a degree in any other University.



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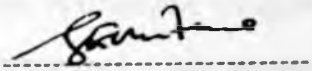

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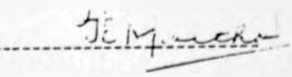

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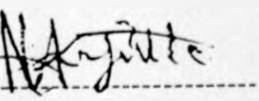

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DEDICATION

This work is dedicated to my parents, Mr. Thomas G. Mukhwana and Mrs. Anne Namarome Mukhwana for their foresightedness in education success and achievements, a thing that has been a source of great inspiration to their children over the years.

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ABSTRACT

This study was undertaken to identify the types of helminth parasites in camels, their prevalence rates in different seasons, the effects of age and sex of camels on helminth infestation rates and to compare the efficacy of three anthelmintics, namely albendazole, levamisole and thiophanate in the treatment of gastrointestinal nematodes in camels (*Camelus dromedarius*) owned by the local community in Lorroki Division, Samburu District, Kenya.

During the survey, 255 camels had their faecal samples taken once over a period of five months. These included 59 camels in November 1992, 66 in December 1992, 47 in January 1993, 46 in February 1993 and 37 in March 1993. The faecal samples were subjected to the McMaster egg counting technique and coproculture. The worm eggs and recovered nematode larvae were identified using standard parasitological techniques.

Blood was collected in heparinized capillary tubes for determination of the packed cell volume (PCV) which was used as an indicator of the anemia status. Examination of the buffy coat and blood smears was done to rule out the presence of haemoparasites.

Out of the 255 camels examined as previously described, 76 clinically healthy camels but which had moderate to heavy worm egg counts (EPG of more than 400) were selected and used in the anthelmintic drug study. These camels which included both males and females comprised all age groups. PCV values for all the animals was determined once before and one month after treatment. The selected camels were randomly distributed (n=19) by

age, sex, EPG counts and household into three treatment and one control group.

The survey on helminthiasis showed that peak strongyle worm egg counts in this area occur during and soon after the rains. Calves and adults had higher worm egg counts than immatures. When assessing the effects of sex on worm egg burdens, it was found that female camels had higher ($p < 0.05$) worm egg counts than males.

The data showed that 80% of all eggs that were identified were those of strongyle nematodes. Other parasite eggs identified included those of tapeworms (especially *Moniezia spp*), *Strongyloides spp*, *Trichuris spp.* and *Fasciola spp.* Larval culture and identification showed that *Haemonchus spp* and *Trichostrongylus spp* were the most common and probably the most pathogenic gastrointestinal helminths of camels in this area. Other nematode parasites identified included *Cooperia spp*, *Bunostomum spp*, *Oesophagostomum spp*, *Strongyloides spp* and *Ostertagia spp.*

When assessing the efficacy of the three drugs studied, it was found that the mean PCV values in all the treated camels were significantly higher ($p < 0.05$) than those of the untreated controls one month after treatment.

The present study indicates that thiophanate at a dose of 60 mg/kg body weight was the best drug as shown by the significant reduction in the post-treatment nematode worm egg counts. Albendazole at a dose of 10 mg/kg and levamisole (at a dose of 10 mg/kg) came next in that order with levamisole being the least effective.

This study reports, for the first time, the presence of *Fasciola spp* in camels in Kenya. It also indicates that peak worm infestations

occur mostly during the rain season and that *Haemonchus spp* is the most common GIT parasite in camels.The study also showed that thiophanate and albendazole promise to be highly effective, safe and fast acting drugs for use in treating nematode infections in camels of all ages.

CHAPTER ONE

INTRODUCTION

Camels continue to be an integral component of an ecosystem in which the vegetation of the marginal lands can be converted to human food. This is because, all over the world, camels have been found to be superbly adapted to their respective environments. Inspite of this, camels are susceptible to a number of viral, bacterial, mycotic, protozoal and parasitic diseases (Richard, 1984). Among all these diseases, helminthiasis is ranked as the second major cause of economic loss in camel production (Richard, 1976). Economic losses result from impairment of physiological functions with a consequential decrease in weight gain, milk production, working capacity and reproductive performance.

It is generally believed that of the internal parasites of the camel, gastrointestinal nematodes are of the most serious economic consequence. This is based on the overall numbers of worms, numbers of genera and species present, general level of pathogenicity and widespread distribution.

The most common genera of nematodes reported in camels include: *Haemonchus, Trichuris, Nematodirus, Strongyloides, Bunostomum and Oesophagostomum* (Rutagwenda, 1985; Wilson, 1988). Of these, *Haemonchus longistipes* and *Trichostrongylus probolurus* have been recognized as being the most pathogenic and economically important parasites of camels in many countries (Steward, 1950; Malek, 1959; Altaif, 1974; El Bihari and Kawasmeh, 1980; Abdul-Salam and Farah, 1988; Onyali and Onwuliri, 1989).

The use of anthelmintics drugs forms the main link in the chain of any systems of helminthiasis control in domestic animals. They play the important roles of destroying and eliminating intestinal parasites and reducing contamination of pastures. Therefore, it is imperative that the relative efficacies of the available anthelmintics is known with reasonable accuracy to enable effective parasite control (Reinecke *et al.*, 1962). Several methods are in use for determining the efficacy of an anthelmintic drug or a combination of drugs. These include the faecal egg count method in the live animal (Gordon,1950), the critical techniques of Hall and Forster (1918) and the controlled test of Moskey and Harwood (1941). The easiest and most commonly used technique is the faecal egg count method.

In general, systematic studies of the disease conditions caused by helminths and their management in camels are scanty and hence, in most developing countries parasite control programmes are based on haphazard and random use of anthelmintics and usually extrapolated from experience in cattle and other domestic animals. While these procedures could be affording some protection against diseases and even mortality, they are frequently not effective in preventing the exposure of the animals to high levels of infestation (Brundson, 1980). Consequently, production losses still occur as a result of reinfection in the interval between treatment. This negligence has been attributed partly to the devalued economic worth of the camel.

This situation is worsened by the fact that many farmers hardly attempt deworming their camels. This fact, coupled by sharing of grazing fields and watering points tremendously increase the chances of re-infection for those who deworm their camels.

The challenge of camel helminthiasis calls for the introduction of cost-effective strategic control programmes that minimize the effects of worms in camels. To achieve this, one must combine information regarding the efficacy of different anthelmintics under field conditions with epidemiological data developed for each specific geographic area. In Kenya, such data has not been documented.

Reported anthelmintic drug trials in camels include those of ivermectin (Frolka and Rostinska, 1984; Jones, 1987), thiabendazole (Graber, 1966; Chandrasekharan *et al.*, 1970; Kapur and Sharma, 1972), parbendazole (Chandrasekharan *et al.*, 1971; Frolka and Rostinska, 1984; Frolka, 1988), Oxfendazole (Michael *et al.*, 1980) , levamisole (Walley, 1966; Lodha *et al.*, 1977) and fenbendazole (Rutagwenda and Munyua, 1983). No anthelmintic drug trials have reported the efficacy of albendazole and thiophanate in treating camel helmithiasis.

Some workers have recommended that camels can be treated with the same drugs as other large domestic animals. However, Wilson (1988) warns that this must be done with caution especially when new drugs are tried in camels. This is because camels have been shown to be idiosyncratic in their reactions to drugs. Graber (1966) reported toxicity signs in camels following use of tetramisole. He however showed that thiabendazole is a good and safe anthelmintic drug for use in camels.

The objectives of this study were:

1) To determine the genera of gastrointestinal helminths present in camels in Lorroki Division, Samburu District, Kenya.

2) To examine the seasonal abundance of gastrointestinal nematodes in different age groups and sexes of camels during different seasons as an indicator of periods of transmission.

3) To compare the efficacy of albendazole, levamisole and thiophanate in the treatment of gastrointestinal nematode infections of camels of both sexes and all age groups using the faecal egg count method and the packed cell volume .

CHAPTER TWO

LITERATURE REVIEW

2.1.: GASTROINTESTINAL HELMINTHS OF CAMELS

The camel is a creature of the arid and semi-arid areas, a habitat generally considered not to be conducive to the development and transmission of helminth parasites. However, several researchers have found a surprisingly large and diverse fauna of helminths comprising representatives of all classes of these metazoan parasites (EL Bihari, 1985; Wilson, 1988).

In camels, helminthiasis, is a chronic problem which occurs with an infection rate as high as 90% in natural conditions (Richard, 1984). However, some cases of mixed nematode infections have been reported to precipitate acute conditions. (Arzoun *et al.*, 1984a).

2.1.1: Gastrointestinal nematodes (roundworms)

Nematodes are the most important internal parasites of camels (Steward, 1950, Malek, 1959, Graber *et al.*, 1967; Wilson, 1988). Nematodiasis in camels is characterized by diarrhoea, general debility, reduced growth rates and milk yields, increased calving intervals, innappetance, anaemia, and consumption of large amounts of sand (pica) (Arzoun *et al.*, 1984b). Wilson (1988) has reported that common camel nematodes belong to the following genera; *Trichuris, Nematodirus, Strongyloides, Haemonchus* and *Trichostrongylus*.. Camels are infected with these parasites when they graze on infested pasture. But, *Strongyloides spp* is reported to infect camels by skin penetration.

Several surveys indicate that camel nematodiasis occurs with varying prevalences in different countries and even within countries. Richard (1976) found that 92% of all camels examined in Ethiopia had internal parasites of which 80% were *Strongyles*, 10% *Strongyloides spp* and 16% *Trichuris spp*. Wilson *et al.* (1984) reported a similar level of infestation in Kenya. They revealed that in Kenya *Haemonchus contortus*, the stomach worm of sheep was the most common strongyle nematode in adult camels and that *Strongyloides spp* was common in all ages and *Ascaris spp* was uncommon.

Reports from most camel keeping areas however, indicate that *H. longistipes* is the commonest and most pathogenic internal parasite of the camel (Steward, 1950; Malek, 1959; Graber *et al.*, 1967; EL Bihari and Kawasmeh, 1980; Arzoun *et al.*, 1984a; Tager-Kagan, 1984; Onyali and Onwuliri, 1989; Tembely *et al.* 1992). According to several researchers, *H. longistipes* usually occurs as a mixed nematode infection mostly with *Trichostrongylus spp*. However, Arzoun *et al.* (1984a) found on post mortem examination that apart from ruminal amphistomes, *H. longistipes* was the only helminth found in the gastrointestinal tracts of the camels examined.

H. longistipes is reported to be a serious blood sucker and causes high mortality rates in tropical Africa (Onyali and Onwuliri, 1989). This parasite is responsible for 72% of all deaths caused by helminths in Chad (Onyali and Onwuliri, 1989). Rutagwenda (1985) and Wosene (1991) respectively found a high prevalence of *Haemonchus spp* in Kenya and Ethiopia. Other parasites that have been reported in Kenyan camels include *Trichostrongylus spp* and

Oesophagostomum spp. Trichuris spp. has been reported to be common among Turkana camels (Njanja, 1991) and camels in the Ogaden (Ethiopia) (Wosene, 1991).

While working with camels in Iraq and Kuwait (Altaif, 1974; Abdul-Salam and Farah, 1988), it was found that *Trichostrongylus probolurus* was the most prevalent helminth parasite present in all camels that they examined. They further demonstrated that the parasite was more common in calves and was associated with emaciation and diarrhoea. This parasite has been reported to cause considerable pathogenicity in camels (Steward, 1950; Tembely *et al.*, 1992).

Faecal examinations from a herd of ten bactarian camels by Frolka (1988) revealed infections with nine nematode genera and *Eimeria spp.* The most frequent and deleterious nematode was *Trichuris spp* and the only camel that died of massive nematodiasis yielded *Trichuris ovis, Chabertia ovina, Trichostrongylus spp, Ostertagia spp, Nematodirus spp* and *Capillaria sp.*

Other common gastrointestinal nematodes reported in the camel include *Cooperia spp, Camelostrongylus mentulatus, Parabronema skrjabini* (Lodha *et al.*, 1977), *Oesophagostomum spp* and *Impalaia spp* (Tager-Kagan, 1984; Tembely *et al.*, 1992). These parasites and others are however considered to be of little importance in the camel. Table 1 shows the major gastrointestinal helminths of the camel.

Table 1: Common gastrointestinal helminths of camels (Modified from EL Bihari, 1985)

	Parasite	Location
1-	*Haemonchus. longistipes*	Abomasum
2-	*Camelostrongylus mentulatus*	Abomasum
3-	*Trichostrongylus probolurus*	Duodenum
4-	*Trichostrongylus colubriformis*	Duodenum & abomasum
5-	*Trichostrongylus vitrinus*	Intestines & abomasum
6-	*Trichuris ovis*	Caecum & colon
7-	*Trichuris globulosa*	Caecum & colon
8-	*Trichuris cameli*	Caecum & colon
9-	*Strongyloides papillosus*	Duodenum
10-	*Oesophagostomum spp*	Large intestine
11-	*Bunostomum spp*	Small intestine
12-	*Nematodirus spp*	Small intestine
13-	*Haemonchus contortus*	Abomasum
14-	*Ostertagia spp*	Abomasum
15-	*Cooperia spp*	Small intestine
16-	*Moniezia expansa*	Small intestine
17-	*Stilezia vittata*	Small intestine
18-	*Fasciola hepatica*)	Bile ducts, rarely ectopic in lungs
19-	*Fasciola gigantica*)	

2.1.2: Gastrointestinal cestodes (tapeworms)

According to Altaif (1974) and Abdulrahman and Bornstein (1991) intestinal tapeworms are universally present in camels. Camels are reported to be susceptible to infections of both the adult and larval stages of cestodes. Gastrointestinal cestodes reported to occur in camels include *Moniezia expansa, Stilezia vittata* and *Avitellina spp* (Richard, 1976; Tager-Kagan, 1984; Wilson, 1988).

S. vittata is very common in the intestines especially of the Arabian camels, although no pathogenic effects have so far been attributed to it (EL Bihari, 1985). *M. expansa* is said to be fairly common and its presence is usually detected at postmortem or when segments are passed out in the faeces. Its occurrence has been reported in Ethiopian camels by Wosene (1991) and in Somali camels by Abdulrahman and Bornstein (1991). In Kenya, this tapeworm is common (Wilson *et al.*, 1984) although it is not known to be pathogenic (Rutagwenda, 1985). However, the parasite may obstruct the gastrointestinal tract and cause death in young animals (Blood and Radostitis, 1989; Soulsby, 1986).

2.1.3.: Gastrointestinal trematodes

Although the environment in which camels live does not seem to favour high prevalences of liver flukes, they seem to occur in a fair proportion of camels. Magzoub and Kassim (1978) reported infestations of *Fasciola gigantica* and *F. hepatica* in camels of Saudi Arabia. Al-Khalidi *et al.* (1990) on examining faecal samples from 283 camels in Iraq using the sedimentation method, found a high infection rate of *Fasciola spp* especially during the summer period.

Fascioliasis is generally associated with high rainfall and irrigation schemes that provide conducive environments in which land snails, the intermediate hosts survive and transmit infections to camels. Thus, in Saudi Arabia, camels from the East of the country on the Persian Gulf have a higher incidence of fascioliasis than those from other areas. It has also been noted in the Sudan that camels around the River Nile and its major tributaries (where irrigation schemes are common) have a higher incidence of fascioliasis. Fascioliasis has not been reported in camels in Kenya.

The only pathological change which has been noted in camel fascioliasis is the thickening of the bile ducts which may result in partial or total condemnation of the affected livers at meat inspection (EL Bihari, 1985).

