A CROSS-SECTIONAL STUDY OF GASTRO-INTESTINAL NEMATODIASIS, GROSS SKIN CONDITIONS AND ECTOPARASITES OF DONKEYS IN MWINGI DISTRICT, KENYA.

BY

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DECLARATIONS.

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

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DEDICATION

This work is dedicated to my guardian, Mr. James Semakula Kagenda, who made selfless sacrifice for me.

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ABSTRACT.

This study was designed to investigate the prevalence gastro-intestinal nematodes, gross skin conditions and ectoparasites in Mwingi District, Kenya. The associations between known management and husbandry risk factors and donkeys nematodiasis were assessed. The effectiveness of ivermectin[R] against the nematodes was evaluated.

Faecal sampling was done on 254 donkeys randomly selected from 186 herds. These donkeys were also examined for presence of ectoparasites and gross skin lesions and their body conditions and ages determined. Information on donkey management and husbandry practices on 168 farms was gathered using on-farm visit questionnaires.

McMaster technique was used to determine the nematode egg counts per gram (epg) of faeces. Samples positive for nematode eggs were cultured and the larvae characterised. Similarly, all the ticks were characterised. The skin scrapings were examined for mites and cultured for fungi.

Fifty and thirty donkey farms in Kyuso and Mwingi divisions respectively were used in evaluating the effectiveness of Ivermectin[R]. Pre-treatment faecal sampling was done before administering Ivermectin[R] subcutaneously at 200 micrograms per kilogram body weight. Drug effectiveness was determined as percent faecal egg reduction between the pre- and post-treatment egg counts.

A donkey herd was considered positive for nematodiasis if the epg for at least one of its donkeys was above five hundreds. Descriptive statistics, analysis of variance, t-test, Mann-Whitney test, logistic regression and discriminant analyses were performed on the data.

Eighty three percent of the herds had nematodiasis. The mean egg counts for Mwingi and Migwani statistically ($P < 0.05$) differed from those of Kyuso and Mumoni. There was no statistical ($P > 0.05$) difference between the division-specific means of epg for Mwingi and Migwani and between those of Kyuso and Mumoni.

The sex of the owner, average age of the herd, deworming status, the level of hygiene in the holding premises and farm location (division) were marginally ($P < 0.1$) associated with nematodiasis. Donkey herds that belonged to women or were kept in "dirty" *bomas* or were not dewormed had high risks for nematodiasis, with odds ratios of 14.6, 3.92, and 3.82 respectively. Donkey herds whose average age was above two years had a marginal (OR = 2.3) risk for nematodiasis. An overall correct classification of 67% of herds having nematodiasis herds was achieved using discriminant analysis. The herd cases in Mwingi, Migwani and Mumoni overlapped on the scatter plot while those in Kyuso were clearly differentiated from the rest.

Strongylus vulgaris, S. edentatus, S. equinus, Cyanthostomum coronatum, C. tetracanum, C. radius, Strongyloides species and *ascarids were the gastro-intestinal nematodes that affected the donkeys.*

The pre-treatment mean epgs for Kyuso and Mwingi did not statistically ($P > 0.05$) differ. Ivermectin ^{R} was highly effective (> 99%) in both divisions. Results of both t- and Mann-Whitney tests for assessing the within division drug efficacy were highly significant ($P = 0.00001$). There were no statistical ($P > 0.05$) differences between the drug effectiveness for the pre- and post-treatment epgs at the division and herd levels.

Twenty three percent of the study herds did not have ectoparasites. Overall herd tick prevalence was 77%. Seventy four percent of these herds had *Rhipicephalus pulchellus*, 13% had *Rh. appendiculatus* and 13 % had both *Rh. pulchellus* and *Rh. appendiculatus*. No other ectoparasites were observed. Wounds, overgrown hooves, alopecia and combinations of these were the gross skin lesions observed. Overall, twenty out of twenty two (96%) skin scrapings were positive for fungi. Of these fungi, 80% were *Trichophyton spp*, 5% *Epidermophyton spp*, 5% *Microsporum* species.

Based on these findings, prospective studies should be designed to establish the bionomics and infection patterns of donkey gastro-intestinal nematode larvae, determine the impact of gastro-intestinal nematodes on donkey health and performance, clinically evaluate other affordable antihelmintics and attempt to isolate the active ingredients in the herbal preparations used to treat donkey worms in Mwingi District.

CHAPTER ONE

1.1. INTRODUCTION.

The lack of adequate transport of both people and goods is a major constraint to efficient production and development in the rural areas of Africa, such as Mwingi District in Kenya. The provision of efficient transport in these areas is difficult because of lack of capital to purchase or even hire motorised vehicles, poor terrain and very narrow roads (Fielding, 1987). Thus, animals such as horses, mules, donkeys and oxen provide an alternative environmentally friendly, reliable and renewable source of draught power.

Although Mwingi District is a semi-arid area (Pratt and Gwaynne, 1977), it has a high agricultural potential. The fertile soils in most parts of the district and the rangelands can support considerable livestock and wildlife production. However, the little, unreliable and erratic rainfall constrains the full realisation of this potential since it can only support subsistence crop and livestock agriculture. The economic returns from this level of production are too meagre to create substantial competition for the scarce national resources towards provision of good feeder roads and purchase of motorised vehicles.

The lack of good access roads coupled with the inability of the majority of the people to afford motorised transport leave animal power as the best choice of transport in most parts of Mwingi District. Furthermore, the harsh daily temperatures as well as the prolonged scarcity of forage and water do not favour efficient use of other draught animals apart from donkeys (*Equus asinus*). This is because donkeys have

relatively low feed and water requirements and are less selective feeders than mules and horses (Weipers, 1978). The slow bacterial digestion of roughage stored in the spacious colon and caecum enables donkeys to survive on adequate quantities of rough, course forage even in prolonged periods of lack of water (Dill *et al.*, 1980; McCarthy, 1989). Like camels, goats and sheep, donkeys absorb fluids and electrolytes more efficiently than Zebu cattle (Maloiy and Clemens, 1980). Donkeys adapt more easily to adverse conditions and tend to perform better than the other equine species (Dill *et al.*, 1980). If allowed to acclimatise, donkeys can do well in temperatures between 0 and 30°C and relative humidity of 30 to 70 percent (Sainsbury, 1989). Although temperatures above 22°C reduce feed intake in donkeys, they do not affect digestibility (Maloiy, 1973). Donkeys are docile, easy to manage, relatively easier to train and can work for longer hours than oxen (Maloiy *et al.*, 1980). They are inherently resistant to rinderpest, foot and mouth disease and rarely suffer from African horse sickness (Fielding, 1987). In addition, unlike machines, donkeys can adapt to environmental changes, require less capital input and lower operational costs. The offsprings provide cheaper replacements (Ramanswany, 1985).

Donkeys in Mwingi District are mainly used to fetch water and to carry farm produce to homes and to marketing centres. They are also used to transport firewood, charcoal and building materials. Socially, they are used to pay dowry and are often sold and the money used to pay school fees.

The ratio of the donkey population to human population engaged in agriculture in Africa is declining (Fielding, 1987). This decline has been attributed to poor nutrition,

specific diseases and lack of adequate health care (Ramanswany, 1985). Wells (1985) reported that helminths and ectoparasites are the greatest limitation to maximum output from working donkeys. Stress from overwork, excessive travel, wounds, overgrown hooves, hoof ulcers, pododermatitis, dermatitis, muscle and tendon strains as well as nutritional deficiencies also negatively affect donkey performance (Falvey, 1985; Bolbol and Saleh, 1987).

Although Mfitilodze and Hutchnison (1988) did a controlled study on the bionomics of equine nematode larvae in the dry tropical area of Australia, quantitative information on equine helminth infection in the developing tropical and sub-tropical areas is still lacking (Bliss, 1989; Sewell, 1991). Apart from postmortem reports for example by Ngatia and Kuria (1991), there is insufficient information on the type and level of donkey gastro-intestinal nematodiasis in Kenya. This information is necessary in determining the pathogenic effects and the most cost-beneficial and effective management measures to adopt in combating donkey helminthiasis.