2.1.4: Diagnosis of camel gastrointestinal helminths

Arzoun *et al.* (1984b) enumerated and described the clinical signs of helminthiasis in experimentally infected camels. However, these signs are seldom seen under natural conditions, and hence a definitive diagnosis is required as it forms an integral part in the camel helminthiasis control programme. This involves taking faecal samples from suspected camels and determining the number of eggs per gramme of faeces (EPG) (Soulsby, 1986). This is a quantitative index that is used to score the intensity of infection in animals. Five hundred eggs per gram of faeces is normally taken to be the pathogenic threshold in camels (Rutagwenda, 1985). In addition, direct microscopic examination of faeces is useful as it may reveal whole worms and proglottids of tapeworms.

Nematodirus spp, when present in large numbers are passed out attached on the outside of faecal droppings and being held by strands of mucus. In most mixed infections, mere detection of eggs is not enough and larval culture and identification should always be attempted. Diagnosis of *Fasciola spp* and whipworms infections should be carried out using techniques established for sheep and cattle (Anon, 1986).

2.1.5 Epidemiology of camel gastrointestinal helminths

The epidemiological picture of camel helminthiasis is probably similar to that of the better studied helminthiasis of other ruminants. Although the conditions in which the camels are usually kept throughout the world are not favourable for helminth parasite transmission, more than 60 different species of helminths are known to occur in these areas (EL Bihari, 1985).

The reasons for the occurrence of economically significant helminthiases in camels may be multiple and interactive. Many factors such as stocking density, immune status of hosts, environmental temperature, humidity, soil structure, vegetation type, drainage, nutritional status of hosts, concurrent diseases, mineral deficiencies, age and sex of hosts which may singly or in association with others determine or influence the occurrence of helminthiasis (Brundson, 1980).

Depending on the type of management, it has been found that there is some degree of interchange of helminth parasites between camels, sheep, goats and probably wild animals. This is of particular relevance to transhumant communities whose camels are usually

herded together with goats and sheep and are often kept in the same enclosures ("bomas") at night (EL Bihari, 1985).

Onyali and Onwuliri (1989) attributed the high prevalence of camel *Trichostrongylus colubriformis, Cooperia pectinata, Oesophagostomum columbianum* and *Strongyloides papillosus* which are common nematodes of sheep, cattle and goats in Nigeria to transmission from these animals to camels. This finding was reinforced by the observation that camels occasionally grazed alongside the other animals in the areas of study.

Experimentally, *H. longistipes* has been successively adapted to goats and less successfully to sheep (Arzoun *et al.*, 1983). In both, cases, overt infections were reported and adult worms recovered. Baitursinov and Berkinbaev (1989) in an ecological study of camel parasites in South Eastern Kazakh (USSR) found out that there was inter-transimission of helminth parasites between camels and sheep. They also recorded five species of camel parasites for the first time in this area. These included *Moniezia benedeni, Chabertia ovina, Nematodirus dromedarii, Nematodirus oiratianum* and *Nematodirella longissimespiculata*. Out of the 32 parasites that they isolated, 22 were nematodes, 3 Eimeria, 4 trematodes and 3 cestodes.

The low stocking rates of the camel in its traditional habitat and the long intervals between waterings reduce the frequency of close contact with other animals. This in turn minimizes the occurrence of several helminth parasites which are shared between camels and other animals. This reduced inter-transfer of helminthiases is further augmented by the fact that camels usually graze and browse in a radius of 50 km around the watering point while cattle, sheep

and goats graze within 20 km from the nearest water point (Bremaud, 1969, cited by Richard, 1984).

A one year study of trichostrongyloid egg output in camels in Saudi Arabia (EL Bihari and Kawasmeh, 1980) found that egg production peaked at the start of the short winter rains. This period also concided with peak infection of camels. These researchers suggested that routine dosing with anthelmintics may be done just before the start of the short rains. In Kenya (Njanja, 1991) demonstrated that high EPG. levels in camels occurred during the wet and early dry seasons. The EPG values decreased progressively during the late dry season only to begin rising again at the onset of the rains.

Hypobiosis, a process whereby there is inhibition of larval development has been reported to occur in camels. Retardation of growth by *H. longistipes* in the abomasum of camels during the dry season (Arzoun *et al.*, 1984a) has been observed.

The high prevalence of tapeworm infections in camels is thought to be due to lack of toilets among most pastoral communities while fascioliasis is more common in areas with high amounts of rainfall, near irrigation schemes, rivers and dams (Magzoub and Kassim, 1978).

Camel owners in Kenya, hardly ever attempt deworming, although they know that helminthiasis is a problem. The later coupled with communal use of grazing fields and watering points in traditional camel keeping areas increases the chances and rate of re-infection even when deworming is done by some few farmers.

In the arid and semi-arid environment in which camels are kept in Kenya, there is a complex interaction between parasitism and nutritional stress, the two are often difficult to separate (Njanja,1991).

2.1.6 Control of camel helminthiasis

Eradication of most helminth infections is not practical and most regimes aim at controlling parasites to levels compatible with economic production. In sub-saharan Africa control strategies are often "protective" in nature and are based on haphazard and random use of anthelmintics. Effective parasite control programmes can only be achieved by integrating grazing management, use of anthelmintics and dependence on acquisition of immunity. However, interactions of many factors in the arid and semi-arid areas limit the successful application of these three approaches. This is because an integrated control programme requires an understanding of the inter-relationships that exist between the various sources of pasture contamination, the availability of infective larvae and the knowledge of seasonal fluctuations of helminthiasis. (Brundson, 1980).

It is difficult to recommend a universal regime for administration of anthelmintics. This is because the value of any anthelmintic in a helminth control programme is determined after one has understood the management system (of animals) in question, climatic conditions, economics of production, susceptibility of animals after infestation and other epidemiological data. Because of the ever escalating costs of anthelmintics, it has

become necessary for one to strategically use the most cost-effective treatment.

2.2.0: Introduction to anthelmintics

Anthelmintics are drugs that act against helminth parasites that inhabit the alimentary tract, the lungs, the liver and the circulatory system and other parts of the body. Currently, there is a wide range of anthelmintics in the market manufactured by different companies. An ideal anthelmintic, however, should fulfil the following characteristics (Brander *et al.*, 1991; Edward,1982).

1. Efficacy: The drug must have a high level of antiparasitic action when used under natural conditions. That is, it must be able to eliminate at least 95% of all the gastrointestinal nematodes when used. The percent efficacy of the drug against immature, larval and adult worms must be accurately known. An efficacy of 100% is undesirable as it totally eliminates the source of antigenic stimulation and hence may weaken the animals acquired resistance to the parasite.
2. Wide therapeutic index: This is the ratio of the toxic dose to the therapeutic dose. The drug should be toxic to the parasite but have a good margin of safety for the host. Drugs are usually much safer for the host when their mode of action involves biochemical pathways that are not shared by the parasite and the host.
3. It should be affordable.

4. It should have a wide spectrum of activity.
5. Its activity should be against both mature and immature stages of the worms.
6. The drug should not require any alteration of the normal day to day activities of the animal after or before treatment. It should not impaire development of the treated animal nor its offsprings.
7. The drug should be easy to administer.
8. It should have a short residue period in tissues so that withdrawal periods for milk and meat are shortened.

2.3.0: LEVAMISOLE.

2.3.1 Clinical trials of levamisole

Levamisole is a major anthelmintic used in food producing animals belonging to the group of anthelmintics called imidazothiazoles. It has been widely studied all over the world in it's original form of tetramisole, and has been found to be very effective against mature nematodes and somehow less effective against immature forms (Walley, 1966). The combined activity of levamisole and bithionol sulfoxide (Wormicid$^{(R)}$ plus, Cosmos) has been studied in Kenya by Maribei (1985) in both sheep and cattle and was found to be very effective against major adult nematodes.

Extensive field and laboratory trials of the effects of levamisole against nematodes has proved the high and consistent efficacy of the drug.

Studies carried out in the camel showed that levamisole hydrochloride was effective in treating helminthiasis although its action was inconsistent (Lodha *et al.*, 1977). However, the drug was found to be ineffective in treating *Trichuris spp.* in sheep (Walley, 1966).

2.3.2.: The pharmacology of levamisole

Levamisole, whose chemical name is (1-2:3:5;6 -tetrahydro-6-phenyl-imidazo (2,1-6) thiazole hydrochloride, is the L-isomer of tetramisole. It is a white crystalline compound which is highly soluble in water. It is given either by injection or using the oral route (Brander *et al.*, 1991). Figure 1 shows the structure of levamisole hydrochloride.

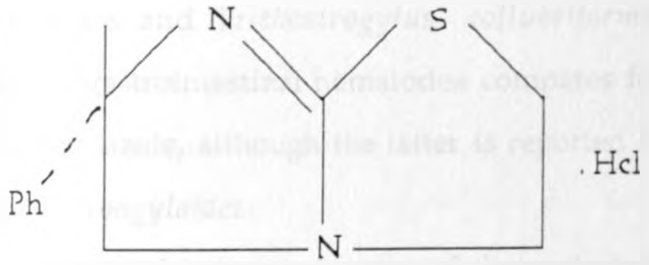

Figure 1:. Levamisole hydrochloride

Levamisole causes sustained muscle contractions that lead to paralysis of the nematodes. The drug acts as a ganglionic stimulant (cholinomimetic) and at high concentrations it inhibits the fumarate reductase system (Van Neuten, 1972; Prichard, 1973) just like the benzimidazoles. Following treatment, most nematodes are expelled within 24 hours.

Absorption and excretion of levamisole is rapid following oral administration of the radioactive labelled drug to rats at a dose of 15

mg/kg. At least 40% of the drug is excreted in urine within 12 hours (Brander *et al.*, 1991). The rest of the drug is excreted over a period of 8 days through various routes. Tissue residues of the drug are not appreciable and levamisole is not detected in most organs of the body 7 days after therapy. The identified metabolites are said to be less toxic (Edward, 1982) than the parent compound.

2.3.3: Indications and toxicity of levamisole

Levamisole is a broad spectrum anthelmintic which is active against adult stages of *Haemonchus, Ostertagia, Trichostrongylus, Cooperia, Nematodirus, Bunostomum, Oesophagostomum, Metastrongylus, Ascaris, Hyostrongylus* and *Trichuris* in ruminants. In addition, it is active against benzimidazole resistant *H. contortus* and *Trichostrogylus collubriformis*. It's efficacy for ruminant gastrointestinal nematodes compares favourably with that of thiabendazole, although the latter is reported to be more effective against *Strongyloides*.

Larval and immature stages of the gastrointestinal parasites of ruminants are not as effectively removed by levamisole as the adults. In the camel, levamisole has been found to be less effective in treating infections of *Trichuris globulosa* when compared with methyridine and morantel tartrate (Lodha *et al.*, 1977). The action of levamisole was said to be inconsistent, when given at the recommended dose of 15mg/kg. However the drug is effective in treating infection of camels with *Nematodirus, Strongyloides* and *H. longistipes* (Lodha *et al.*, 1977).

Levamisole is tolerated well at the recommended dose rate. When an animal is overdosed, both muscarinic and nicotinic effects are exerted and hence in levamisole intoxication signs of salivation, defecation, respiratory distress, increase in motility of the GIT, slowing of the heart rate and a rise in blood pressure are noticed.

2.3.4.: Modulation of the immune system

Treatment of animals with levamisole has been found to enhance the immune response especially in old and chronically ill animals. The drug stimulates a cell mediated immune reaction by potentiating the rate of T-lymphocyte differentiation, responsiveness to antigens and mitogens and activity of the effector lymphocytes.

2.4.0: ALBENDAZOLE

2.4.1.: Clinical field trials of albendazole

No work has been published on the efficacy of the benzimidazole anthelmintic, albendazole whose chemical name is (methyl 5-(propylthio)-1H-benzimidazo-2-y1) carbamate, against gastrointestinal nematodes of camels. However, a large amount of literature is available outlining the compound's effectiveness in treating nematode, cestode and trematode infections in other domestic animals including cattle, sheep, goats, horses and pigs.

Comparative trials against camel helminths with methyridine, morantel tartrate, tetramisole hydrochloride and thiabendazole at 90 mg/kg showed that thiabendazole was the least effective of the four anthelmintics tested (Lodha *et al.* 1977).

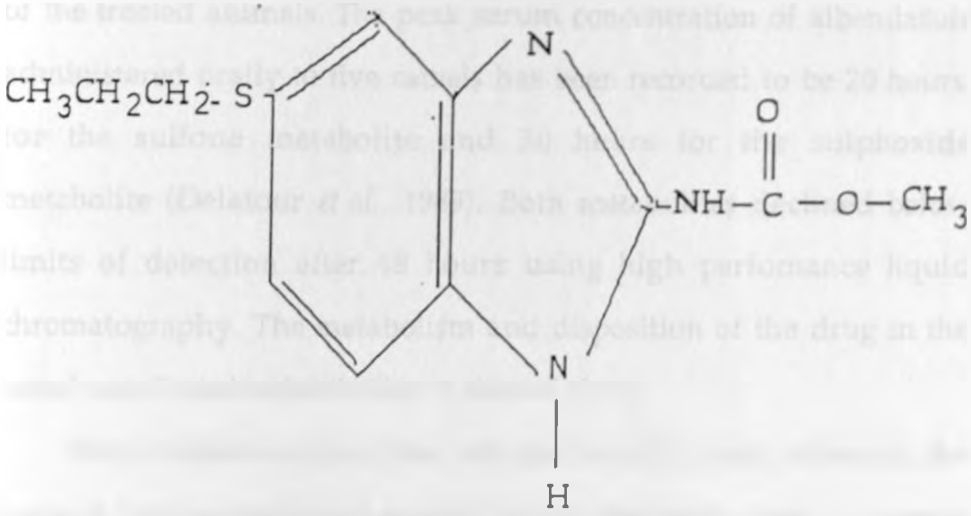

Figure 2:. Albendazole

2.4.2.: The pharmacology of albendazole

The drug is very stable, white and odourless. It is insoluble in water and only slightly soluble in most organic solvents. It was discovered and developed by scientists at the Apple brook Research Center, U.S.A., through a modification of the structure of thiabendazole. It is metabolized and excreted much more slowly than thiabendazole and has a much greater activity at lower doses (Georgi *et al.*, 1991). Figure 2 shows the structure of albendazole.

Absorption of benzimidazoles from the GIT is generally limited probably due to their insolubility in water. However, albendazole is absorbed to a much greater degree than most other drugs in this group and 47% of the administered dose is recovered in urine over a 7 day period. The majority of the albendazole dose excreted has been identified as three metabolites; sulfoxide, sulfone and 2-aminosulfone (Delatour *et al.*, 1989). It is generally thought that albendazole sulfoxide is the active substance in the blood and tissues

of the treated animals. The peak serum concentration of albendazole administered orally to five camels has been recorded to be 20 hours, for the sulfone metabolite and 30 hours for the sulphoxide metabolite (Delatour *et al.*, 1989). Both metabolites declined below limits of detection after 48 hours using high perfomance liquid chromatography. The metabolism and disposition of the drug in the camel was found to be similar to that of sheep.

Benzimidazoles affect the cellular integrity, and although the basis of their anthelmintic activity is not absolutely clear, it appears that their ability to bind to tubulin and inhibit it's polymerization into microtubules is their primary mode of action (Behm and Byrant, 1985; Waller, 1986). The drugs inhibit the fumarate reductase system thereby interfering with the energy generating metabolism of the parasite.

2.4.3: Indications and contraindications of albendazole.

Albendazole is used at a dose of 10 mg/kg for the removal of the adult and larval forms of *Haemonchus spp, Ostertagia spp,* including the fourth stage inhibited larvae of *Trichostrongylus axei, Trichostrongylus colubriformis, Nematodirus spathiger, Nematodirus helvetianus, Cooperia punctata, Cooperia oncophora, Bunostumum phlebotomum, Oesophagostomum radiatum, Moniezia expansa, Moniezia benedeni* and *Fasciola hepatica.*

Albendazole is well tolerated by domestic and wild animals. It has been demonstrated to be free of side effects at therapeutic doses even when administered to young, sick and debilitated animals.

Embryotoxic and teratogenic effects have been associated with administration of albendazole to sheep and cattle at a single dose of 10mg/kg during early pregnancy (Delatour *et al.*, 1989). Hence, the drug is contraindicated in these two species of animals during the first 45 days of pregnancy.

2.5.0: THIOPHANATE

Thiophanate is sometimes classified as a benzimidazole. This is because, in the body of animals it is converted by cyclisation into benzimidazole carbamates.

2.5.1: The pharmacology of thiophanate

The chemical name of thiophanate is diethyl 4,4'0-phenylene bis (3-thioallophanate), or alternatively 1,2-bis (3-ethoxycarbonyl-2-thioureido)-benzene. The structure of thiophanate is shown in Figure 3.

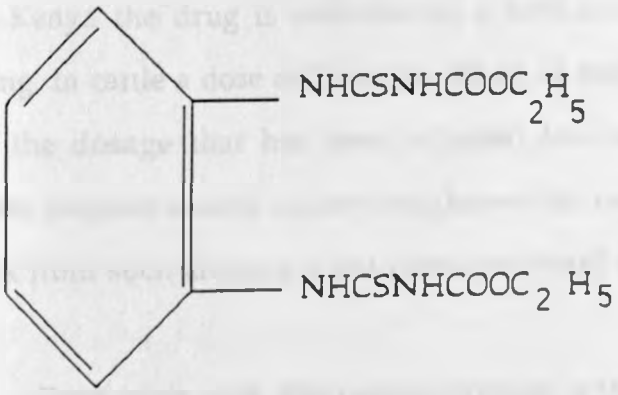

Figure 3:. Thiophanate

The drug is stable, pale yellowish-brown crystalline solid that is slightly soluble in water, methanol, elthyl acetate and acetone. It is very soluble in cyclohexanone.

Thiophanate is absorbed rapidly and distributed to all parts of the body. Peak plasma levels have been recorded to occur within 8 hours of administration. Most of the drug is excreted from the body in 72 hours mostly through faeces and urine.

2.5.2.: Indications of thiophanate

Thiophanate is a broadspectrum anthelmintic that is extremely effective against adult and larval forms of the main GIT nematodes of cattle, sheep and goats. These include *Haemonchus contortus, Trichostrongylus axei, Ostertagia spp,* other *Trichostrongylus spp, Nematodirus spp, Bunostomum spp, Oesophagostomum spp* and *Chabertia ovina.* Clinical trials of this drug have not been reported in the camel.

In Kenya the drug is available as a 20% w/v suspension for drenching. In cattle a dose of 15 ml per 50 kg of body weight is used. This is the dosage that has been adopted for camels. Following treatment, animals should not be slaughtered for meat within 7 days and milk from such animals is not consumed until after 3 days.

2.6.: Drug trials with other anthelmintics in the camel.

Treatment of worm conditions in the camel depends on the levels of infestation and the species of parasites involved. Several anthelmintic drugs have been tried in the camel with mixed results. Jones (1987) reported successful use of Ivermectin (Ivomec, MSD) in

the treatment of helminth parasites . This drug, at a subcutaneous dose of 200mcg/kg was found to be active against *H. longistipes, Trichostrongylus spp, Impalaia spp,*and sarcoptes.In India, Ivermectin has been tried using the same dose and route of administration and shown to be effective in treating camels infected with *Haemonchus longistipes, Trichuris spp* and *Nematodirella dromedarii* apart from having a spectacular therapeutic effect against mites and improving the status of anaemia and other haematological factors. Frolka and Rostinska (1984) found Ivermectin at a dose of 200mcg/kg to be ineffective in treating a mixed nematode infection with *Nematodirus* and *Trichuris,* the two being the predominant genera at the Lesna Zoological Gardens , (Zechoslovakia) in Bactarian camels.

In a study in Niger, Tager-Kagan (1984) demonstrated that *H. longistipes* was the most important intestinal parasite. Other parasites recorded included *Stilezia spp, Impalaia nudicollis, Oesophagostomum columbianum,Trichuris globulosa, Trichostrongylus spp and Globidium cameli.* It was recommended in this area that mass treatment with Morantel at a dose of 7.5 mg/kg may be useful.

Chandrasekharan *et al.*(1970) claimed that thiabendazole at a dose of 50 mg/kg bodyweight was effective in treating gastrointestinal nematodiasis in two camels in India. Kapur and Sharma (1972), also in India, treated each of the 14 camels infected with *Haemonchus, Ostertagia, Trichostrongylus, Oesophagostomum, Nematodirus* and *Strongyloides spp* with 40 mg/kg bodyweight of thiabendazole orally twice at an interval of

two weeks. The first dose reduced egg counts by 51-75% and the second dose cleared most animals of all the parasites.

From a study in Chad, Graber (1966) recommended a dose of 100-150 mg/kg of thiabendazole for treatment of camels infected with *Strongyloides papillosus, Trichostrongylus vitrinus, Trichostrongylus probolurus* and *Impalaia nudicollis* which were found to be particularly dangerous for the camels in the area of study. A dose of 300 mg/kg was however recommended for camels infected with *Haemonchus longistipes* and *Oesophagostomum columbianum.*

Thiabendazole is said to be safe in camels, except when they are chronically infected with other diseases such as trypanosomiasis, multiple abscesses or pneumonia. (Graber, 1966) in which case half the recommended dose should be administered. It has been established that following treatment with this drug, the health status of treated camels improves quickly especially when pasture is available.

In comparing the efficacies of four anthelmintics in racing camels in Qatar against natural nematode infections, Sharma (1991) recorded 100% efficacy in camels treated with fenbendazole, oxfendazole and ivermectin by day 7 after treatment. Complete cure (100% efficacy) with thiabendazole was not noted until day 30 after treatmetnt. In this study, faecal samples from experimental camels was examined for worm eggs on days 7, 15 and 30 after treatment.

Chandrasekharan *et al.* (1971) dosed a camel with parbendazole at 20 mg/kg and reported that the drug was completely effective against *Trichostrongylus spp* but ineffective against *Moniezia spp.*

In another trial with benzimidazole anthelmintics, Frolka and Rostinska (1984) found mebendazole at a dose of 15 mg/kg (on two consecutive days) to be ineffective in treating camels infected predominantly with *Trichuris* and *Nematodirus spp.* But, mebendazole (10 mg\kg on days 1-3 and 24) was found to be the most effective drug in treating camels which had *Trichuris spp* as the most deleterious nematode (Frolka, 1988).

A single dose of mebendazole, orally at 10 mg\kg body weight in Bactarian (two humped) camels suffering from lungworm infection produced cessation of excretion of the lungworm larvae by 4 weeks but after 10 weeks, five of the 10 camels treated were found to be passing many larvae again. Forstner *et al.* (1977) cited by Michael *et al.* (1980) administered mebendazole at a dose of 10 mg\kg in feed daily for 14 days to various zoo ruminants including camels and observed a satisfactory reduction in egg count.

Michael *et al* (1980) administered oxfendazole orally at a dose of 4.5 mg/kg body weight in adult camels in poor condition with a natural infection of nematodes and cestodes of the genera *Haemonchus, Ostertagia, Bunostomum, Chabertia, Oesophagostomum, Trichuris* and *Moniezia* reduced faecal egg counts from 82-99% when compared with the control animals. They found that the few nematode eggs still present in the faeces of treated animals were non-viable on culture by the 10th day. This indicated a prolonged ovicidal activity in camels.

2.7.: Anthelmintic resistance and its control

Resistance to anthelmintics is said to be present when there is a greater frequency of parasites within a population that are able to tolerate therapeutic doses of an anthelmintic than in a normal proportion of the same species. Anthelmintic drug resistance has emerged as the most important problem confronting the successful control of nematode parasites world wide (Waller, 1987). Resistance seems to occur in the most important nematode parasites and the problem has reached alarming proportions in areas where the abomasal parasite, *Haemonchus contortus* exists. The greatest resistance problem is associated with the benzimidazole group of anthelmintics.

Although the significance of the problem varies between and within countries and farming systems, there is little likelihood that it will disappear on it's own accord. Currently, progress is being made in the use of non-therapeutic methods of helminth control (Nansen, 1993; Gronvold *et al.* 1993), although these are unlikely to provide any practical alternatives in the foreseeable future. Nor, can the pharmaceutical industry be expected to solve the problem because of the long period and the exceedingly high costs involved in developing a completely new class of drugs (Waller, 1987).

Consequently, the answer must lie in carefully husbanding the currently available anthelmintics by providing farmers with programmes that give good levels of parasite control while at the same time maintaining high productivity in animals with few anthelmintic treatments. This is important because despite recent advances in non-chemotherapeutic control, anthelmintics will

continue to dominate roundworm control programmes for a long time to come.

2.8.:. CONDUCTING CLINICAL FIELD TRIALS

Clinical trials are conducted primarily to evaluate further the efficacy of the product as used by the consumer in the field and to extend experience on the safety of the drug when it is applied in different clinical conditions. It is also useful in extending the use of old drugs in animals in which they are not normally used.

The study should take care of the effects of different climatic conditions, strain variation (of the parasite), drug resistance and performance under different feeding and management practices (Powers *et al.*, 1982).

Severely infected animals indigenous to the locale should always be included in field drug trials. The drug to be used should be in its final formulation and should be given at the recommended dose using the routes indicated by the manufacturer.

Three methods are generally used in determining the efficacy of an anthelmintic or a combination of them. These include, the faecal egg count method (Gordon, 1950), the critical techniques as described by Hall and Forster (1918) and the controlled test (Moskey and Harwood, 1941). The most commonly used technique is the faecal egg count reduction method. Two faecal egg counts should be performed on each animal before drugs are administered. A minimum of three EPG readings should be performed on each animal following treatment (Reinecke, 1980). An adequate number of control animals should be used in the study and with the

exception of treatment, control animals should be handled like those on treatment. A minimum of 6 animals per treatment group is recommended.

2.8.1.1: The faecal egg count method

The test provides an estimate of the anthelmintic efficacy by comparing faecal worm egg counts of groups of animals before and after treatment. The test does not require highly trained personnel, expensive resources, sophisticated equipment or facilities. One of the shortcomings of this procedure is that anthelmintic treatment may cause a temporary suppression in worm egg output without any worm loss. Failure of an anthelmintic considerably to reduce egg counts indicates resistance, or ineffectiveness but most natural infections are with a mixture of species and only one species may be resistant. Hence, in addition to faecal egg counts, infective larvae derived from pre-and post treatment faecal cultures should be identified. If egg counts are low, this method may fail to detect resistance. Furthermore, egg counts cannot detect the presence of immature parasites that may survive treatment and develop into adult parasites and contribute to the post-treatment egg counts. However, the faecal egg count method is the best initial screening procedure for assessing anthelmintic efficacy (or resistance) in the field because it allows all anthelmintics to be tested at the same time.

CHAPTER THREE

MATERIALS AND METHODS

3.1.0 THE STUDY AREA

The study was carried out in Lorroki Division of Samburu District, Kenya. The area is situated on the lower side of Samburu District bordering Turkana, Baringo and Laikipia districts. The division has hilly dissected (undulating) plains with occasional arid stony areas. Most of the division is made up of plains interupted with hills. The mean annual rainfall (1992 figures) is 798.75 mm.

The majority of the farms have large numbers of livestock including sheep, goats, cattle and few camels. The average number of camels per household in this area is about 16 (Simpkin, Personal Communication, 1991). Animals graze communally in this area and often converge at the few watering points that are available in the division to take water. The watering points mostly take the form of stagnant water that collects during the rain season with some areas having wells. In selecting the farms for this study, preference was given to those that were accessible and convinient.

3.1.1: Rainfall data.

The amount of rainfall received in the area during the study period was recorded at the Divisional headquarters in Suguta Marmar by the Ministry of Agriculture staff. The prevalence of GIT nematodes during different rain seasons was compared among different age groups and sexes of camels.

3.2.0:. SELECTION AND MANAGEMENT OF CAMELS.

Two hundred and fifty five camels belonging to 27 farmers in Lorroki Division, Samburu District were used for the initial screening for the different types of gastrointestinal helminths. Most of the animals sampled had not received any veterinary input including deworming in the past one year.

Fifty nine of these camels were examined during the dry period in November 1992; 66 in December 1992; 47 in January 1993; 46 in February 1993 and 37 in March 1993. Thirty three camels that had PCV values of less than 24% were examined for trypanosomiasis and helminthiasis utilizing the techniques of faecal egg counts, thin blood smears and examination of the buffy coat. Faecal samples from anaemic camels were cultured to identify the nematodes responsible for the anaemia.

Seventy six camels that were found to have moderate to heavy worm egg counts were selected for the anthelmintic efficacy study. These came from 13 different manyattas (households). Table 2 shows the age structure of the camels used in this study. The camels were randomly distributed into three treatment groups and one control group of 19 animals each. The drugs used in this clinical efficacy study included albendazole (Valbazen$^{(R)}$, Ciba Geigy), levamisole (Nilverm$^{(R)}$ Cooper) and thiophanate (Nemafax$^{(R)}$, Rhone Poulenc). Control camels received dilute orange juice. The efficacy of the various drugs was compared between the different sexes and age groups of camels although the number of immature camels used was low. The animals used for clinical drug trials had their weights and ages estimated as described by Wilson (1988).

All the animals used in this study were under the care of their respective owners or their herdsmen. They were herded together with other camels and other domestic animals. The animals were penned at night in separate enclosures (bomas) at the various owners' homesteads.The management was generally traditional with the herdsmen deciding where to graze and when and where to water the camels. On average the animals were watered once weekly. Because of the drought that occurred during the most part of 1992, most animals from the other drier parts of the district were brought into the division. Hence, during most of the study period (November, 1992 to May 1993) most parts of the division were severely overgrazed and there was a lot of overcrowding around the few available watering points. There was no supplementation of the study animals.

Table 2. **Age structure of camels used in the anthelmintic drug trials**

Group	Drug used	No. of farms	No. of animals						
			Calves		Immature		Mature		Total
			F	M	Bulls	Heifers	F	M	
1-	Albendazole	11	2	1	0	7	8	1	19
2-	Levamisole	12	1	2	0	6	10	0	19
3-	Thiophanate	10	1	1	1	6	9	1	19
4-	Placebo (control)	10	1	1	1	7	7	2	19
	Total		5	5	2	26	34	4	76

Key:

1- Calf = <1 year

2- Immature bull/Heifer = >1 year < 4 years

3- Adult = >4 years old

3.3.0: SAMPLING AND LABORATORY PROCEDURES

3.3.1:. Blood samples

3.3.1.1: Determination of packed cell volume (PCV).

PCV. was determined using blood that was collected from the jugular vein of each animal using a 19 x $1^1/_2$" gauge needle. The blood was drawn directly into a heparinized capillary tube and the end sealed using crista seal.

The samples were transported to a room in Kisima town where they were placed in a microhaematocrit centrifuge (Hawksley, England) and centrifuged at 10,000 rpm for 3 minutes. The tubes

were then placed in a microhaematocrit reader (Hawksley, England) and the PCV. (expressed as a percentage) was read as the volume of the red blood cells to the total volume of the whole blood in the capillary.

The PCV was used as an indicator of anaemia. PCV values were determined once before treatment and one month after administration of drugs for animals used in the drug trials. During the survey, 160 camels in poor condition had their PCV values determined. An animal with a PCV value of less than 24% was taken to have anaemia (Higgins and Kock, 1984).

3.3.1.2.: Examination for haemoparasites.