This study was therefore designed with the following objectives:

1) To investigate the major causes of donkey gastro-intestinal nematodiasis and ectoparasitosis in Mwingi District.
2) To assess the associations between known risk factors and the gastro-intestinal nematodiasis.
3) To evaluate the effectiveness of Ivermectin [R] against the gastro-intestinal nematodiasis in donkeys.
4) To investigate the gross skin conditions and ectoparasites of donkeys.

CHAPTER TWO

2.0. LITERATURE REVIEW

2.1. Aetiology of donkey nematodiasis.

The commonest nematodes that affect donkeys belong to the genera *Strongylus* and *Trichonema* (Dunn, 1978; Fowler, 1989). However, *Ascarids, Trichostrongylus axei, Parascaris, Oxyuris equi* and *Dictyocaulus arnifieldi* also affect donkeys (Dunn, 1978; Gothe and Heil, 1984; Fowler, 1989; Pandey and Eysker, 1990; Mattioli *et al.*, 1994). The nematodes that affect domestic equine in Kenya have been given as *Strongylus asini, Strongylus vulgaris, Strongylus edentatus, Triodontophorus serratus, Trichonema alveatum, Trichonema coronatum, Cyclocodontophorus bicoronatum, Dipetalonema sp.* and *Onchocerca spp* (Round, 1962). *Setaria equina, Strongylus vulgaris, S. equinus, S. edentatus, Trichonema (cyclostomum) spp* and *Tricostomum spp* have been recovered from donkeys at Kabete (Ngatia and Kuria, 1991).

2.1.1. The life cycles of equine nematodes.

Female nematodes either lay eggs or pass out larvae (Dunn, 1978). The thin-shelled eggs vary greatly in shape and size (Dunn, 1978; Soulsby, 1989) and are passed out of an infected host in faeces (Hansen and Perry, 1990). The life cycle of a nematode is either direct or indirect depending upon whether the first stage larvae (L1's) live freely in the environment or undergo development and adjustment inside an intermediate host

(Dunn, 1978).

In the direct life cycle, the eggs either hatch into L1's which live freely and moult through second stage larvae (L2's) to the infective third stage larvae (L3's) as seen in *Strongylids* and *Trichostrongylids* or they may not hatch but develop to L1's which moult to L2's and the infective L3's as occurs in *Parascaris* (Dunn, 1978). L1's of *Strongyloides* species develop through L2's to L3's which are either infective (homogenic cycle) or not infective (heterogenetic cycle) depending on availability of favourable environmental conditions (Dunn, 1978; Soulsby, 1989). In the heterogenic cycle, L3's first develop into free-living males and females that later produce infective L3's. This cycle predominates in favourable environmental conditions (Soulsby, 1989).

Following disintegration of the faecal matter having the larvae on pasture by, for example, rain and/or coprophagous beetles, the ensheathed L3's disseminate both horizontally and vertically about the faecal pat (English, 1979b). This translocation is seasonal in the tropics (Hutchinson *et al.*, 1989).

Horizontal dissemination occurs by both active and passive migrations. These are aided by coprophagous beetles and other dung-inhabiting organisms (English, 1979a; Mfitilodze and Hutchinson, 1988). The larvae rarely migrate beyond 30 cm from the faecal pat, with the majority moving 15 cm away (English, 1979b). This puts animals grazing within this radius at a great risk of ingesting very high numbers of infective L3's (Hutchinson *et al.*, 1989).

Vertical dissemination of larvae up the grass blades occurs only in the early morning, in the evening and during dull weather (Soulsby, 1989), in the presence of a

thin film of moisture (Croll, 1975; English, 1979a,b; Hansen and Perry, 1990). The larvae climb the grass blades to quest for suitable hosts to infect (English, 1979a; Hansen and Perry, 1990).

In both the *strongylid* and *parascaris*, the definitive host gets infected through ingestion of the infective L3's on forage. In strongyloides, the definitive host gets infected either by ingestion of L3's, or the L3's penetrate the host's integument or vertically through milk in suckling foals (Lyons *et al.*, 1973). The ingested L3's exsheath inside the lumen of the gut of the host.

All equine strongyles invade tissues (Round, 1968). Those that penetrate the gut and wander through other organs in the body form the "migratory" group. They include the large strongyles viz *Strongylus vulgaris, S.edentatus,* and *S.equinus and ascarids. The* "non-migratory" nematodes remain localised in the digestive tract. They include the *Cyanthostomes* and *Triodontophorus spp* (Dunn, 1978). In the horse, the larvae of migratory strongylids penetrate the small and large intestines within a few days following infection and wander through the abdominal cavity and organs (Duncan and Dargie, 1975; Soulsby, 1989). After tissue migration, the larvae return to the gut to mature, copulate and for the females to lay eggs. The prepatent period of the migratory strongyles (from infection with L3's to appearance of eggs in the faeces) ranges from six months to a year (Round, 1968; Duncan, 1974; Duncan and Dargie, 1975a; Duncan and Pirie, 1975).

The infective L3's of *strongyloides* nematodes that penetrate the host skin enter blood capillaries and venules and are carried to the lungs (Lyons *et al.*, 1973). Similarly,

the ingested L3's of *Strongyloides* penetrate the gut wall into the blood stream to the lungs. In both cases the larvae break through the lung alveoli, migrate up the respiratory tract and are swallowed into the intestines where they mature and lay eggs (Lyons *et al.*, 1973). Systemic infection with *Strongyloides* does not occur following prenatal and colostral infections (Lyons *et al.*, 1973).

The exsheathed L3's of *Trichonemas* and *Triodontophorus species* invade the tubular glands of the large intestine and later emerge and moult to L5's (Ogbourne, 1975, 1978). The growth of L3's of Cyanthostomes in the cysts in the wall of the caecum and colon is inhibited by presence of mixed adult worm infection in the gut lumen (Fowler, 1989). Infections with small strongyles take a minimum of eight weeks in horses (Round, 1968) and about two weeks in donkeys (Fowler, 1989) to become patent. Several species of *Trichonema* may be involved in a single infection (Round, 1968).

In the indirect life cycle, development of the infective L3's occurs in the intermediate hosts such as snails, insects and earth worms (Soulsby, 1989). The definitive host gets infected by ingesting the intermediate host(s) or through inoculation when the larvae break through the proboscis of the intermediate hosts when the latter are feeding (Dunn, 1978; Soulsby, 1989). The nematodes which go through this type of life cycle include *Spiruroides, Metastrongyloides* and *Filaroides*.

2.1.2. Distribution of donkey nematodiasis.

2.1.2.1. Factors that influence the occurrence and distribution of donkey nematodiasis:

2.1.2.1.1. Occurrence of donkey nematodiasis.

Generally, donkey nematodiasis occurs in all areas of the world where equines especially zebras and horses are kept (Round, 1968; Duncan, 1989). Donkey nematodiasis due to *Trichonemas* is ubiquitous and does not vary from area to area (Fowler, 1989; Sewell, 1991). In natural gastro-nematodiasis in donkeys both large and small strongyles occur (Round, 1968; Bliss, 1989).

2.1.2.1.2. Climatic factors.

The epidemiology of donkey GIT nematodiasis depends largely upon favourable moisture and temperature (22-26°C) for the survival and development of the pre-parasitic eggs and free living larvae on pasture (English, 1979a,b; Bliss, 1989). In the wet and warm seasons, hatching of strongylid eggs begins within one week of being passed out in faeces and is complete by the end of two weeks (English, 1979b). In higher temperatures, hatching proceeds at a faster rate but the survival rates of the larvae are significantly reduced due to shortage of food in the reserves (Rogers, 1940 cited by English, 1979a). This reduces the number of potential infective larvae on pasture (Duncan, 1974; Hutchinson *et al.*, 1989). Low temperatures delay both the hatching of eggs and the development of larvae (Dunn, 1978; English, 1979a; Hansen and Perry, 1990) but favour relatively larger populations of the potential infective L3's on pasture.