(a) Examination of the buffy coat

After reading the PCV., the capillary tubes were broken 1 mm below and 3 cm above the leucocyte layer using a diamond pencil. The isolated segment contains 5 microlitres of erythrocytes, leucocytes and 15 microlitres of serum. These were expelled onto a slide and covered with a 22 X 22 mm cover slip. The slides were examined under the microscope at X40 objective for trypanosome parasites (without staining). All camels used in the drug trials were subjected to this test before drugs were administered.

(b) Blood smears

This was used to further rule out the presence of haemoparaistes both at the start and during the course of the drug trials. Blood smears were prepared from a small drop of blood placed on a clean slide 1 cm from the edge. The edge of another slide was

placed on the first, at an angle of 30-45 degrees. The blood was allowed to spread by capillary action along the angle formed by the two slides (Murray *et al.*,1983). The angled slide was moved along the first one with a steady movement drawing the blood behind it to spread the drop evenly on the first slide.

The blood was immediately dried in the air and stained using dilute giemsa (1:10), after fixation in methyl alcohol for 2-5 minutes. The prepared slides were allowed to stand for 30-60 minutes in the dilute Giemsa. After this the stain was washed off using neutral water and drip dried in a vertical position. The slides were examined at X100 objective using oil emersion.

3.3.2:. Analysis of faecal samples

3.3.2.1.: Baseline helminthiasis survey:

Faecal samples were collected from the rectum into plastic faecal pots. This was done once for each of the 255 camels, during the months of November,1992 to March, 1993. Nematode and cestode eggs were concentrated by floatation while those of trematodes were concentrated by sedimentation. Floatation involved the use of the modified McMaster egg counting technique (Anon, 1979).

3.3.2.2: The modified McMaster egg counting technique

Glass vials that had two marks at 28 ml and 30 ml levels were used. A saturated magnesium sulphate solution was poured into the vial up to the 28 ml mark. By displacement, 2 grams of faeces were added until the level rose to the upper mark of 30 ml. The contents were mixed thoroughly and passed through a coffee strainer. The filtrate was stirred with a dropper and, while stirring a dropper full

of the mixture was withdrawn and used to fill the counting chamber of the McMaster slide. The slide was left for 10 minutes to allow the eggs to rise to the top of the slide. The slide was then examined under low power (x10 objective) of the microscope and all the eggs in the centimetre square of the slide were counted and identified using standard parasitological keys (Soulsby, 1986). The count obtained was multiplied by 100 to get the total number of eggs per gram of faeces (EPG).

3.3.2.3.: Examination for trematode eggs

Three grammes of faeces were homogenized with water and the suspension passed through a coarse mesh sieve (about 250 microns). The material retained on the screen was thoroughly washed using a fine water jet and the debri discarded.

The filtrate was transfered to a conical flask and allowed to stand for 2 minutes. Thereafter the supernatant was removed and the remainder transfered to a flat bottomed tube. After sedimentation for a further 2 minutes, the supernatant was again drawn off and a few drops of 5% methylene blue added and the sediment examined under the microscope using low power objective (X10). Trematode eggs(yellow), when present were readily visible against the pale blue background.

3.3.2.4: Coproculture for infective nematode larvae

Fresh samples from few animals that showed high EPG. values (>1000) and anaemia were cultured using the established technique

(Anon, 1986). The cultures were done per household, and were mostly from animals that were later used for the anthelmintic drug trials.

Procedure:

About 20 g of faeces was crushed, a little water added just to wet them and placed in a jar with a tightly fitting lid. The faeces were incubated for 7 days at room temperature and on the 8th day, the jar was taken out, filled with water and inverted on a petri dish on which some drops of water were put. The preparation was left for 24 hours after which the larvae were harvested by pipetting the contents on the petri dish and transfering them to a second petri dish. The larvae were killed by adding lugols' iodine and identified under the microscope by standard methods (Soulsby, 1986).

3.4.0: Determination of anthelmintic efficacy

The 76 selected camels were randomly distributed according to age, sex, farm/household and EPG. values into three treatment and one control group (Table 2). Animals in the control group were given a placebo that consisted of dilute orange juice .The dosages used were those recommended by the manufacturers as follows:-

a) Group 1: Albendazole (Valbazen^{R}, Ciba Geigy) : 10mg/kg body weight
b) Group 2: Levamisole (Nilverm^{R}, Cooper) : 7.5mg/kg body weight
c) Group 3: Thiophanate (Nemafax^{R}, Rhone Poulenc) : 15ml/50kg body weight
d) Group 4: placebo (control).

The only nematode eggs counted are those of parasites that are known to cause major economic losses in camels.

Pre-treatment EPG was done twice one week apart before treatment of the camels with anthelmintics started and the average of the 2 nematode worm egg counts was used as the EPG reading on day 0. All faecal samples were collected between 10 am and 12 pm to avoid diurnal variations in worm egg counts (Anon, 1986).

Following treatment faecal samples were collected for determination of nematode worm egg counts on days 1, 2, 3, 14, 21 and 28. The animals were also closely monitored for haemoparasitosis and other diseases over the 4 week period. Those found to be sick were promptly treated. The animals were also closely observed for any reactions to the anthelmintics used in this study.

3.5.0: Data analysis

Data were subjected to analysis of variance (ANOVA) (Wayne, 1987) using IBM computer with the the SAS (SAS Institute Inc., Cary, NC, USA) statistical package. Tukey's Highest Significant difference (HSD) test was used to determine if there was a significant difference in the group means at 5% level of significance.

CHAPTER FOUR

RESULTS

4.1.0: STRONGYLE WORM EGG COUNTS DURING THE BASELINESURVEY

4.1.1: Levels of GIT nematodes in relation to total rainfall in Lorroki Division during the study period

The mean monthly strongyle egg counts for the camels used in the baseline helminth survey and the total rainfall figures in the study area during the months of November 1992 to March 1993 are presented in Table 3. The results show that mean strongyle egg counts increased from 379.7 EPG in November 1992 to 961.7 in January 1993. They then dropped to 747.8 in February 1993 and finally to 391.9 at the end of the survey period, in March 1993. Figure 4 shows the mean strongyle egg counts of the camels in relation to total rainfall recorded in mm.

Table 3: Mean monthly Strongyle egg counts of camels in relation to rainfall in Lorroki division of Samburu district.

Month	Total rainfall (mm)	Mean ± SD Strongyle egg counts (Number of samples in brackets)
November 1992	51.3	379.67 ± 432.23 (59)
December 1992	77.4	683.33 ± 1084.50 (66)
January 1993	105.4	961.70 ± 1934.0 (47)
February 1993	18.0	747.83 ± 1183.70 (46)
March 1993	1.1	391.89 ± 530.92 (37)

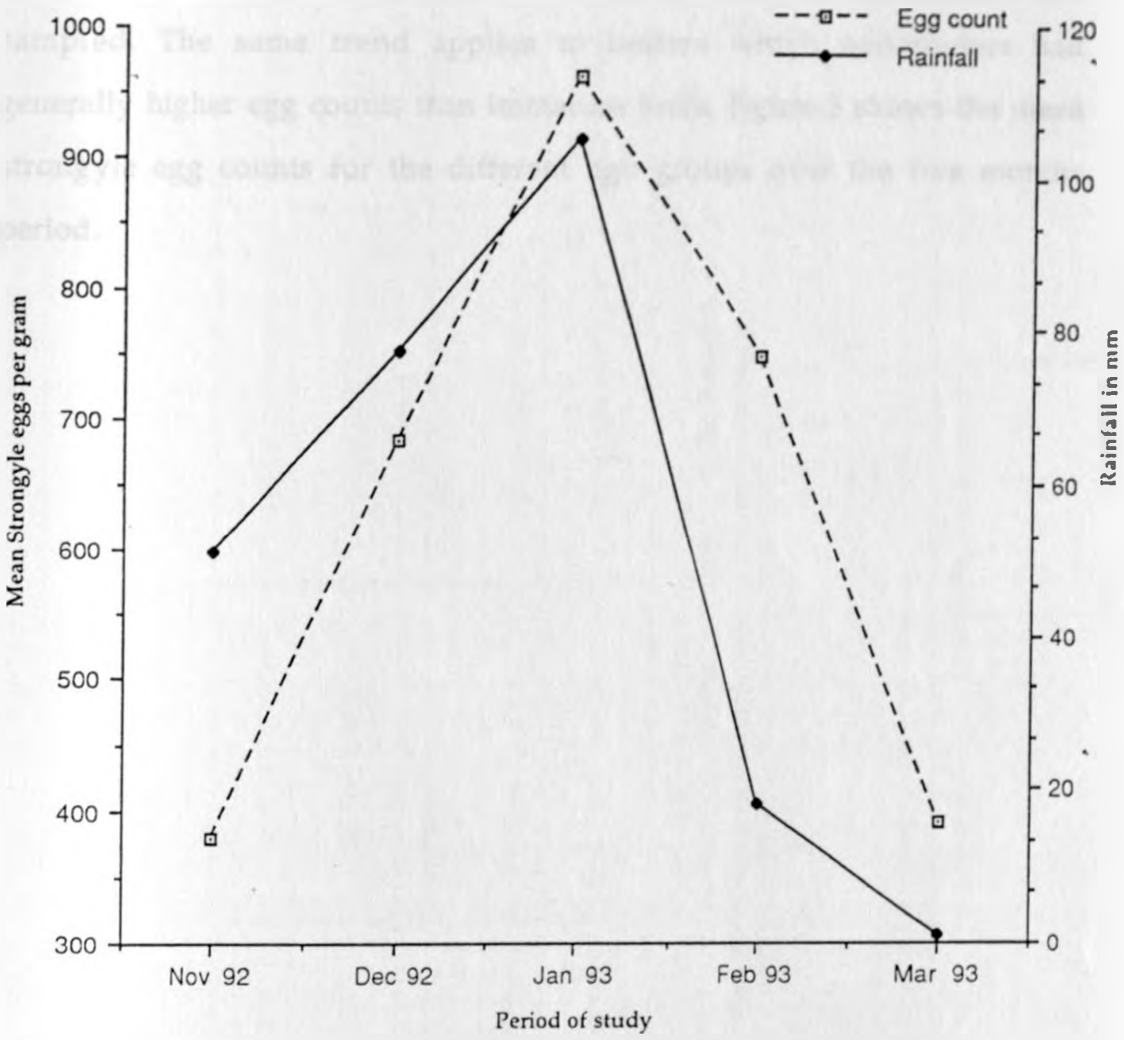

Figure 4: Mean strongyle egg counts of camels in relation to total rainfall (mm) in Lorroki division

4.1.2: Mean strongyle egg counts in relation to age during the survey

Table 4 shows the mean monthly strongyle egg counts in different age groups of camels used in this study. Data from this study shows that calves had lower strongyle egg counts than adults over the five months study period except in November 1992 and January 1993. Although the sample size for the immature bulls was generally low, the data suggest that their worm egg counts were mostly lower than those of calves except in

November 1992 and January 1993, when only one camel in this category was sampled. The same trend applies to heifers which nonetheless had generally higher egg counts than immature bulls. Figure 5 shows the mean strongyle egg counts for the different age groups over the five months period.

TABLE 4:

Mean ± SD Strongyle egg counts for the different age groups of camels during the survey (Number of samples in brackets)

Month	Calves (< 1 year old)	Immatures (> 1 year <4 years) Bulls	Heifers	Adults (>4 years)
November 1992	454.58 ± 663.87(11)	460.0 ± 572.71(5)	400.0 ± 362.53(15)	325.0 ± 338.43(28)
December 1992	388.89 ± 261.94 (9)	175.0 ± 95.74(4)	277.78 ± 315.35(9)	872.73 ± 73 ± 73.0(44)
January 1993	1458.30 ± 2363.90(12)	100.0 ± 173.21(3)	408.33 ± 334.28(12)	1125.0 ± 2293.0(20)
February 1993	522.22 ± 940.45(9)	100.0 ± 100.0(3)	916.67 ± 110.70(12)	836.36 ± 1384.10(22)
March 1993	316.67 ± 483.39 (6)	600.0 ± 0(1)	485.71 ± 985.61(7)	373.91 ± 369.54(23)

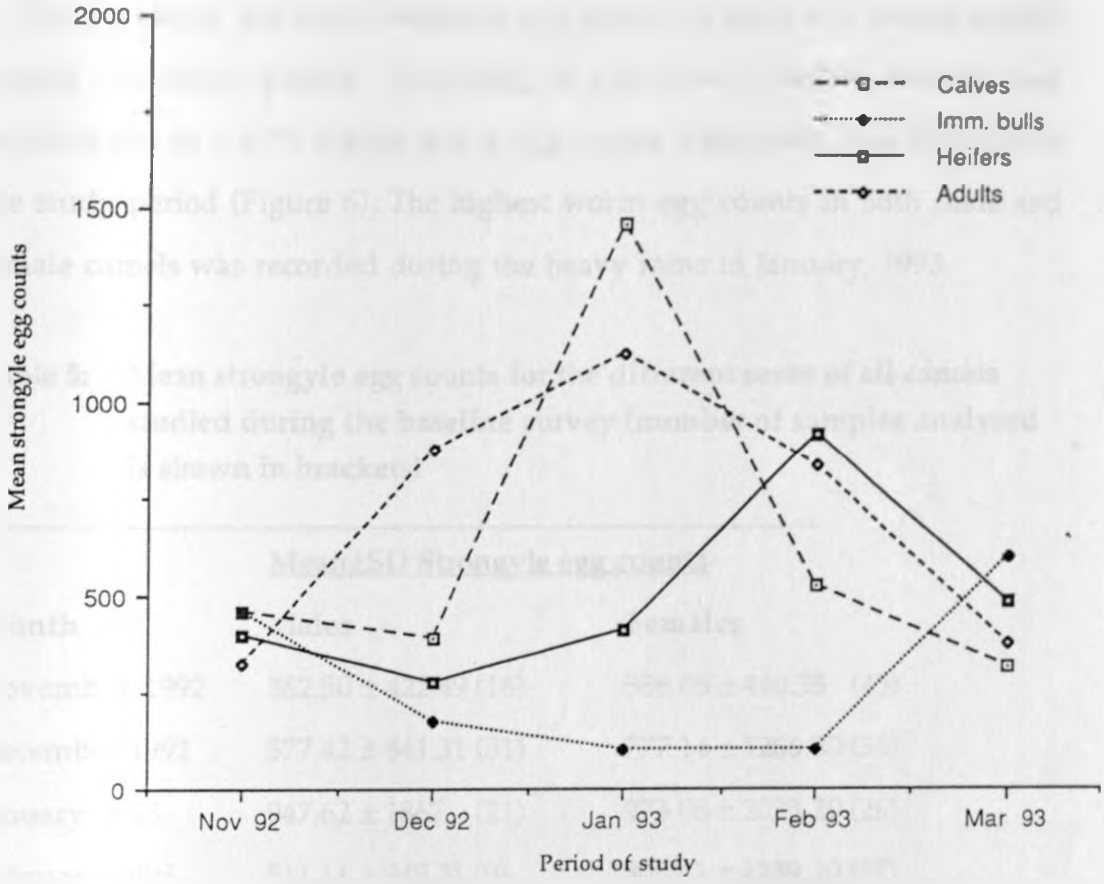

Figure 5 Mean strongyle egg counts for the different age groups of camels over the study period

During the wettest month of the study period (January 1993) calves had the highest worm egg counts followed by adults, while the immatures (both bulls and heifers had the highest egg counts during the dry month of March 1993 (and in November 1992 for the immature bulls).

4.1.3: Mean strongyle egg counts in relation to sex during the baseline survey

Table 5 shows the mean strongyle egg counts in male and female camels during the study period. According to this study, female animals had significantly ($p < 0.05$) higher worm egg counts than male ones throughout the study period (Figure 6). The highest worm egg counts in both male and female camels was recorded during the heavy rains in January, 1993.