Larval development on pasture lasts one week to several months depending upon availability of favourable humidity, temperature and adequate shade (English, 1979a,b; Hansen and Perry, 1990). During hot weather, the larvae migrate back to the ground and into the soil (English, 1979b). High environmental temperatures cause desiccation and kill the larvae (English, 1979b; Soulsby, 1989). The free-living L3's of nematodes retain their cuticle, making them highly resistant to such adverse environmental temperatures and desiccation. Vegetation and faecal matter promote the survival of the larvae through sheltering the latter from the lethal ultra violet light and heat from the sun (Michel, 1969; Nansen, 1987; Hansen and Perry, 1990). The vegetation cover promotes survival of larvae at the ground level by providing lower daily maximum temperatures, higher relative humidity and calm air (Geiger, 1965 cited by English, 1979b). Heavy rain washes the larvae off the grass blades, breaks the faeces and exposes the larvae to the lethal ultra-violet light (Hutchinson *et al.*, 1989; Hansen and perry, 1990).

Rainfall is the most important factor in the distribution of nematode parasites (Hansen and Perry, 1990), particulary in the tropics (Hutchinson *et al.*, 1989). The distribution of vegetation cover, important for the survival of the free-living larval stages, tends to vary directly with rainfall (Round, 1968). In general, similar species of nematodes tend to occur in a wide range of climatic zones (Sewell, 1991).

2.1.2.1.3. Host factors.

2.1.2.1.3.1. Host species.

Zebras and horses share the same species of nematodes with donkeys and disseminate the worms wherever they are raised (Dunn, 1978; Sewell, 1991). They are also alternate hosts of donkey nematodes (Soulsby, 1989). Nematodes are generally not highly host-specific and animals sharing the same environment tend to acquire similar parasites (Dunn, 1978). However, domestic ruminants are not infected by donkey nematodes (Mattioli *et al.* 1994).

2.1.2.1.3.2. Age and sex.

Although donkeys of all ages and sex are equally susceptible to both large and small strongyles (Round, 1968; Duncan, 1974), the young growing donkeys are often more severely affected than the adults (Dunn, 1978; Sewell, 1991). Older donkeys develop tolerance to nematodes and some may carry heavy infections without serious effects to their general health (Soulsby, 1989). *Strongyloides* and *Parascaris* are predominantly found in foals (Sewell, 1991). *Strongyloides* tends to clear spontaneously at six months of age (Fowler, 1989).

2.1.2.1.3.3. Host immunity.

All stages of helminths, whether migratory or not, secrete and excrete glycoproteins and small molecular proteinous antigens which stimulate both humoral and cellular immune responses in the host (Carson *et al.*, 1975; Kay, 1979; Capron *et al.*,

1980).

In the humoral response, IgE predominates (Jarret and Miller, 1982), but IgG and IgM are also produced. The host tries to eliminate the nematodes that do not penetrate the intestinal wall by mounting acute inflammatory responses, in the gut mucosa, against the antigens released by these worms into the host gut (Befus and Bienestock, 1982). The absorbed antigens access the lymphocytes and macrophages below the epithelium which process them (Smith and Peacock, 1980; Owen *et al.*, 1981; Befus and Bienenstock, 1982). Proliferation and differentiation of IgA, IgE and at times IgG and IgM-producing cells as well as T-lymphocytes may occur in the draining lymph nodes. The sensitised cells in the blood circulation later localise in the intestinal lamina propria, epithelium and other mucosae for anti-parasitic and immuno-regulatory activities (Bienenstock and Befus, 1980; Stokes *et al.*, 1980; Furhrmann and Cebra, 1981; Richman *et al.*, 1981; Wakelin, 1984). Production of interferon is enhanced (Herberman *et al.*, 1979) and mast cells proliferate in the mucosae of resistant hosts (Befus *et al.*, 1979; Handlarger and Rothwell, 1981). The IgA that is produced by mucosal plasma cells and released into the gut lumen by epithelial cells, together with systemic IgA secreted by the liver in bile protects the host by binding the helminth antigens and prevents them from being absorbed (Walker, 1975; Fisher *et al.*, 1979; Peppard *et al.*, 1981). The antibody-worm antigen immune complexes may stimulate increased secretion of protective mucus by the goblet cells of the gut mucosa (Walker and Block, 1977; Musoke *et al.*, 1978). Worm expulsion from the lumen of the intestine follows re-exposure of worm antigens to the sensitised mast cells. The interaction between IgE molecules on the plasma membranes of sensitised

these cells and the specific nematode antigens stimulates the onset of anaphylactic reactions which are characterised by increased mucus secretion, oedema of the mucosa and increased peristaltic movements (Stewart, 1965; Dobson, 1967; Harsh and Race, 1975; Befus and Bienenstock, 1982). The worms detach from the mucosa and are removed from the host by the rapid peristaltic movement of the fluid-filled gut contents (Wakelin, 1978). This "self-cure" mechanism is not species-specific since challenges by unrelated worms lead to expulsion of all the worms present (Stewart, 1965; Mogbel *and Wakelin,* 1979). The worms are expelled when they are still alive (Stoll cited by Wakelin, 1978). The histamine and serotonin that are released during the inflammatory reaction have a direct lethal effect on the worms (Befus and Bienestock, 1982).

The antigens of the gut-penetrating nematodes are accessible to the macrophages in the lamina propria and to the systemic circulation (Wakelin, 1978). When these antigens are presented to sensitised mast cells, the cells degranulate and release pharmacological mediators of inflammation such as eosinophilic chemotactic factor, which stimulate further infiltration, proliferation and localisation of eosinophils, basophils, neutrophils, macrophages and lymphocytes in the area of infection (Miller, 1980; Jarret and Miller, 1982). The pharmacological mediators also activate the Fc receptors on eosinophils thereby enhancing the cytotoxic capacity of the latter (Kay, 1979; Capron *et al.,* 1980; Jarret and Miller, 1982).

In case of cellular response, it is only eosinophils, macrophages and neutrophils that participate in antibody dependent cytotoxicity (ADCC) against parasites (Capron et al., 1981), since cells of the lymphoid series, including natural killer cells, lack the

capacity to damage the outer membrane of nematodes (Jarret and Miller, 1982). The contents of eosinophil granules, including the major basic protein, peroxidase, histaminase, phospholipase D and arylsulphatase B, attack and kill the parasite (McLaren *et al.*, 1978; Butterworth *et al.*, 1979; Henderson *et al.*, 1980; Capron *et al.*, 1982; Roit, 1991). Peptide chemotactic factors released by eosinophils and other polymorph cells during the allergic reaction cause target tissues to generate secondary mediators such as prostaglandin E and the slow reacting substance of anaphylaxis which damage the worms (Goezt *et al.*, 1979).

In general, host immunity against nematodes is partial and species-specific (Befus and Bienenstock, 1982). Consequently, infected animals tend to develop chronic and intense gastro-intestinal infection in natural conditions whereby small continuous or interrupted infections slowly build up to heavy worm burdens (Wakelin, 1978). The chronically infected donkeys disseminate the parasite and are sources of infection to the unexposed animals. Pregnant and lactating animals are particularly more susceptible to helminth infection due to depressed immunity (Wakelin, 1978). Reproductively active females are an important source of infection for the susceptible young who, because they are yet to develop immunity, respond ineffectively and become chronically infected (Duncan, 1974; Wakelin, 1978). Duncan (1974) observed an increased faecal egg output in mares after foaling although the increase was not closely related to foaling or lactation.

2.1.2.1.4. Donkey management.

A high population density of donkeys generally favours wide distribution of nematodiasis through provision of susceptible hosts and, if infected, contamination of a wide area of the environment (Wakelin, 1978; Anderson and May, 1980). The fibrous donkey faecal pat persists for long without complete disintegration. Thus, it provides shelter to infective L3's and makes the stocking rate of donkeys a risk factor for nematodiasis in "unhygienic" premises (Thomas, 1982).

Accumulated donkey faecal matter acts as growth media for nematode larvae. This creates a source of heavy worm challenge to the donkeys and favours the occurrence of nematodiasis (Bliss, 1989; Mattioli *et al.* 1994). At the population level, natural helminthiasis tends to over disperse, with the majority of parasites occurring in few hosts and a few parasites occurring in the majority of hosts (Wakelin, 1978). Routine use of antihelminthics may limit the occurrence of some nematode species such as *Strongylus vulgaris* (Duncan, 1974; Herd, 1986b). Communal grazing, grazing along road sides, fence rows, hill sides and cultivated gardens favour wide dissemination of nematodes (Bliss, 1989). These, together with poor feeding and work overload, highly predispose donkeys to helminthiasis. Such donkeys tend to harbour heavy worm burdens and contaminate pastures from which other donkeys get infected (Gibson, 1963; Mattioli *et al,* 1994).