Table 5: Mean strongyle egg counts for the different sexes of all camels studied during the baseline survey (number of samples analysed is shown in brackets)

	Mean±SD Strongyle egg counts	
Month	Males	Females
November 1992	362.50 ± 422.49 (16)	386.05 ± 440.55 (43)
December 1992	577.42 ± 841.31 (31)	777.14 ± 1266.80 (35)
January 1993	947.62 ± 1867 (21)	973.08 ± 2023.20 (26)
February 1993	511.11 ± 945.31 (9)	805.41 ± 1239.20 (37)
March 1993	387.50 ± 491.17 (19)	393.10 ± 549.63 (29)

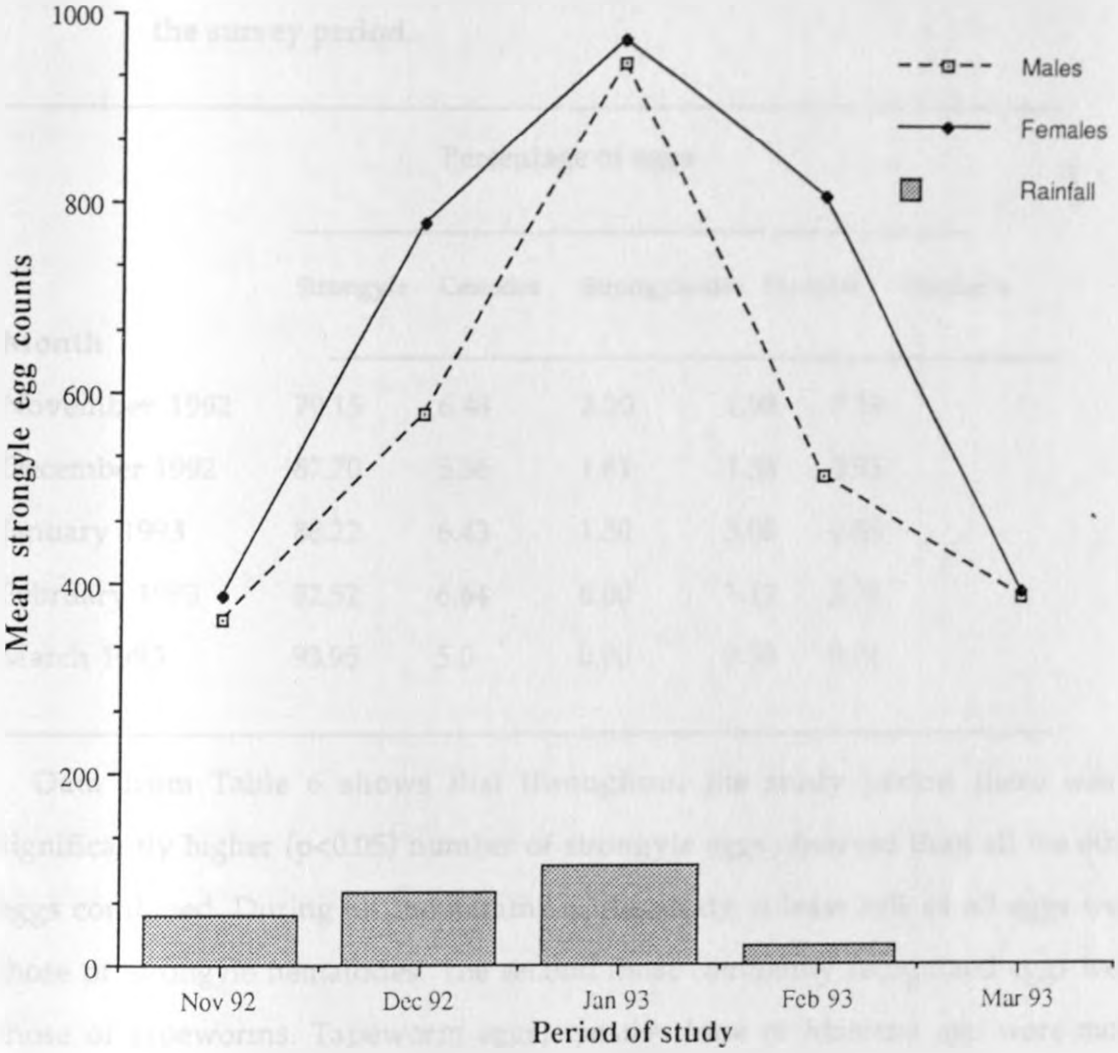

Figure 6: Mean strongyle egg counts in relation to sex of camels during the survey period.

4.2.0: Types of worm eggs identified during the baseline survey.

Although this study gave more emphasis to strongyle eggs because of the recognized health and production constraints imposed on the camel by the strongyle nematodes, several other types of eggs were recognized during the study. Table 6 shows the percentages of the different eggs identified during the survey.

Table 6: Percentage of different worm eggs identified during the survey period.

	Percentage of eggs				
Month	Strongyle	Cestodes	Strongyloides	Fasciola	Trichuris
November 1992	79.15	6.48	5.20	1.98	7.19
December 1992	87.70	5.36	1.61	1.38	3.95
January 1993	88.22	6.43	1.50	3.00	0.85
February 1993	82.52	6.64	6.00	1.12	3.72
March 1993	93.95	5.0	0.00	0.30	0.74

Data from Table 6 shows that throughout the study period there was a significantly higher ($p<0.05$) number of strongyle eggs observed than all the other eggs combined. During all the months of the study at least 80% of all eggs were those of strongyle nematodes. The second most commonly recognized eggs were those of tapeworms. Tapeworm eggs, mostly those of *Moniezia spp* were more common in calves and adult females. Segments of this tapeworm were visible in the faeces of these animals especially during the rain season. Eggs of *Strongyloides spp* and *Trichuris spp* were identified in a fair proportion of the animals sampled. Eggs of *Fasciola spp* occurred at low levels throughout the study period.

4.3.0: Larval culture and identification of the various nematodes

The different types of infective nematode larvae isolated on culture and identification are shown in Table 7.

Table 7: Nematode larvae recovered during the survey period as a percentage of the total

Parasite	No. of farms where it was identified	% of the total parasites identified
Haemonchus spp	14	48.62
Trichostrongylus spp	10	32.14
Cooperia spp	7	9.78
Bunostomum spp	5	5.29
Oesophagostomum spp	3	2.61
Strongyloides spp	3	0.91
Ostertagia spp	1	0.65

The results show that *Haemonchus spp* was by far the most common strongyle nematode present. *Trichostrongylus spp* was also very common while *Cooperia spp* and *Bunostomum spp* occurred at relatively low levels in a fair proportion of the herds. *Oesophagostomum spp. Strongyloides spp* and *Ostertagia spp* were the least encountered.

4.4.0: COMPARATIVE EFFICACY OF THE ANTHELMINTICS

4.4.1: The packed cell volume (PCV).

Mean PCV values of camels in different treatment groups before and after treatment are shown in Table 8. Before treatment, all the groups had mean PCV values above the critical minimum (24%).

Table 8: PCV values for camels in different treatment groups (n=19) before and after treatment

Group	Drug	Mean ± SD pre-treatment PCV (%)	Mean ± SD post-treatment PCV(%)
1	Albendazole	24.89 ± 3.59	24.95 ± 3.24
2	Levamisole	24.16 ± 3.93	24.16 ± 2.77
3	Thiophanate	24.00 ± 4.29	25.16 ± 3.42
4	Control	24.21 ± 4.02	23.32 ± 3.97

The data shows that all treatment groups had significantly ($P < 0.05$) higher PCV values than the control group at the end of the experiment. Hence treatment alleviated anaemia and it was noticed that more camels in the treatment groups maintained good body conditions during and after the study period when compared with the non-treated ones. Age and sex had no significant effect ($P > 0.05$) on the efficacy of the different drugs used. When examined individually, thiophanate caused the biggest improvement in PCV followed by albendazole. Levamisole did not cause any change while the anaemia status in the control camels worsened.

4.4.2: Overall post treatment worm egg counts

The pre-and post treatment mean egg counts in the treatment and control groups are shown in table 9. There was no significant difference ($P > 0.05$) in the levels to which the three drugs reduced the nematode worm egg counts on the first day after treatment. On this day, the data indicates a less than 50% fall in mean nematode egg counts except for thiophanate which caused a 66.19% fall in worm egg counts. Figure 7 illustrates the results of this anthelmintic drug study.

Table 9: A two way table of treatments and mean worm egg counts per gramme of faeces before and after treatment

Treatment/days	Pre-treatment	Post-treatment mean E.P.G values					
	mean E.P.G	1	3	7	14	21	28
Albendazole	1276.30	1021.1	42.1	121.1	0	47.4	47.4
Levamisole	1215.80	736.80	736.8	426.3	47.4	59.9	136.8
Thiophanate	1634.2	552.6	78.6	89.5	52.6	33.2	126.3
Control	1147.4	694.7	710.5	778.9	1078.9	910.5	1178.9

The data indicates a 65-97% fall in nematode worm egg counts values by the third day. The fall in worm egg counts on this day were 65%,96.7% and 95.2% for levamisole, albendazole and thiophanate respectively. Mean worm egg counts for the control animals also showed a fall of 39.5% on the first day and there after started rising exceeding the pre-treatment mean worm egg count of control animals by day 28. However, all the three drugs significantly ($P < 0.05$) reduced the nematode egg counts on all the post treatment days after day 3 when compared with that of the untreated control camels

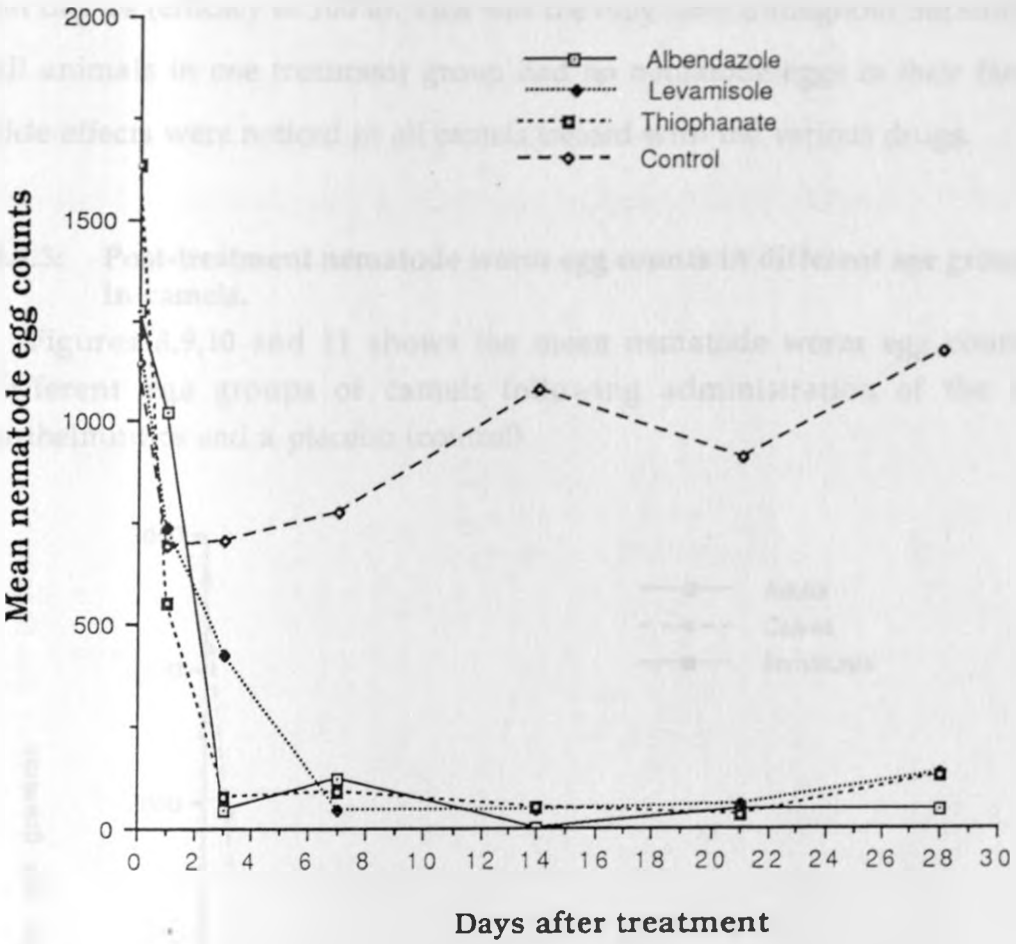

Figure 7.: Mean nematode worm egg counts in different treatment groups following administration of the drugs.

From figure 7 it can be seen that thiophanate caused the most rapid fall in nematode egg counts followed by albendazole. Levamisole took almost one week to reduce the egg counts to levels that had been reached by the other two drugs by day three. After day 7 the performance of the three drugs was almost the same except towards the end (day 28) when animals that had received levamisole and thiophanate seemed to void more nematode eggs than those that had received albendazole.

Animals that received albendazole had no worm eggs voided in their faeces on day 14 (efficacy of 100%). This was the only time throughout the study when all animals in one treatment group had no nematode eggs in their faeces. No side effects were noticed in all camels treated with the various drugs.

4.4.3: Post-treatment nematode worm egg counts in different age groups in camels.

Figures 8,9,10 and 11 shows the mean nematode worm egg counts in different age groups of camels following administration of the three anthelmintics and a placebo (control).

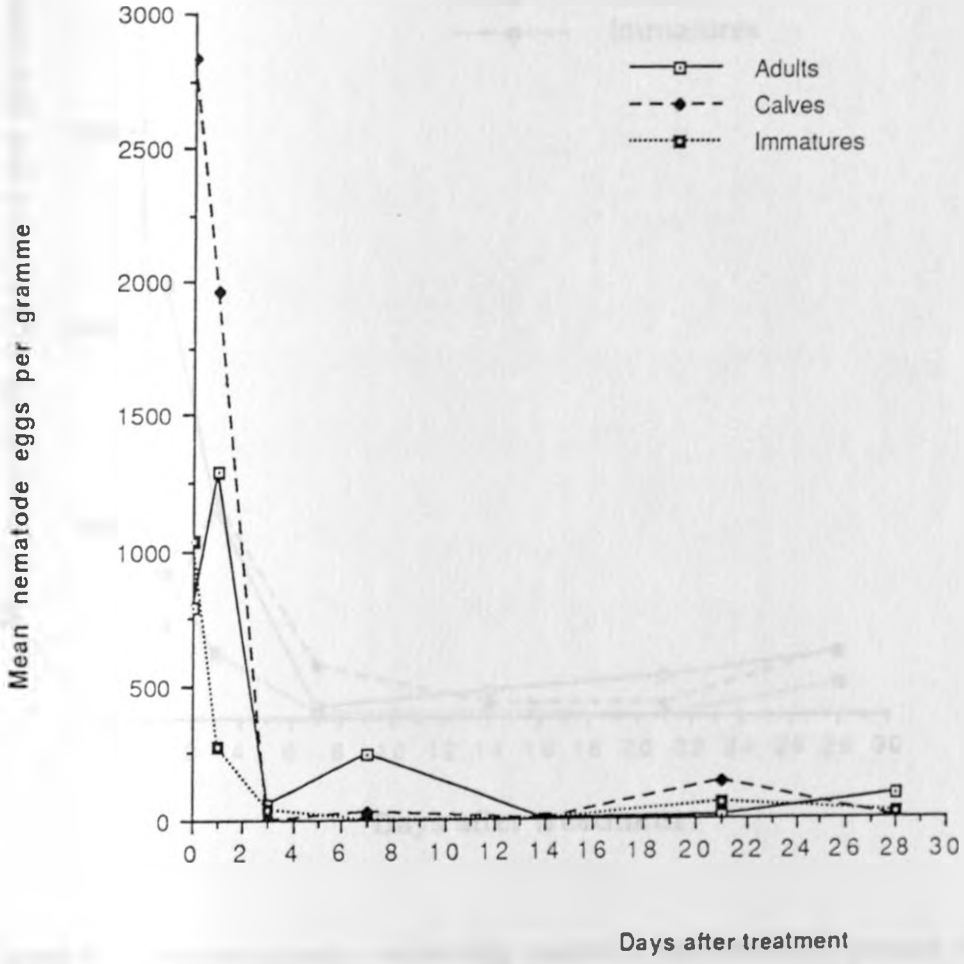

Figure 8: Mean nematode worm egg counts in different age groups after treatment with albendazole

The results show that albendazole was more effective in the immatures and calves, but less effective in adults. The drug had an efficacy of 100% in immatures and calves on days 7 and 28 after treatment respectively. It showed the same efficacy in all camels on day 14 after treatment. The action of the drug in adult camels was somehow inconsistent.