2.1.3. Pathogenesis and clinical manifestations of donkey nematodiasis. 1A

the adults of the super family *Strongylinae* parasitise the large intestine of donkeys (Dunn, 1978). They are plug feeders and attach themselves to the intestinal wall by drawing a mass of intestinal mucosa into their buccal capsules (Duncan and Dargie, 1975; Duncan and Pirie, 1975; Dunn, 1978). The worms secrete enzymes which digest away the mucosa. The amount of damage by an individual worm is directly related to the size of its buccal capsule which determines the size of plug drawn (Dunn, 1978). The worms create crater-like ulcers which bleed and through which plasma proteins including albumin are lost (Duncan and Dargie, 1975). In severe cases, penetrating ulcers may develop in the gut with subsequent life threatening peritonitis and bleeding (Blood and Radostits, 1989). There is villus atrophy, cryptic hyperplasia, formation of granulomas, intestinal hypertrophy, alterations in intestinal absorption and fluid secretion as well as changes in myo-electric activity and pancreatic secretion (Duncan and Dargie, 1975; Schanbacher *et al.*, 1978; Brasilus, 1979; Castro *et al.*, 1979; Dembinsk *et al.*, 1979). Whereas *Trichonematidae* cause desquamative catarrhal enteritis in the affected donkey (Ogbourne, 1978), the female adults of *Strongyloides* species bury themselves in the mucosa of the host intestines and reduce the intestinal absorptive surface area (Soulsby, 1989).

The migratory larval stages of the large strongyles cause more wide spread and considerable pathological changes in the abdominal organs including the liver, lungs, kidneys, pancreas and the wall of the gut (Dunn, 1978; Fowler, 1989; Blood and Radostits, 1989; Symons, 1989) than do the adult large strongyles in the gut. *Strongylus*

vulgaris larvae in the anterior mesenteric artery and its branches damage the walls of the blood vessels, creating aneurisms and forming emboli and thrombi Ogbourne and Duncan, 1977; Blood and Radostits, 1989). The emboli, particulary formed by L4's, may block the blood supply to the epithelium of the large intestines leading to localised ischaemia and formation of abscesses in the gut mucosa (Dunn, 1978; Blood and Radostits, 1989; Soulsby, 1989). Involvement of the iliac arteries leads to lameness (Soulsby, 1989; Blood and Radostis, 1989).

In foals, *Parascaris* larvae penetrate the gut wall and the majority migrate to and damage the liver (Dunn, 1978). The larvae get carried by blood to mainly the heart and lungs but also to the spleen and kidneys where they get arrested in the capillaries and cause infarction (Dunn, 1978; Soulsby, 1989).

Tissue stages of nematodes resist destruction by the host immune system by having a multi-layered cuticle made up of unique proteins that are not affected by cell mediated immunity (Lumsden, 1975). They also release secretions which cleave IgG molecules (Mazingue *et al.*, 1980; Auriault *et al.*, 1981). This nematode resistance may lead to chronic inflammatory reactions and formation of granulomas in the infected tissues (Jarret and Miller, 1982; Roit, 1991).

The clinical manifestations of donkey nematodiasis include loss of appetite, unthriftiness, pyrexia, anaemia, diarrhoea, rough coat, oedema of the intermandibular and lower abdominal regions and development of a pot belly particulary in the young donkeys (Duncan and Dargie, 1975; Blood and Radostits, 1989; Fowler, 1989). Diarrhoea is more common in infections with small strongyles than it is with large

strongyles (Dunn, 1978). Rectal prolapse (Dhoble *et al.*, 1990), as well as irritation in the perineal area accompanied with rubbing against solid objects (Soulsby, 1989; Blood and Radostits, 1989; Fowler, 1989) occur in infestations with *Oxyuris equi*.

2.1.4. Impact of donkey nematodiasis.

Nematodiasis causes unthriftiness and reduced production in the affected donkeys (Clayton, 1986; Drudge and Lyons, 1986; Reinemeyer, 1986). For example, *P. equorum* has been reported to impair growth of young donkeys resulting in small-sized and weak adult donkeys (Clayton and Duncan, 1978). It also reduces draught and reproductive efficiency in working donkeys (Duncan and Dargie, 1975). The reproductive inefficiency, reduced growth rate and mortality keep the donkey population below demand (Fielding, 1987). There is reduced availability of animal protein and farm fuel (Orev and Abu-Rabia, 1989) as well as loss of income from sale of donkey dung (Svendsen, 1989). Svendsen (1989) has reported helminthiasis to be the major cause of death of donkeys in the developing world.

2.1.5. Diagnosis of donkey nematodiasis.

Diagnosis of nematodiasis in donkeys is based on clinical signs, blood and faecal examination as well as post mortem examination. These are briefly reviewed below:

2.1.5.1. Clinical signs.

The use of clinical signs in the diagnosis of nematodiasis is subjective and largely dependent on experience (Round, 1968). The sensitivity and specificity of clinical signs as a diagnostic test for nematodiasis are very low since the clinical signs often overlap with those of malnutrition and other chronic infectious diseases (Morgan and Hawkins. 1960; Blood and Radostits, 1989). Donkeys in clinically good condition may have low levels of gastro-intestinal nematodiasis to which they may eventually succumb (Round, 1968).

2.1.5.2. Blood and faecal examination.

This may be done on live or dead animals. In the use of blood examination for diagnosis of nematodiasis, the haematocrit and haemoglobin levels as well as the total and differential white blood cell counts are evaluated. The average cutoff values for these parameters in donkeys have been given by Fowler (1989). The parameters tend to vary a lot between individuals (Round, 1968; Fowler, 1989). For example, high eosinophilia is indicative of high exposure to infection and/or systemic larval migration but severely affected animals may have a low eosinophil count when the bone marrow is exhausted (Round, 1968).

Faeces are examined both macroscopically and microscopically for presence of eggs, larvae and whole or parts of worms (Hansen and Perry, 1990; Soulsby, 1989). Whole or parts of worms are examined using a direct smear [Ministry of Agriculture Fisheries and Food (M. A. F. F)., 1986; Soulsby, 1989].

The qualitative and quantitative diagnostic techniques based on presence of worm eggs in faeces (M. A. F. F , 1986; Soulsby, 1989) are briefly reviewed below:

2.1.5.2.1. Qualitative techniques of faecal examination.

These include direct smear and concentration techniques (Soulsby, 1989). They are for rapid diagnosis but are not used to determine the severity of nematodiasis (M. A. F. F., 1986; Soulsby, 1989).

2.1.5.2.1.1. Direct smear.

A small amount of faeces is mounted on a glass slide and examined directly under a microscope. This technique has poor sensitivity in low grade helminthiasis (Soulsby, 1989).

2.1.5.2.1.2. Concentration techniques.

These are used to detect low grade infections in a relatively short time (Soulsby, 1989). The suspected faecal sample is mixed with a solution of either Sodium chloride, Zinc sulphate, Sucrose or Magnesium sulphate which has a specific gravity greater than that of nematode eggs (Soulsby, 1989). The floating eggs are picked up with a cover slip for microscopic examination.

2.1.5.2.2. Quantitative techniques.

The quantitative techniques involve counting of eggs and expressing the number in terms of eggs per gramme (epg) of faeces to determine the severity of infection (Round, 1968; M. A. F. F., 1986; Soulsby, 1989; Hansen and Perry, 1990). The techniques include Stoll's dilution method and the more commonly used McMaster egg counting technique (Dunn, 1978; M. A. F. F., 1986; Soulsby, 1989). A guide proposed by Soulsby (1989) is used to interpret the faecal egg counts of equine nematodes. An epg of 500 shows a mild infection, epg between 800 and 1000 is a moderate infection while one of 1500 and above is a severe infection. However, proper interpretation of the results requires experience and should always be related to the clinical picture of the affected animal (Soulsby, 1989).