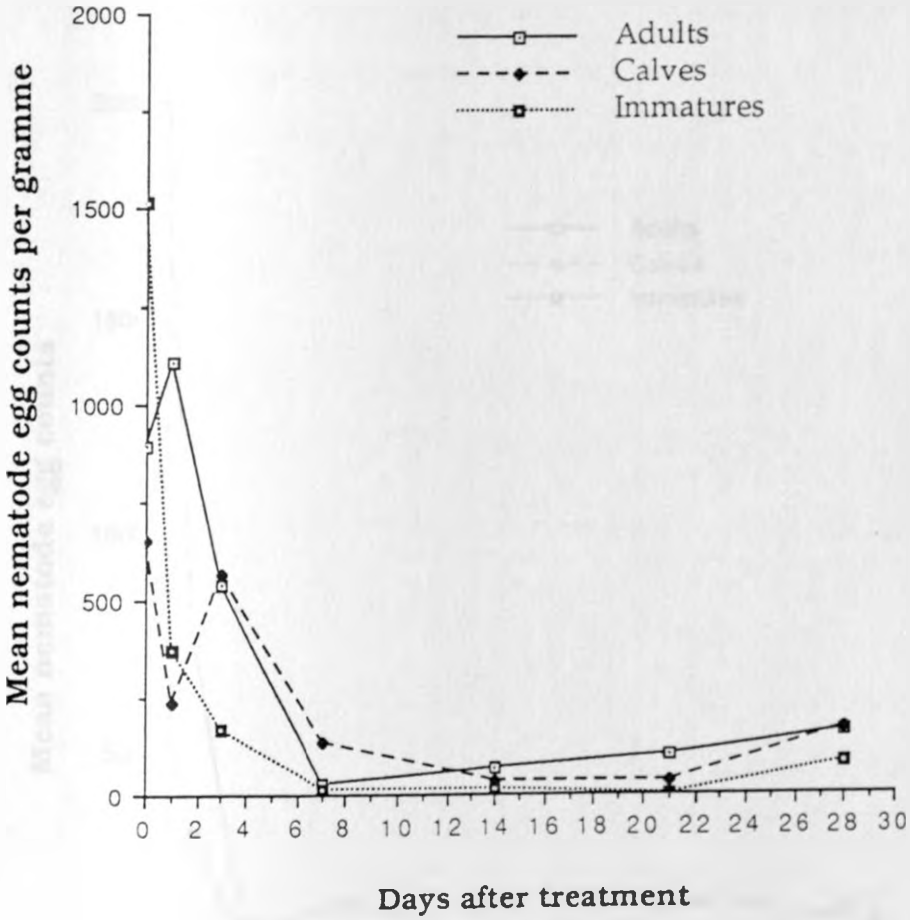

Figure 9: Mean nematode worm egg counts in different age groups of camels treated with levamisole

Levamisole apparently took one week to reduce nematode worm egg counts in all age groups to any appreciable levels. The drug took almost two weeks to significantly reduce nematode egg counts in calves, but the counts were up again by day 21. The egg counts in adult camels also picked up fairly fast and was appreciably high by day 28 after treatment. The drug did not show an efficacy of 100% in any of the age groups throughout the one month study period.

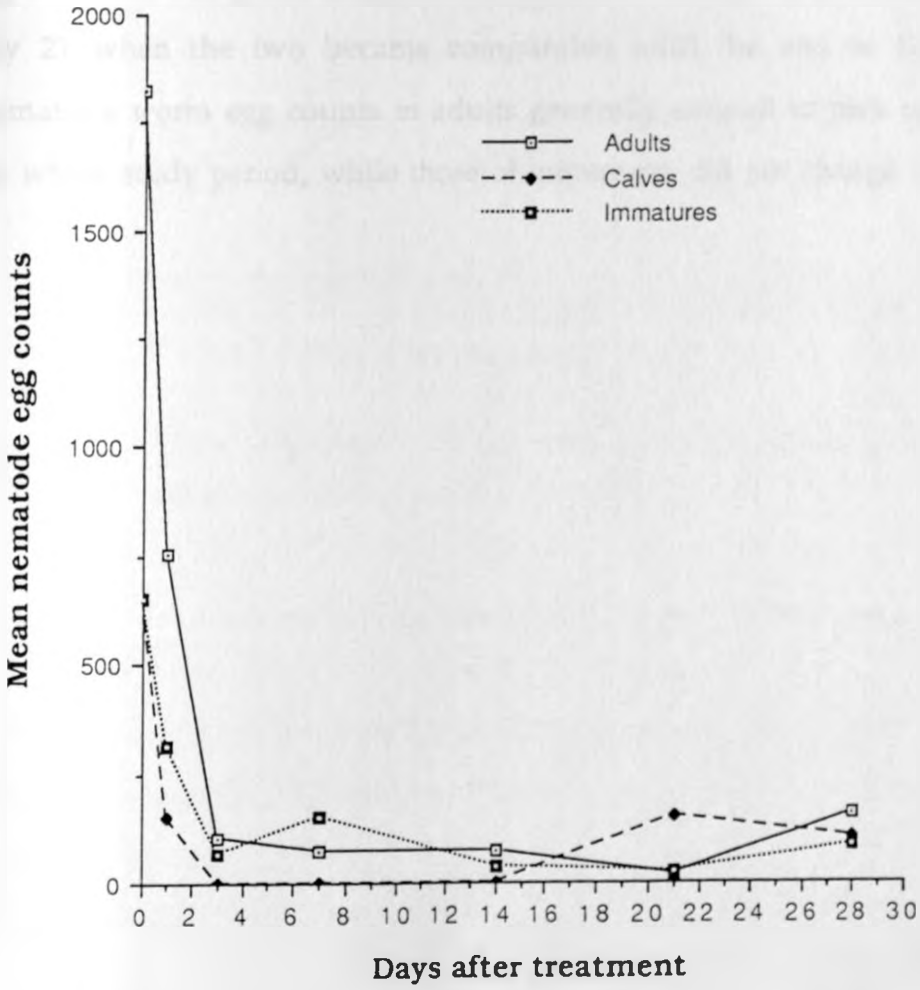

Figure 10: Mean nematode worm egg counts in camels of different age groups treated with thiophanate

Thiophanate was apparently very effective in calves where it showed an efficacy of 100% on days 3, 7 and 14 after treatment. The efficacy of this drug was good in all age groups by day 3 after treatment although egg counts remained fairly high in adults and immatures until day 14. There after calves and adults seemed to pass out more nematode eggs than the immatures.

Within the control group (figure 10) calves had the highest ($P < 0.05$) nematode worm egg counts during much of the study period.However, the egg counts in this group dropped to the same level as those of immatures by day 21 when the two became comparable until the end of the study. Nematode worm egg counts in adults generally seemed to pick up during the whole study period, while those of immatures did not change much.

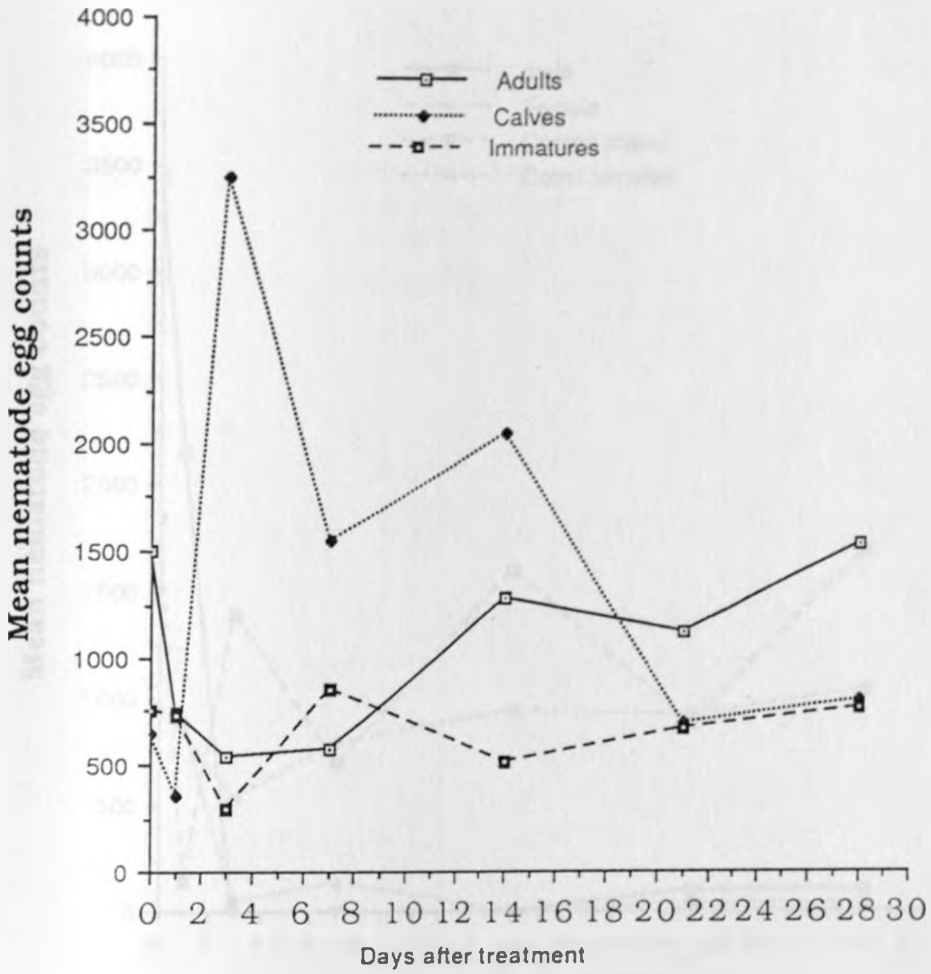

Figure 11: Mean nematode worm egg counts in camels of different age groups that received a placebo (Control).

4.4.4: Post-treatment nematode worm egg counts in different sexes of camels.

Figures 12,13 and 14 shows the mean nematode worm egg counts in male and female camels following administration of the three drugs and a placebo (control).

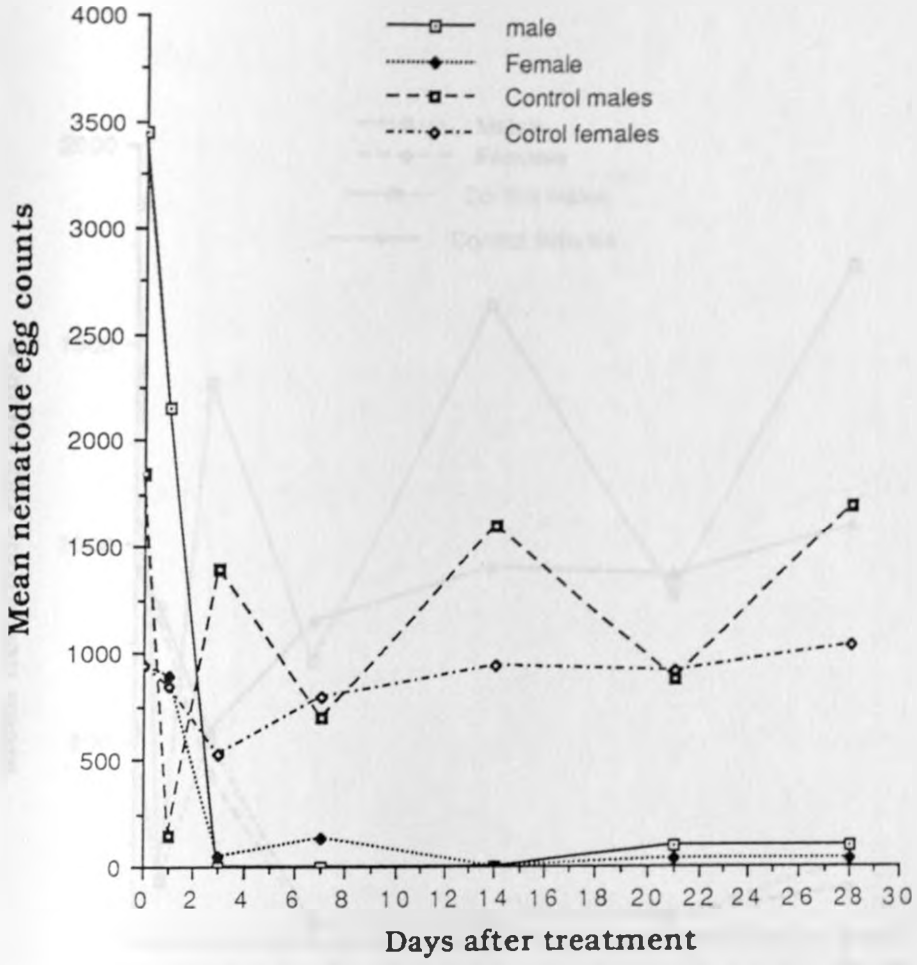

Figure 12: **Mean nematode egg counts in male and female of camels treated with albendazole**

Albendazole had a very good efficacy in male and female camels used in this study as illustrated by figure 12. Nematode worm egg counts increased slightly in female camels after day 3 but they were down again by day 14 after treatment. At the end of one month, male camels had more nematode worm egg counts than females.