There are general limitations to using faecal egg counts to quantify the severity of helminthiasis in donkeys. For example, the absence of eggs in faeces may not mean absence of infection as the worms may either be still immature and not laying eggs (Round, 1968) or their fecundity may be low. Severely infected donkeys tend to expel mature and fertile adult worms. But it has been observed that the population of immature worms in the colon and caecum of those donkeys remains large (Round, 1968). In contrast, the presence of eggs does not give the degree of infection since worms are a normal occurrence in many animals and carrier status is common (Hansen and Perry, 1990). Thus, finding a few worm eggs in donkey faeces may not necessarily indicate presence of disease. Furthermore, there is a general lack of correlation between epg and the number of adult nematodes in the donkey (Round, 1968).

Generally, the use of faecal examination in the diagnosis of nematodiasis is affected by various factors. That is, the uneven distribution of eggs throughout the faeces, the amount of faeces passed out, the season of the year, strong host immunity which increases the prepatent period and lowers egg output, the sensitivity of the test being used and the competence of the individual carrying out the examination significantly influence the accuracy and outcome of the diagnosis (Round, 1968; Hansen and Perry, 1990). In addition, the protocol of carrying out the test influences the results. For example, the accuracy of the McMaster technique is highly influenced by the dilution of the floatation fluid and the amount of time a loaded slide is left to stand for the nematode eggs to float (Dunn and Keymer, 1986).

Since each of these diagnostic techniques has shortcomings associated with it, it is safer to combine clinical diagnosis with faecal and blood examination in order to make a more accurate diagnosis of donkey nematodiasis (Round, 1968).

2.1.5.3. Post mortem examination.

If systematically done, post mortem examination is the "gold standard" for the tests described in the preceding subsections. Its sensitivity and specificity approximate 100%. It is the most reliable method of diagnosing helminthiasis both qualitatively and quantitatively (Dunn, 1978; Hansen and perry, 1990). It is, however, of little use in live animals. Gastro-intestinal nematodiasis causes similar pathological lesions in horses and donkeys (Ngatia and Kuria, 1991).

2.1.6. Management of donkey nematodiasis.

A balanced diet coupled with proper pasture management help to prevent occurrence of nematodiasis in donkeys (Duncan, 1975; Falvey, 1985; Scot, 1989).

The control of nematodiasis in donkeys involves both chemical and non-chemical methods (Duncan and Dargie, 1975). The non-chemical methods include regular removal of donkey faeces from pasture to increase the area of herbage free of infective larvae (Herd, 1986a; Hutchinson *et al.*, 1989) and hence lower the risk of infection to the grazing donkeys (Herd, 1986a).

Composting the manure reduces the oxygen potential around the buried larvae while the fermentation process increases the temperature in the faeces thereby killing the larvae (Herd, 1986a). Coprophagous beetles reduce the number of potential infective larvae through burying the faeces, ingestion of eggs and larvae as well as burrowing through and causing rapid desiccation of the faeces (Mfitilodze and Hutchinson, 1988; Hutchinson *et al.*, 1989). Desiccation of the faecal pat is particulary important in the control of worms in the semi-arid areas. This is because the dry environmental conditions remove moisture from the faeces to below critical survival level for the larvae (Hutchinson *et al.*, 1989).

Chemical control methods involve strategic administration of anthelminthics at the right time and frequency to break the life cycle of the worms (Dunn, 1978; Soulsby, 1989; Hutchnison *et al.*, 1989). In the tropics, equines are dewormed during the dry season when the pasture is "helminthologically sterile" to minimise pasture contamination during or just after the onset of the wet season (Hutchnison *et al.*, 1989). Several types

of anthelmintic preparations with varying efficacies are used. These include Ivermectin[R], Pyrantel, Benzimidazole (Fenbendazole and Oxibendazole) and Dichlorvos (Herd, 1986a,b; Bliss, 1989). Administration of sub-optimal levels of the drugs commonly causes drug resistance (Herd, 1986b) especially by the encysted late third and fourth stage larvae of *Cyanthostomes* (Reinemeyer, 1986).

Ivermectin[R] is in the avermectin group of drugs produced by *Streptomyces avermectins*. It is a 22,23 dihydroavermectins B1, a derivative of avermectin. Ivermectin[R] acts by potentiating the inhibitory effect of gamma-aminobutyric acid (GABA) upon neural transfer at the interneurone-motor neurone junctions, causing flaccid paralysis of the nematodes (Merck Veterinary Manual, 1986). The paralysed worms are removed from the lumen of the gut by peristaltic movements as they can no longer secure themselves on the intestinal mucosa. Ivermectin[R] is administered either sub-cutaneously or per os (as a paste) at a rate of 200 micrograms/Kg body weight. Both routes are equally effective against a broad range of internal and external animal parasites, but the sub-cutaneous route is more effective against ectoparasites (Merck veterinary manual, 1986).

Lihua *et al.* (1994) found encysted late third stage and fourth stage *Cyanthostome* larvae completely resistant to Ivermectin[R]. Moxidectin[R] which is in the same chemical group as Ivermectin [R] has a low efficacy (63 to 79%) against these larvae (Lihua *et al.*, 1994). Although Benzimidazoles have been found to be effective against encysted third and fourth stage *Cyanthostome* larvae, their efficacy tends to fall with intensive use (Lihua *et al,* 1994).

Fenbendazole given at 10 mg/kg body weight is effective against both small and large adult strongyles but it has a variable effect against the larvae. Malan and Reinecke (1979) found out that it was ineffective against encysted larvae while Mcbeath *et al.* (1978) reported a complete efficacy. Dichlorvos® at 31 mg/kg body weight is also ineffective against encysted L4's (Reinecke *et al.*, 1980).

2.2. Actiology of donkey ectoparasitosis.

The ectoparasites of donkeys include flies such as *Musca domestica*, tsetse flies and *Stomoxys,* as well as *Habronema* (screw worms) (Georgi, 1974; Fowler, 1989). Blood or lymph-sucking parasites such as ticks, lice (El-Gawward *et al.*, 1987) and mites [sarcoptes, psoroptes and chorioptes (Fowler, 1989)] also affect donkeys.

2.2.1. Life cycles of the ectoparasites of donkeys.

Lice are single host and they undergo incomplete metamorphosis whereby the adults lay eggs which hatch into nymphs resembling the adult stages (Soulsby, 1989). The young ones go through three nymphal stages before they mature into adults (Soulsby, 1989; Fowler, 1989). Ticks and mites lay eggs which hatch into larvae. The larvae moult into nymphs which in turn develop into adults. The life cycle of Ixodidae ticks may be single host, two host or three host depending on the number of times the tick drops off and re-attaches onto its host as it develops through the different stages. Hard ticks, unlike soft ticks, attach and feed on their hosts for prolonged periods of time before they fall off to lay eggs (Wakelin, 1984; Soulsby, 1989). All the other ectoparasites of donkeys

undergo complete metamorphosis whereby they lay eggs which hatch into active and feeding larvae. The larvae in turn undergo ecdysis to become dormant pupae which later moult into adults (Soulsby, 1989).

2.2.2. Distribution of donkey ectoparasites.

Most ectoparasites of horses affect donkeys as well (Blood and Radostits, 1989) and they are cosmopolitan in distribution (Soulsby, 1989). They are also found on wild equine such as the zebra (Onyango, 1990).

2.2.2.1. Factors that influence the occurrence and distribution of donkey ectoparasitosis.

2.2.2.1.1. Host factors.

Young donkeys and those on very poor plane of nutrition often have ineffective immunity and this highly predisposes them to ectoparasitosis (Soulsby, 1989). In contrast, immune competent animals resist ectoparasites by mounting protective inflammatory reactions (Brown and Askenase, 1983) against the potent protein immunogens which are secreted by the ectoparasites into the bite wounds during the feeding process (Tatchell, 1969; Wakelin, 1984). These localised skin reactions involve interactions between T-lymphocytes, basophils and eosinophils (Wikel, 1980; Askenase, 1980; Askenase *et al.*, 1982), with the T-lymphocytes as the effective cells (Wakelin, 1984). The basophils degranulate and release pharmacological mediators of inflammation which cause vasodilatation, increase permeability of blood vessels and attract eosinophils and

macrophages into the area (Berenberg *et al.*, 1972).

The antigen-antibody complexes formed at the dermal-epidermal junction in the vicinity of the feeding tick activate the complement system which in turn attracts more basophils and neutrophils to the area (Berenberg *et al.*,, 1972; Brown and Knap, 1980) to further resist the parasites.

The host skin is adapted to respond to antigens from ectoparasites. It is richly vascularised and this promotes delivery of both humoral and cellular defence components to the site of infestation (Tatchell and Moorhouse, 1968). The resident mast cells and cells of langerhans hasten the onset and progress of immune reactions (Wakelin, 1984).

The manifestation of immunity varies with both the host and specific ectoparasites (Brown and Askenase, 1983). The effects range from simple rejection of the parasites, with no or little damage to it, through interference with feeding time for parasites such as ticks which attach on hosts for relatively long periods of time, reduction in engorgement weights, inhibition of egg laying, decreased egg viability to death of the parasites (Willadsen, 1980; Brown and Askenase, 1983).

The alterations in the tissues at the feeding sites change the quality and quantity of blood available to the ectoparasites leading to reduced uptake of nutrients and reduced metabolism in the parasites (Willadsen, 1980; Wakelin, 1984). The parasites mainly die from starvation and desiccation (Brown and Askenase, 1983). The donkey response mostly affects ectoparasites such as ticks which feed for long periods of time (Tatchell, 1969).

Wildlife including zebras, rats and squirrels are alternate hosts of donkey ticks

(Onyango, 1990; Soulsby, 1989) and they disseminate and maintain them in the absence of donkeys.

2.2.2.1.2. Management factors.

Donkeys that are not sprayed tend to harbour ticks and sometimes lice (Canacoo, 1991). Communally grazed donkeys pick a lot of parasites from each other and from pasture (Fowler, 1989).

2.2.2.1.3. Climatic factors.

Spatial and temporal distributions of the ectoparasites of donkeys are dependent on the availability of a favourable amount of moisture and ambient temperature for the parasites to survive and multiply (Blood and Radostits, 1989; Soulsby, 1989).

2.2.3. Pathogenesis and clinical manifestations of donkey ectoparasitosis.

The localised host reaction to the immunogens of ectoparasites is characterised by oedema, increased neutrophil infiltration, haemorrhage and collagen necrosis (Berenberg *et al.*, 1972). Often there is pruritis, alopecia and skin induration at the site of attachment of the ectoparasite (Brown and Knap, 1980). It is worthy noting that the structure of the mouth parts of ixodidae ticks is well adapted for incising the skin and sucking blood (Wakelin, 1984).

Mites penetrate the skin to suck lymph and in the process cause localised dermatitis resulting in thickening and wrinkling of the skin, pruritis, oozing of lymph,

formation of scabs and alopecia (Tuzer *et al.*, 1988; Fowler, 1989; Soulsby, 1989). The lesions may involve the whole body as seen in *Sarcoptes* and *Psoroptes* mange or just the legs as in *Chorioptes* mange (Fowler, 1989).

The adult *Gasterophylus* flies, mosquitoes, ticks, *Tabanus, Chrysops, Haematopota, Hypobosca equina, Pangonia* and *Stomoxys* cause a lot of worry to the affected donkeys leading to interruption of feeding and hence reduced donkey productivity (Tuzer *et al.*, 1988; Soulsby, 1989). Screw worms cause tissue haemorrhage while ticks such as *Rhipicephalus pulchellus*, the louse *Haematopinus asini*, mosquitoes and flies including tsetse flies, *Stomoxys* and *Haematopota* suck blood (Soulsby, 1989). This may cause anaemia. *Damalinia equi*, *Chorioptes equi*, *Psoroptes equi* and *Sarcoptes scabies equi* cause localised intense itching which makes the donkey scratch and bite itself resulting in alopecia and painful wounds (Tuzer *et al.*, 1988; Soulsby, 1989).

2.2.4. Importance of donkey ectoparasitosis.

Ticks, such as *Hyalomma spp,* and biting flies for example *Tabanus* and mosquitoes disseminate bacterial, viral and protozoal diseases of donkeys (Linthicum *et al.*, 1992; Turell *et al.*, 1992). The diseases may cause reduced conception rates, abortion and death thereby hindering growth of the donkey population (Starkey, 1990). The wounds caused by auto-mutilation, the reduced feed intake, anaemia and diseases transmitted by ectoparasites negatively affect the health and work output of the affected donkeys (Falvey, 1985; Starkey, 1990). Tuzer *et al.* (1988) reported death of a donkey from severe sarcoptic mange.

2.2.5. Diagnosis of donkey ectoparasitosis.

Mature ticks and some of the biting and nuisance flies may, with experience, be grossly identified. Clinical signs such as scratching and biting of body parts by the donkey may be suggestive of mange (Blood and Radostits, 1986). Confirmatory diagnosis of donkey ectoparasitosis involves microscopic examination of the parasites and/or skin scrapings (Soulsby, 1989).

The biting flies are trapped with a net and fixed with 70 % alcohol in stoppable bottles while ticks are picked off the body and kept on moist cotton wool (Soulsby, 1989). The samples are then processed for macroscopic and microscopic examination. Diagnosis of mange involves scrapping the infected skin site with a scalpel blade followed by digestion of tissue debris in the suspected sample with 10% potassium hydroxide to free the parasites (Benbrook and Sloss, 1961). The parasites are then identified microscopically.

2.2.6. Management of donkey ectoparasitosis.

The most effective management of donkey ectoparasitosis starts with a thorough survey of the location and bionomics of the parasites, followed by strategically designed control techniques (Wilson *et al.*, 1977). Ectoparasite control strategies include keeping donkeys indoors to prevent ectoparasites from reaching the donkey, manipulating the environment to destroy the breeding sites of the parasite, mechanical trapping of the parasites, use of natural predators of the parasites as well as use of chemicals (Wilson *et al.*, 1977; Sainsbury, 1989). The chemicals used include IvermectinR [which is effective against mange (Abu-Samra, *et al.*, 1987) and ticks (Wilson, 1993)], Lindane

and Bacticol® (Canacoo, 1991). These control methods are usually integrated to achieve the most cost effective ectoparasite control (Wilson *et al.*, 1977; Soulsby, 1989).

2.3. Donkey dermatomycosis.

2.3.1. Aetiology and distribution of donkey dermatomycosis.

The commonest cause of donkey dermatomycosis is *Trichophyton mentagrophytes* (Blood and Radostits, 1989). *Microsporum spp*, *Chysosporium keratinophilum* and *Epidermophyton spp* also affect donkeys (Blood and Radostits, 1989). Affected animals develop a species-specific immunity and the nutritional status of the donkey determines the duration and severity of infection (Blood and Radostits, 1989). Dermatomycosis has a world wide distribution, although some species may be limited to some geographical areas (Austwick, 1972; Bagy, 1986). Very young donkeys whose immunity is not yet fully developed as well as the elderly and unthrifty donkeys with waning or compromised immune systems are highly susceptible to dermatomycosis (Pascoe, 1981). Slightly alkaline pH of the skin and warm and humid atmosphere predispose donkeys to dermatomycosis (Pascoe, 1981; Blood and Radostits, 1989).

Dermatomycosis spreads directly by body to body contacts and through contact with contaminated fomites (Austwick, 1972; Blood and Radostits, 1989). Presence of susceptible hosts in large numbers coupled with their behavioural characteristics such as licking augments the spread of the disease (Edwardson and Andrews, 1979). Wind-borne fungal spores spread widely thereby infecting susceptible donkeys that may be far from the source of infection (Austwick, 1972). Tick-bite wounds are portals of entry for fungal

spores and therefore favour occurrence of fungal infection (Austwick, 1972).