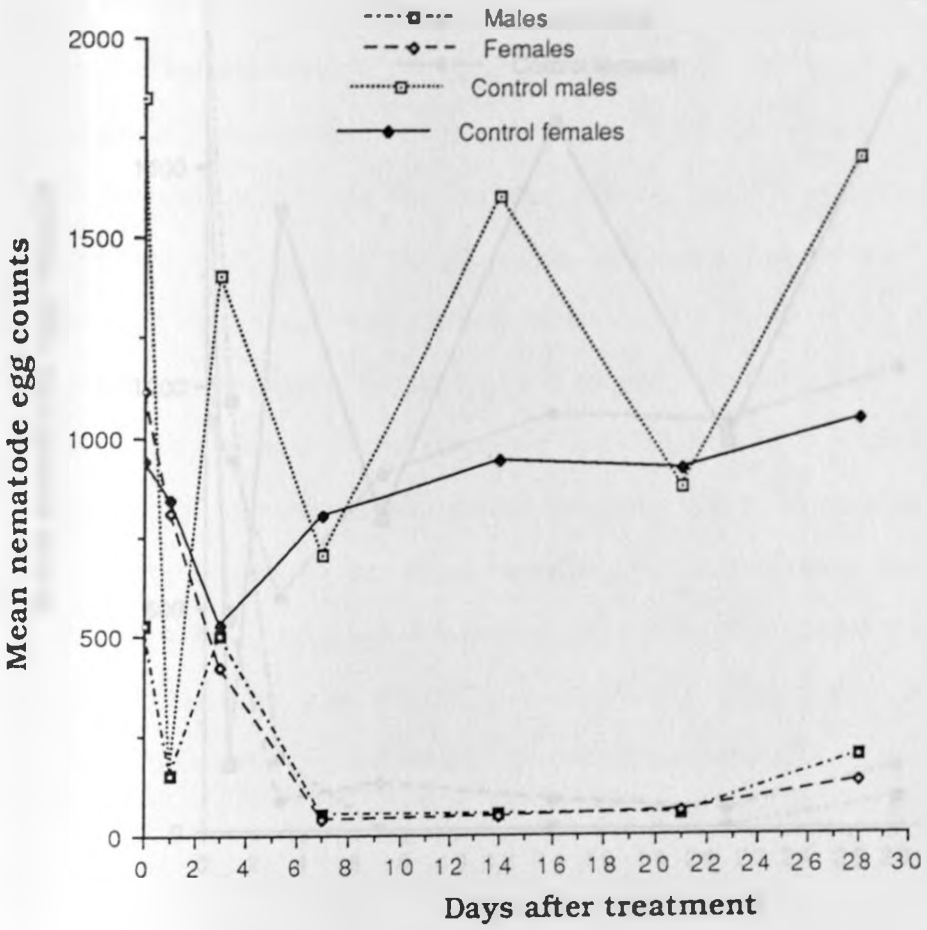

Figure 13: Mean nematode egg counts in male and female camels treated with levamisole

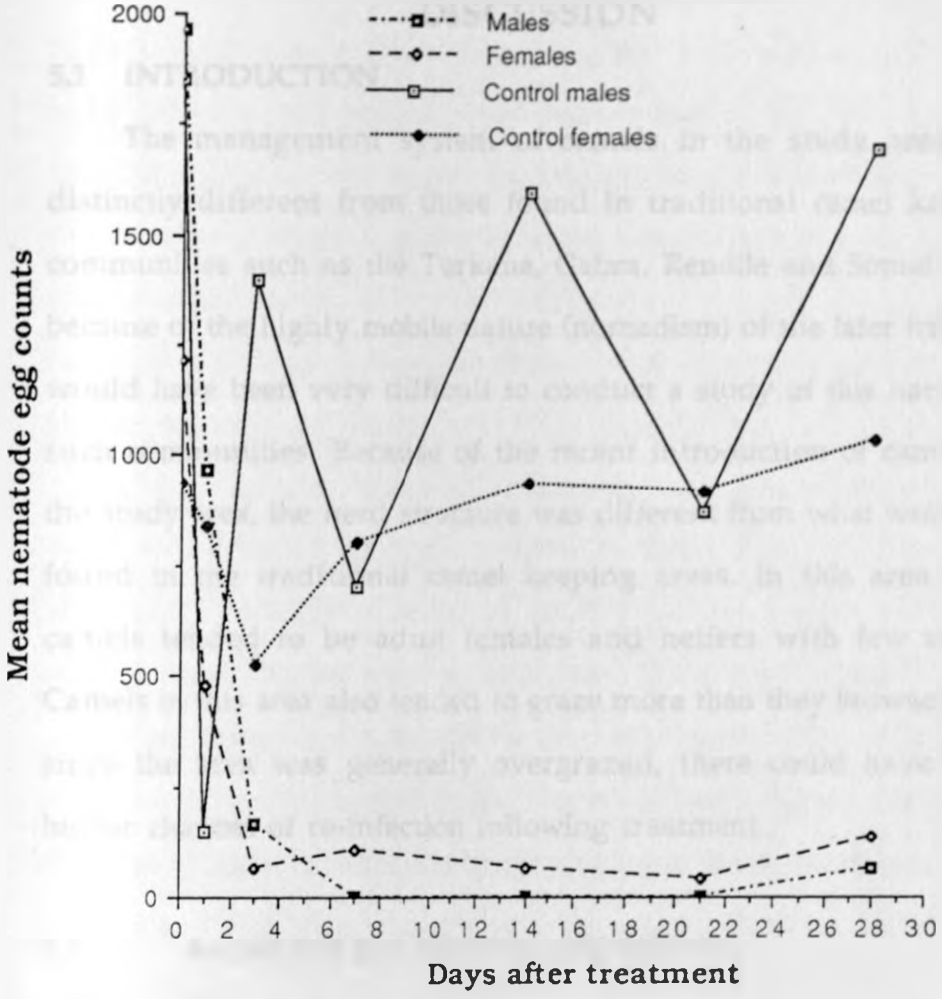

Figure 14:. Mean nematode egg counts in different sexes of camels treated with Thiophanate.

The action of levamisole in both male and female camels was comparable and followed the same pattern seen for age groups. Thiophanate was apparently more effective in males than in female camels during much of the experimental period. In the control group males had higher nematode worm egg counts than females during most of the study period. The egg counts among the males had a very high variation during the study.

CHAPTER FIVE

DISCUSSION

5.1 INTRODUCTION

The management system of camels in the study area was distinctly different from those found in traditional camel keeping communities such as the Turkana, Gabra, Rendile and Somali. But, because of the highly mobile nature (nomadism) of the later tribes, it would have been very difficult to conduct a study of this nature in such communities. Because of the recent introduction of camels in the study area, the herd structure was different from what would be found in the traditional camel keeping areas. In this area most camels tended to be adult females and heifers with few males. Camels in this area also tended to graze more than they browsed and since the area was generally overgrazed, there could have been higher chances of re-infection following treatment.

5.2: BASELINE HELMINTHIASIS SURVEY

5.2.1: Worm egg counts

It was observed that peak strongyle egg production in untreated camels was recorded during the high unexpected rains of January 1993. The high amount rainfall could have favoured the survival of infective larvae on the pasture. This has been reported previously in Kenya (Rutagwenda, 1985; Njanja 1991), Ethiopia (Richard, 1984) and Saudi Arabia (EL Bihari and Kawasmeh, 1980).

Despite the fact that there was very little rain in this area throughout much of 1992, the worm egg counts in November 1992 were fairly high. The same was observed after the heavy rains in

March 1993 when despite recording just a trace amount of rainfall (1.1 mm), the worm egg counts were high. This has been reported in Nigeria and Kenya (Rutagwenda, 1985) and was attributed to inhibited immature stages of the worms that resume development as a result of a decline in the immune status of the hosts during the dry seasons when pasture is scarce and camels have to walk for long distances in search of water and pasture. Arzoun *et al.* (1984a) reported a similar phenomena (hypobiosis) in camels infected with *H. longistipes*.

Generally, the results of strongyle worm egg counts showed that adult camels had higher worm burdens than the immatures and calves. However, the calves seemed to have higher worm egg counts than the immatures and the worm egg counts for the immature bulls continued decreasing even during the time when rains were heaviest. Although, the study period was short, the findings agree with what has been reported in cattle, sheep and goats (Soulsby, 1986). The mature animals, especially the females are mostly under the stress of pregnancy and lactation. This could have reduced the immune status and could have been responsible for the high worm counts among adult females. The undeveloped immunity in calves could haave been responsible for the the high worm egg counts. The results also indicate that the females had higher worm egg counts than males throughout the study period. This could still be due to stress in females that is generally lacking in the males.

5.2.2.: The types of worm eggs identified

Throughout the study period, eggs of strongyle nematodes were the most common. This agrees with the findings of earlier workers (Richard, 1976, Lodha *et al.*, 1977; Wilson *et al.*, 1984; Arzoun *et al.*, 1984b) that nematodes are the most common and most pathogenic parasites of the camel. In this study, a fairly high number of cestode eggs was recorded. This confirms the findings of Alfaif (1974), Richard (1976), Wilson (1988) and Abdulrahman and Bornstein (1991). The low prevalence of *Strongyloides spp* and *Trichuris spp* reported in this study was lower than what has been found previously (Wilson *et al* 1984; Wilson, 1988; Njanja, 1991, Wosene, 1991)

Eggs of *Fasciola spp* occurred at low levels throughout this study. This is the first time that fascioliasis is being reported in camels in Kenya. However, this parasite has been reported in camels in Saudi Arabia by Magzoub and Kassim (1978) and in the Sudan (Malek, 1959). The presence of *Fasciola spp* in this area could be due to the fairly high rainfall that occurs here compared to the further North of Kenya where most research on camels has been done. High amounts of rainfall has been known to provide a conducive environment in which the snails, the intermediate hosts survive and pass on infection to animals. The camels could also be getting the fasciola infections from the large number of cattle and small ruminants that are present in this area. Interchange of helminth parasites between camels and other domestic animals has been reported (Arzoun *et al.*, 1983; El Bihari, 1985; Baitursinov and Berkinbaev, 1989; Onyali and Onwuliri, 1989)

5.2.3: Larval culture and identification

The results indicate a high incidence of *Haemonchus spp* in camels. Although this parasite was not characterized fully upto the species level, probably the majority could have been *Haemonchus longistipes* and a few *Haemonchus contortus*. The high incidence of *Haemonchus spp* in Kenya has been reported before by Wilson *et al.* (1984) and Rutagwenda (1985). However, *Haemonchus longistipes* is recognized as the most common and most pathogenic internal parasite of camels (Steward, 1950, Malek; 1959; Graber *et al* 1967, EL Bihari and Kawasmeh, 1980, Arzoun *et al.* 1984a, Tager-Kagan, 1984, Onyali and Onwuliri, 1989).

The high incidence of *Trichostrongylus spp* that was recorded in this study has also been reported by other workers (Wosene 1991). Altaif (1974) and Abdul-Salam and Farah (1988) respectively found that in Iraq and Kuwait, *Trichostrongylus probolurus* was the most common helminth parasite of camels and could have been the most pathogenic.

The other parasites that were recorded in this study have been reported with different prevalence rates in different countries *Oesophagostomum spp* has been reported in the camel by Tager-Kagan (1984) and Kapur and Sharma (1972), *Ostertagia spp* by Kapur and Sharma (1972) and Michael *et al.* (1980), *Strongyloides spp* by Graber (1966) and Kapur and Sharma (1972), *Bunostomum spp* by Michael *et al.* (1980) and *Cooperia spp* by Frolka (1988).

5.3.0: DRUG TRIALS

5.3.1: The packed cell volume

The study showed significant differences ($P<0.05$) in PCV values between the treated and untreated control camels one month after the drugs were administered. The treated camels had higher PCV values than the controls, showing that they probably had a better health status. Since the presence of trypanosomiasis had been ruled out in these animals, it seems the drugs were effective in reducing the worm loads to levels where the anaemia status was eliminated.

Hence the three drugs, administered at the recommended dosage rates had positive effects on PCV values and possibly on productivity. This action of albendazole has been reported for thiabendazole (also a benzimidazole) in camels by Njanja (1991). No reports exist on the actions of levamisole, albendazole and thiophanate in improving PCV values in the camel.

5.3.2: Overall anthelmintic efficacy

The levels to which the three anthelmintics reduced the nematode worm egg counts on day one after treatment was comparable to the nematode worm egg counts of the control animals.

Thiophanate was apparently more effective than levamisole and albendazole upto the third day after treatment as it caused a greater reduction in post-treatment nematode egg counts. This action of thiophanate in camels has not been reported, but the

efficacy is comparable with what has been found for this drug in cattle, sheep and goats (Brander *et al.*, 1991).

Although the rate at which albendazole reduced the worm egg counts in the first three days, was slower than that by thiophanate it had the highest efficacy by day three after treatment. This is also the only drug that showed a 100% efficacy by day 14 following treatment.

Levamisole apparently took almost one week after treatment to reduce the nematode egg counts to levels that had been reached by albendazole and thiophanate on post-treatment day three. This slow and inconsistent action of levamisole in camels had been reported by Walley (1966) and Lodha *et al.*, (1977) . However, the efficacy of this drug in cattle and sheep in Kenya, in its combined form with bithionol sulphoxide (Wormicid^{R}-plus, Cosmos) was found to be very high (Maribei, 1985). Several other workers (Walley, 1966) have proved the high and consistent efficacy of levamisole in treating nematodes of cattle, sheep and goats.

After post-treatment day 7, the performance of the three anthelmintics was apparently the same until after one month when camels that had received levamisole and thiophanate seemed to void more worm eggs than those that had received albendazole. This could probably be due to the prolonged ovicidal action of albendazole which has been reported in camels for oxfendazole (also a benzimidazole) by Michael *et al.*, (1980). Although thiophanate has also been found to be ovicidal (unlike levamisole) to worm eggs in cattle and other animals, it's action in this study was not comparable to that of albendazole. This action of thiophanate could be due to it's

very early excretion (within 72 hours) from the body of treated animals (Brander *et al.*, 1991).

The rapid and high efficacy of albendazole that was recorded in this study has been reported for other benzimidazoles. Thiabendazole has been found to be effective in treating camel helminthiasis (Graber 1966; Chandrasekharan *et al.*, 1970; Kapur and Sharma, 1972). However, Lodha *et al.* (1977) found in a comparative study that thiabendazole was the least effective in treating camel helminthiasis when compared with methyridine, morantel tartrate and tetramisole (levamisole) hydrochloride.

Other benzimidazoles that have been found to be effective in treating camel helminthiasis include mebendazole (Forstner *et al.*, 1977, cited by Michael *et al.*, 1980) and oxfendazole (Michael *et al.*, 1980). However mebendazole is reported to be ineffective in treating lungworm infections. No studies have been done to compare the efficacy of anthelmintics among different age groups and sexes of camels.

The following conclusions and findings can be made from this study:.

1- The study confirms that peak worm egg counts in camels occur during and soon after the heavy rains.

2- The study confirms that *Haemonchus spp* is the commonest and could be the most pathogenic helminth of the camel.

3- The study indicates that thiophanate was the best drug as shown by the significant reduction in the post-treatment nematode worm egg counts and improvement in the anaemia status. Albendazole and levamisole came next in that order with the later being the least effective.

4- The study indicated that the age and sex of camels had no effect on the efficacy of the various drugs used.

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APPENDICES

Key to the appendices

1- Sex 0 = Male
1 = Female

2= Trichu= Trichuris eggs

3= Strloides = Strongyloides eggs

4= Cesto = Cestode eggs

5= Trem = Trematode eggs.

6= Total = Total number of worm eggs.

7= Age C = 1 = Calf
A = 4 = Adult
H = 2 = Heifer
I = 3 = Immature

8-Post 1-6 = Post-treatment e.p.g readings on days 1,3,7,14,21 and 28.

9-Avpre = Average e.p.g readings before treatment.

Appendix 1: Worm egg counts in November, 1992.