2.3.3. Pathogenesis and clinical manifestation of donkey dermatomycosis.

Fungal arthrospores gain entry into the skin through skin wounds and abrasions (Austwick, 1972) and lodge in the necks of the hair follicles, beneath epidermal scales or beneath blood and serum on superficial wounds (Austwick, 1972). Generally, the fungi attack the stratum corneum of the skin and the hair fibres (Pascoe, 1981; Blood and Radostits, 1989). The fibre structure of the affected hair undergoes autolysis and the hair breaks off the body (Blood *et al.*, 1989). Type I and III inflammatory reactions occur in the affected epidermal layers (Austwick, 1972) and produce either mild erythema or severe vesicular and heavily crusted, sometimes granulomatous lesions (Austwick, 1972). Sequestration occurs in chronic infections and the skin debris, hair and fungal hyphae produce crusts (Austwick, 1972). Ring worm fungi are strictly aerobic and die out in the anaerobic crusts in the centre of the lesion (Blood and Radostits, 1989). Thus, the lesion progresses at the periphery where there is enough oxygen. Fungal infection may be asymptomatic or extremely itchy and painful. Suppuration occurs if secondary bacterial infection is involved (Austwick, 1972).

2.3.4. Importance of donkey dermatomycosis.

The automutilation wounds that result from itching and scratching may be so painful that the donkey is reluctant to work (Austwick, 1972). This is particularly so in donkeys that carry loads on the backs. If the wounds are deep and infected, the bacteria

may become systemic (Blood *et al.*, 1989). If *Microsporum* infection becomes systemic, it may cause abortion (Garg and Machanda, 1986). Reduced output and occasionally death may occur in severe cases.

2.3.5. Diagnosis of donkey dermatomycosis.

Diagnosis of donkey dermatomycosis may be made clinically from the characteristic macroscopic lesions. But these must be differentiated in the laboratory from lesions due to mange (Blood and Radostits, 1989). A direct smear prepared from the suspected skin scrapings or hair from the affected skin is microscopically examined for the presence of hyaline, septate branched hyphae and arthrospores (Austwick, 1972). Ultra violet light may be used to increase the sensitivity of the diagnosis (Libero and Pandhye, 1975). The fungi are isolated by culturing of skin scrapings or hair on Sabouraud's Dextrose glucose Agar (SDA) at room temperature for about four weeks (Austwick; 1972; Libero and Pandhye, 1975). During this period, the culture is regularly observed for presence and rate of growth, texture, topography and colour changes (Libero and Pandhye, 1975). Definite diagnosis is made by mounting some of the growth on a glass slide, staining the preparation with lactophenol blue and microscopically examining it for presence and morphology of hyphae, macroconidia and microconidia (Austwick, 1972; Libero and Pandhye, 1975).

2.3.6. Management of donkey dermatomycosis.

Provision of qualitative and quantitative nutrition and use of infection-free harnesses prevent introduction of dermatomycosis in uninfected donkeys (Blood and Radostits, 1989). Supplementation of malnourished animals with vitamin A also helps to prevent dermatomycosis (Blood and Radostits, 1989). Control strategies against donkey dermatomycosis include isolation and treatment of infected donkeys to contain further spread of infection (Blood and Radostits, 1989). Vaccination against dermatomycosis has been tried with limited success in horses (Andrews and Edwardson, 1981).

Treatment of dermatomycosis may be localised or systemic depending upon the extent of infection (Blood and Radostits, 1989). Localised treatment involves physical removal of the crusts and rubbing the medication such as borotanic acid or natamycin, vigorously into the lesion (Blood and Radostits, 1989). Bordeaux mixture may be used in form of a spray (Oldenkamp, 1979). Potassium iodide preparations are used to treat systemic infections (Blood and Radostits, 1989).

2.4. Wounds.

2.4.1. Aetiology of donkey wounds.

Donkey wounds result mainly from miss-use of harnesses, use of poorly made harnesses, biting, fights, malice and pressure and abrasion from rough surfaced loads (Canacoo, 1991). Ectoparasites such as ticks and lice as well as automutilation when the donkey bites or rubs itself against objects to ease irritation also cause wounds (Austwick, 1972; Blood and Radostits, 1989).

2.4.2. Importance of donkey wounds.

Donkey wounds bleed easily (Jordan,1989) and depending on their severity, they affect donkey health and performance to varying degrees (Yilma *et al.*, 1991). If left unattended, the wounds attract flies leading to fly worry and myiasis. The wounds often get secondary infection resulting in abscessation, and in chronic cases, growth of granulation tissue (Yilma *et al.*, 1991). Wounds along the back line and points of contact between the body and the harness become so painful and reduce donkey output (Canacoo, 1991).

2.4.3. Management of donkey wounds.

Donkey wounds can be prevented by cushioning the points of contact between the harness/load and the body of the donkey (Canacoo, 1991). Castration of unwanted males to reduce fighting (Yilma *et al.*, 1991) and tethering of males until they are required to serve female donkeys would reduce the frequency of wounds (Canacoo, 1991; Yilma *et al.*, 1991).

Treatment of donkey wounds may be either localised, systemic or both depending upon the severity of the wound. Small wounds are treated with topical antibiotics coupled with healing oil to prevent fly worry (Canacoo, 1991). Severe wounds require surgical intervention and parenteral antibiotic given to prevent systemic infection (Jordan, 1989).

CHAPTER THREE

3.0. MATERIALS AND METHODS

3.1 Study area.

This study was carried out in Mwingi District, which is located in the Eastern Province of Kenya. The district lies within the semi-arid zones (Pratt and Gwaynne, 1977). It is situated between 513 metres and 1740 metres above sea level. The upper areas consist of undulating hills while the lower areas are relatively plain. The temperatures are variable, ranging between 25°C and 34°C. February and September are the hottest months of the year while July is the coolest. The vegetation is mainly shrubs of acacia species and wooded grassland which provides the main source of feed to donkeys, cattle and goats. The district receives bimodal rainfall. The long rains begin in October/November while the short rains fall in March/April. The rains are erratic and unreliable, ranging between 300mm and 700mm, with an average of 500 mm per year. The amount of rain received follows landscape features. Table I stratifies the rainfall on the basis of divisions.

TABLE I: The division-specific annual rainfall totals (1994/95) in Mwingi District.

Division	Rainfall (mm)
Central	1306.0
Migwani	1625.7
Mumoni	639.4
Kyuso	436.4

Source: Mwingi District Agricultural Extension office, 1995.

The very high rate of evapotranspiration makes many rivers, streams and dams dry up shortly after the rains. The soils are either sandy, clay or clay-loam. Extensive sand beds, bare rocks, gravel and wide gulleys created across roads by surface run off render most areas of the district inaccessible by motor vehicles except motor cycles. These make donkeys the best alternative means of transport in the district. In 1994, Mwingi District was estimated to have a population of 37000 donkeys (Mwingi District Veterinary Office-unpublished data).

3.2. Study population.

The study population consisted of all donkeys in Mwingi District. The sampled population consisted of donkeys in Kyuso, Mumoni, Central and Migwani divisions of

Mwingi District. The four divisions were conveniently chosen to constitute the study areas. In each of the divisions, the donkey owners were mobilised by veterinary staff and local chiefs. The owners and their donkeys were registered as they arrived at the pre-designated centres. The lists consisted of the name of the owner, the numbers and names of donkeys and the villages.

Each of the four divisions was visited on separate days and a total of 679 donkeys were registered. To make the owners interested and participate in the study, *barazas* were first held during which the Divisional Veterinary Officer or the Locational Chief advised them on the aims and benefits of the study. They were co-operative throughout the study. Because of logistic constraints, only donkeys within 15 to 20 kilometres from the locational headquarters of Kyuso, Khatse, Central, Kakuyu and Migwani were studied.

3.2.1. Sampling of study donkeys.

Neither the prevalence of gastro-intestinal nematodes nor that of ectoparasites affecting donkeys in Kenya was known *apriori*. Therefore, the appropriate sample size (400 donkeys) was estimated (Appendix I) using an allowable error of five percent and assuming an initial fifty percent prevalence of gastro-intestinal nematodes. The fifty percent prevalence was assumed in order to estimate the largest sample size possible. The sample size was adjusted downwards after the initial analyses of some of the faecal samples revealed a prevalence of nematode eggs of eighty percent.