Farm	Animal Number	Sex	Age	Number of eggs recorded: Strongyles	Trichu	Strloides	Cesto	Trem	TOTAL
18	1	0	C	300	0	100	0	0	400
18	2	1	C	600	100	0	0	0	700
18	3	0	I	1400	0	0	100	0	1500
18	4	1	H	100	0	0	0	100	200
18	5	1	H	100	0	0	0	0	100
18	6	0	I	600	0	0	0	0	600
18	7	0	A	400	0	0	0	0	400
18	8	1	A	200	0	0	0	0	200
18	9	1	A	100	0	0	0	0	100
18	10	1	A	500	0	0	0	0	500
18	11	1	A	0	100	0	0	0	100
18	12	1	A	400	0	0	0	0	400
19	1	0	C	300	0	0	0	0	300
19	2	0	C	400	0	0	0	0	400
19	3	1	C	0	100	0	0	0	100
19	4	1	C	200	0	0	0	0	200
19	5	0	C	0	0	100	0	0	100
19	6	1	H	500	0	0	0	0	500
19	7	1	H	300	0	0	0	0	300
19	8	0	I	200	0	0	0	0	200
19	9	0	I	100	0	0	100	0	200
19	10	0	A	0	0	0	0	0	0
19	11	1	A	100	0	0	0	0	100
19	12	1	A	500	100	0	0	0	600
19	13	1	A	0	0	0	100	0	100
19	14	1	A	200	0	0	0	0	200
19	15	1	A	200	0	0	0	0	200
20	1	1	H	100	0	0	0	0	100
20	2	1	H	900	0	0	100	0	1000
20	3	1	H	500	100	0	0	0	600
20	4	1	H	700	0	0	0	100	800
20	5	1	H	100	0	0	0	0	100
20	6	0	A	1300	0	0	100	0	1400
21	1	0	C	0	100	0	0	0	100
21	2	1	H	200	0	0	0	0	200
21	3	1	H	0	0	0	0	0	0
21	4	0	A	300	0	0	0	0	300
21	5	1	A	200	0	0	100	0	300
21	6	1	A	0	0	200	0	0	200
21	7	1	A	800	0	0	100	0	900
21	8	1	A	900	0	0	0	100	1000
21	9	1	A	800	0	0	0	0	800
21	10	1	A	0	0	0	100	0	100
22	1	1	C	800	0	0	0	0	800
22	2	1	C	2300	0	0	0	0	2300
22	3	1	C	100	0	100	0	100	300
22	4	1	H	900	0	0	0	0	900

Appendix 1 continued

22	5	1	H	500	0	100	0	0 600
22	6	1	H	1100	0	0	0	0 1100
22	7	1	H	0	0	0	0	0 0
22	8	0	I	0	0	0	0	0 0
22	9	0	A	200	0	0	0	0 200
22	10	0	A	300	0	0	100	0 400
22	11	1	A	0	0	0	0	0 0
22	12	1	A	0	0	0	0	0 0
22	13	1	A	600	0	0	0	0 600
22	14	1	A	100	0	0	0	0 100
22	15	1	A	200	100	0	0	0 300
22	16	1	A	800	0	0	0	0 800

Appendix 2: Worm egg counts in December, 1992.

			Number of eggs recorded						
No.	sex	Age	Stro	Trichu	Strolides	Cesto	Trem	Total	Farm
1	0	C	C	600	100	0	0	700	1
2	1	C	0	0	0	0	0	0	1
3	1	H	100	0	0	100	0	200	1
4	1	H	200	100	0	0	0	300	1
5	1	H	100	0	0	0	0	100	1
6	0	A	0	0	0	0	0	0	1
7	1	A	500	0	0	0	0	500	1
8	0	A	100	0	100	0	0	200	1
9	0	A	100	0	0	0	0	100	1
10	0	A	600	100	0	0	100	800	2
1	0	C	100	0	0	0	0	100	2
2	0	H	600	0	0	100	0	700	2
3	0	A	0	0	0	0	0	0	2
4	0	A	0	0	0	0	0	0	2
5	0	A	1700	0	0	0	0	1700	2
6	0	A	500	0	0	0	0	500	3
1	1	C	200	0	0	0	0	200	3
2	0	C	600	0	0	0	0	600	3
3	1	A	500	100	0	0	0	600	3
4	1	A	700	0	0	0	0	700	3
5	0	A	900	0		100	0	1000	3
6	1	A	0	0	0	0	0	0	3
7	0	A	400	0	100	0	0	500	3
8	0	A	1000	0	0	0	0	1000	3
9	0	A	700	200	0	0	0	900	3
10	0	A	800	100	0	0	0	900	3
11	0	A	300	0	0	0	0	300	3
12	0	A	800	0	0	0	0	800	3
13	0	A	1400	0	0	0	0	1400	4
1	0	H	500	100	0	0	0	600	4
2	0	H	0	0	0	100	0	100	4
3	1	I	200	0	0	0	100	300	4
4	0	A	100	0	0	0	0	100	4
5	1	A	0	0	0	0	0	0	4
6	1	A	800	0	0	100	100	900	4
7	1	A	2300	100	0	100	0	2500	4
8	1	A	1100	0	0	100	100	1300	4
9	1	A	1000	0	100	0	0	1100	5
1	1	C	200	0	0	0	0	200	5
2	0	I	300	0	0	0	0	300	5
3	1	H	900	0	0	0	0	900	5
4	1	H	100	0	0	0	0	100	5
5	0	A	100	0	0	0	0	100	5
6	0	A	100	0	0	0	0	100	5
7	1	A	100	0	0	0	0	100	5
8	1	A	1200	0	0	0	0	1200	5
9	1	A	200	0	0	0	0	200	5

Appendix 2 (continued)

Animal No.	Sex	Age	Stro	Trichu	Strloides	Cento	Tren	Total	Farm
10	1	A	2300	100	0	0	0	2400	5
11	1	A	300	0	0	0	0	300	5
12	1	A	0	0	0	0	0	0	6
1	0	C	600	0	0	0	0	600	6
2	0	C	500	100	0	100	0	700	6
3	1	C	700	0	0	0	0	700	6
4	1	H	0	0	0	0	0	0	6
5	0	I	100	0	0	0	0	100	6
6	0	I	100	200	0	0	0	300	6
7	0	A	0	0	0	0	0	0	6
8	0	A	700	0	0	0	0	700	6
9	0	A	4500	100	0	0	0	4600	6
10	1	A	600	0	100	0	100	800	6
11	1	A	200	0	0	0	0	200	6
12	1	A	900	0	0	0	0	900	6
13	1	A	100	0	0	0	0	100	6
14	1	A	1300	100	0	0	0	1400	6
15	1	A	300	0	0	0	0	300	6
16	1	A	6200	0	0	100	0	6300	6

Appendix 3: Worm egg counts in January, 1993.

Farm	Animal No.	Sex	Age	Number of eggs recorded: Strongyles	Trichu	Strloides	Cesto	Trem	TOTAL
7	1	0	C	100	0	0	0	0	100
7	2	0	C	300	0	100	0	0	400
7	3	0	C	0	0	0	0	0	0
7	4	0	C	600	0	0	100	0	700
7	5	1	H	200	0	0	0	0	200
7	6	1	H	500	0	0	0	0	500
7	7	0	I	0	0	0	0	0	0
7	8	1	H	0	0	0	0	0	0
7	9	0	A	100	0	0	100	0	200
7	10	0	A	0	0	0	100	100	200
7	11	1	A	1800	0	0	100	0	1900
7	12	1	A	2300	100	0	0	0	2400
8	1	0	C	7300	0	0	0	0	7300
8	2	0	C	3900	0	100	0	0	400
8	3	0	A	800	0	0	0	0	800
8	4	1	C	500	0	0	0	0	500
8	5	1	A	300	100	0	0	100	500
8	6	1	H	100	0	0	0	0	1100
8	7	0	I	300	0	0	0	0	300
8	8	1	A	600	0	0	100	0	700
8	9	1	H	800	0	0	0	0	800
8	10	1	A	10400	0	0	200	0	10600
8	11	1	A	0	0	0	0	0	0
8	12	0	I	0	0	0	0	0	0
8	13	1	A	1900	0	0	0	0	1900
8	14	1	A	100	0	0	0	0	100
9	1	0	C	200	0	0	0	0	200
9	2	0	C	300	0	0	0	0	300
9	3	0	C	0	0	0	0	0	0
9	4	1	H	500	0	0	0	0	500
9	5	0	A	600	0	0	0	0	600
9	6	0	A	300	0	0	0	0	300
9	7	0	A	0	0	0	100	100	200
9	8	0A	0	0	0	0	0	0	
9	9	0	A	800	0	0	0	0	800
9	10	1	A	0	0	0	0	0	100
9	11	1	A	100	0	0	0	0	100
10	1	0	C	100	0	0	0	0	100
10	2	1	H	100	0	0	0	0	100
10	3	1	A	1000	0	0	100	0	1100
11	1	0	C	4200	0	0	100	0	4300
11	2	1	H	100	0	0	100	0	200
11	3	1	H	700	0	0	0	0	700
11	4	1	H	200	0	0	0	0	200
11	5	1	H	1000	0	0	0	0	1000
11	6	1	H	700	100	100	100	0	1000
11	7	1	A	1300	0	0	0	0	1300

Appendix 4: Worm egg counts in February, 1993.

Farm	Animal No.	Sex	Age	Number of eggs recorded Strongyles	Trichu	Strloides	Cesto	Trem	TOTAL
12	1	1	C	100	0	0	0	0	100
12	2	1	C	200	0	0	0	0	200
12	3	0	C	100	0	0	100	0	200
12	4	1	H	700	0	0	0	0	700
12	5	1	H	200	0	100	0	0	300
12	6	1	H	200	0	0	200	0	400
12	7	0	I	100	300	0	0	0	400
12	8	0	I	0	0	100	0	0	100
12	9	1	H	1100	0	0	0	0	1100
12	10	1	A	1800	0	0	0	0	1800
12	11	1	A	1900	0	0	0	0	1900
12	12	1	A	200	100	0	0	0	300
12	13	1	A	300	0	0	0	0	300
13	1	1	H	600	0	0	0	0	600
13	2	0	I	200	0	0	100	0	300
13	3	1	H	300	0	0	0	0	300
13	4	1	A	200	0	0	0	0	200
13	4	1	A	200	0	0	0	0	200
13	5	1	A	2000	0	0	0	0	2000
14	1	1	H	1400	100	0	0	0	1500
14	2	1	H	1100	0	0	100	0	1200
15	1	1	C	200	0	0	0	0	200
15	2	0	C	500	0	100	0	0	600
15	3	1	C	300	0	100	100	0	500
15	4	1	H	200	0	0	0	0	200
15	5	1	A	1300	0	0	100	0	1400
15	6	1	A	200	0	0	0	0	200
15	7	1	A	600	0	0	100	0	700
16	1	1	C	0	0	100	0	0	100
16	2	0	C	300	200	0	0	0	500
16	3	0	C	3000	0	0	0	0	3000
16	4	0	A	300	0	0	0	0	300
16	5	0	A	100	0	0	0	0	100
16	5	1	A	6400	0	0	0	0	6400
16	6	1	A	200	0	0	0	0	200
16	7	1	A	500	0	0	100	0	600
16	8	1	A	100	0	0	200	0	300
16	9	1	A	300	0	0	0	0	300
17	1	1	H	500	0	0	0	0	500
17	2	1	H	500	0	0	0	0	500
17	3	1	H	4200	0	0	0	0	4200
17	4	1	A	700	0	0	0	0	700
17	5	1	A	400	0	0	100	0	500
17	6	1	A	0	0	0	0	0	0
17	7	1	A	100	0	0	0	100	200
17	8	1	A	600	100	0	100	0	800

Appendix 5: Worm egg counts in March, 1992.

Farm	Animal No.	Sex	Age	Number of eggs recorded: Strongyles	Trichu	Strloides	Cesto	Trem	TOTAL
23	1	1	A	800	0	0	0	800	
23	2	1	A	200	0	0	0	0	200
24	1	0	C	100	0	0	0	0	100
24	2	1	H	300	0	0	0	0	300
24	3	1	A	0	0	0	0	0	0
24	4	1	A	800	0	0	0	0	800
25	1	0	C	1300	200	0	0	0	1500
25	2	1	H	0	0	0	0	0	0
25	3	1	H	2700	0	0	0	0	2700
25	4	0	I	600	0	0	0	0	600
25	5	0	A	900	0	0	0	0	900
25	6	1	A	1300	0	0	0	0	1300
25	7	1	A	100	0	0	0	0	100
25	8	1	A	200	0	0	100	0	300
25	9	1	A	200	0	0	0	0	200
25	10	1	A	600	0	0	0	0	600
26	1	0	C	100	0	0	0	0	100
26	2	1	H	300	0	0	0	0	300
26	3	1	H	100	0	0	0	0	100
26	4	0	A	0	0	0	0	0	0
26	5	1	A	900	100	0	0	100	1100
26	6	1	A	100	0	0	0	0	100
26	7	1	A	600	0	0	0	0	600
26	8	1	A	100	0	0	0	0	100
26	9	1	A	100	0	0	0	0	100
26	10	1	A	0	0	0	100	0	100
27	1	0	C	100	0	0	0	0	100
27	2	1	C	200	0	0	0	0	200
27	3	1	C	100	0	0	0	0	100
27	4	1	H	0	0	0	0	0	0
27	5	1	H	0	0	0	0	0	0
27	6	0	A	0	0	0	0	0	0
27	7	1	A	300	0	0	0	0	300
27	8	1	A	400	0	0	0	0	400
27	9	1	A	500	0	0	100	0	600
27	10	1	A	0	0	0	0	0	0
27	11	1	A	500	0	0	0	0	500

Appendix 6: Nematode worm egg counts for camels treated with albendazole over the 28 day period.

Camel				No. of eggs per gramme of faeces					
no.	Age	Sex	Avpre	Post1	Post2	Post3	Post4	Post5	Post6
1	2	0	900	0	0	0	0	0	0
2	1	0	800	1100	0	100	0	100	0
3	4	0	700	500	0	100	0	0	0
4	4	0	1100	3100	100	0	0	0	200
5	4	0	200	200	0	200	0	100	0
6	4	0	500	300	0	0	0	0	100
7	4	1	400	100	0	0	0	0	200
8	2	0	900	500	0	0	0	0	0
9	2	0	1100	300	0	0	0	0	0
10	4	0	2100	2800	0	0	0	0	100
11	4	0	200	2600	0	1900	0	0	100
12	2	0	1300	0	300	0	0	0	100
13	2	0	1350	200	0	0	0	300	0
14	4	0	800	800	400	0	0	0	100
15	2	0	800	900	0	0	0	100	0
16	1	0	1200	600	0	0	0	100	0
17	2	0	900	0	0	0	0	0	0
18	1	1	6500	4200	0	0	0	200	0
19	4	0	1100	1200	0	0	0	0	0

Appendix 7: Nematode worm egg counts for camels treated with Levamisole over the 28 day period.

camel				No. of eggs per gramme of faeces					
no.	Age	Sex	Avpre	Post1	Post2	Post3	Post4	Post5	Post6
20	1	0	900	400	700	300	0	0	100
21	4	0	600	4000	2800	100	100	0	300
22	4	0	900	1000	0	0	200	0	0
23	4	0	800	1000	900	0	0	400	100
24	1	1	450	200	0	100	0	0	0
25	4	0	500	100	400	0	100	0	200
26	4	0	100	2800	500	100	200	200	400
27	4	0	1300	500	300	100	0	100	0
28	1	1	600	100	1000	0	100	100	400
29	2	0	1000	1000	300	0	0	0	0
30	2	0	900	0	600	0	0	0	100
31	4	0	1300	0	0	0	0	200	100
32	4	0	1100	1000	500	0	0	0	100
33	2	0	200	0	0	0	0	0	0
34	2	0	4500	300	0	100	0	0	0
35	2	0	1600	700	0	0	100	0	200
36	4	0	2000	0	0	0	100	0	200
37	2	0	900	200	100	0	0	0	200
38	4	0	300	700	0	0	0	100	200

Appendix 8: Nematode worm egg counts for camels treated with Thiophanate over the 28 day period.

camel				No. of eggs per gramme of faeces					
no.	Age	Sex	Avpre	Post1	Post2	Post3	Post4	Post5	Post6
39	2	0	900	100	200	500	0	0	0
40	4	0	4000	900	100	0	100	0	100
41	4	0	600	1200	0	0	300	0	0
42	4	0	300	300	0	200	0	0	100
43	4	0	2000	0	0	0	0	0	400
44	4	0	400	100	100	0	300	100	400
45	1	1	1100	200	0	0	0	0	0
46	2	0	400	100	0	0	100	30	0
47	2	0	1300	1300	0	0	100	0	200
48	4	0	1100	100	100	200	0	100	100
49	2	0	500	0	0	100	0	0	100
50	4	0	300	300	0	0	100	0	200
51	2	0	300	400	100	100	0	0	200
52	4	1	800	700	400	0	0	0	200
53	4	0	1000	1400	0	200	0	0	100
54	4	1	4000	2000	100	0	0	0	0
55	1	0	200	100	0	0	0	300	200
56	2	0	500	0	100	200	0	100	0
57	4	0	5600	1300	300	200	0	0	100