3.2.1.1. Sampling technique.

Single-stage cluster sampling was done, with donkey herds forming the clusters. The number of donkey herds sampled per division were as follows: 38 herds were selected from Kyuso, 62 from Mumoni, 36 from Migwani and 52 from Central. A simple random sampling, using Random Number Tables, was done and 254 out of the 679 donkeys were selected for this study. The individual donkeys were the units of interest. Thirty four of the selected donkeys were not sampled because the owners had taken them away before they were sampled.

3.3. Collection of samples.

There were no animal handling facilities in four of the five gathering centres. One of the hind legs of each of the randomly selected donkeys was securely tethered with a strong rope to a strong tree. The donkeys were muzzled and held by the ears and the chin to prevent them from biting and to further restrain them. The donkey owners were at all times close-by during sample collection to help in restraining and for the donkeys to feel secure and be at a minimal level of excitement.

Prior to picking the samples, each donkey was observed from a distance for its body condition, demeanour and presence of any gross lesions on the skin and skin derivatives. An appropriate body condition score (McCarthy, 1989, Appendix II) of 1 (good), 2 (average) or 3 (poor) was assigned to the donkey and recorded. The demeanour was described as either dull or bright. The gross lesions of interest included wounds, alopecia, tissue growths, lameness, overgrown hooves and any other hoof condition

thought to affect the health of the donkey.

The donkey was then approached and examined for presence of ectoparasites. The lower and upper lips of the mouth were parted to expose the lower incisor teeth and a fore finger introduced through the gap between the teeth of the lower and upper jaws onto the hard palate. Gentle pressure was then exerted onto the hard palate to make the donkey open its mouth and expose the occlusal surfaces of the lower incisor teeth. Teeth eruption and teeth wear (Fowler, 1989) were used to age donkeys (Appendix III). Donkeys that were apprehensive and could not be aged at the time of sample collection were aged when administering the questionnaire.

3.3.1. Faecal samples.

Faecal samples were, whenever possible, obtained directly from the rectum of each selected donkey. The tail of the donkey was held at its base and raised to create ample space in the perineal area. Obstetric gloves were used to protect both hands against abrasions and *Clostridium tetani* micro-organisms. Little water was used to moisten the gloves to facilitate entry into the rectum. One hand was then gently introduced into the rectum. Faecal material was removed to the outside and grossly observed in day light for its physical appearance and presence of whole or parts of worms. The findings were recorded immediately. Entire worms or worm segments when present were preserved in normal saline.

A faecal sample large enough to completely fill the screw-capped plastic bottle was then picked, tightly packed and closed in the bottle to prevent circulation of oxygen

and hatching of worm eggs. Faecal samples were collected from the ground as soon as the selected donkeys passed stool before they were examined. The samples were labelled with the name of the owner, the name and number of the donkey and were kept in a refrigerator before transporting them over ice to the laboratory.

3.3.2. Ectoparasites and skin scrapings.

Thumb forceps were used to pick some or all ticks off the bodies of donkeys. The parasites were preserved in 70 % alcohol in screw-capped glass bottles. In addition, skin scrapings were obtained using a sharp scalpel blade and transported to the laboratory in dry screw-capped plastic bottles.

3.4. Laboratory analyses of samples.

3.4.1. Analysis of faecal samples.

3.4.1.1 Preparation of floatation fluid.

Five litres of tap water were boiled in a saucepan. Two and a half killogrammes of sodium chloride were weighed out using a balance (Ohaus scale Corp. N.I, New York-USA) and added to the boiling water with vigorous stirring until it could not dissolve any more. A supersaturated solution with a specific gravity ranging between 1.12 and 1.21 was made. The solution was left to cool slowly to room temperature before it was filtered into a plastic urn with a tap. Smaller quantities of this solution were drawn off into plastic water bottles whenever required.

3.4.1.2. Egg floatation and identification.

Twenty eight millilitres of the cool supersaturated solution of Sodium chloride were measured out and placed into calibrated 50-ml dilution containers. Faecal material was then added to the fluid using a spatula to make a total volume of 30 millilitres of a dilution of 1 in 15. Stirring was done using a spatula to disintegrate the faeces and release the worm eggs. The mixture was then filtered through an ordinary tea sieve to remove the large fibrous material. While stirring, some of the filtrate was drawn with a plastic dropper and used to charge a clean McMaster (Sterling Projects Ltd, UK) counting chamber. A separate plastic dropper was used to charge each of the two sides of the slide. The charged slide was left to stand on the table for about three minutes to allow the eggs to rise up to the inner surfaces of the upper limits of the counting chambers. In-between charging, the McMaster slide was washed with clean tap water and dried using cotton gauze and blotting paper.

Eggs and coccidial oocyst, when present, were identified under a microscope (Leitz Wetzcar, German), at a magnification of x100. Strongyle eggs were identified from their ovoid shape, thin egg shell and presence of morulae. (M. A. A. F., 1986; Soulsby, 1989). *Strongyloides* eggs were identified from the ovoid shape and presence of larvae inside them. Eggs that were touching the top and left margins of the slide cells were considered "in" and were counted, whereas those eggs touching the bottom and right hand margins of the cells were considered "out" and were not counted. A differential egg count of both sides of the slide was done using a laboratory hand counter (Clay-Adam, USA). The counts from each side of the chamber were then multiplied by

100 (computed from the volume and dilution of the filtrate in the chamber) to get the total egg count per gramme (epg) of faeces for each of the egg types.

Whole or segments of worms that were recovered during faecal sampling were picked with forceps and mounted on glass slides, covered with cover slips and microscopically identified on the basis of the morphological features on their heads and the tails. A faecal sample was considered positive for worms if whole or part of adult worms and/or if it had worm eggs.

3.4.1.3. Faecal culturing.

To find out whether or not the worms which affected donkeys in all the four divisions were of the same species, the division-specific study samples were handled separately. For the same reason, the within division samples with epg less than 1000 were separated from those with epg equal to or greater than 1000 and separately pooled.

The fibrous faecal material was loosened using a mortar and pestle and thoroughly mixed to have a fairly uniform distribution of the eggs when present. Portions of the mixed materials were picked with a spatula and put in separate half-litre plastic containers with screw stoppers and compacted to prevent them from pouring during the harvesting of larvae. The inner sides of the plastic containers were then wiped clean with moist cotton gauze. The moisture left on the sides of the containers was to promote growth and upward migration of the hatched larvae. The lids of the containers were loosely replaced to allow for gaseous exchange. Each of the containers was labelled with the name of the division from where the samples were picked, the epg category and the

expected incubation period before they were placed in an incubator (National appliances Co, USA) at 27°C for fifteen days.

3.4.1.4. Recovery of larvae.

The larvae were harvested by the jar-over-petri dish method as described in the M. A. A. F. (1986) manual. The samples were removed from the incubator and the lids removed. Each of the containers was filled with tap water up to the brim and an empty petri dish inverted over it. The containers were then turned upside down on the petri dishes and warm normal saline added to the petri dish to promote migration of the larvae. The preparations were left to stand at room temperature for ten hours for the larvae to migrate into the petri dishes. The normal saline containing the larvae was transferred from the petri dishes into glass bottles and kept in a refrigerator until microscopic examination.

3.4.1.5. Identification of larvae.

Two to three drops of well mixed normal saline suspected of having larvae were transferred to a glass slide using a plastic dropper. One or two drops of Lugol's Iodine were added to kill, stretch and stain the larvae to ease identification. The larvae were killed to stop them from moving about on the slides. A drop of lactic acid was added to make the internal organs of the larvae more visible. A coverslip was then laid over gently (to prevent air bubbles from forming under it) and a light microscope [Loborlux 12 (Leitz)-German] used in larval identification. Pathogenic larvae were differentiated

from non-pathogenic ones by the differential intensity of Iodine stain and the absence of a rhabditiform oesophagus. A key by Thienpont *et al.* (1986) was used to identify the pathogenic larvae on the basis of morphological features such as presence or absence of a sheath, the length of the tail sheath in relation to the entire body size, the shape of the head as well as the morphology of the oesophagus.

3.4.2. Identification of ectoparasites.

3.4.2.1. Ticks.

Ticks were picked from the sample bottles using thumb forceps and placed on a glass petri dish. They were examined using a dissection microscope (Leitz, German) at X10 magnification. They were then characterised using a key described in Hoogstraal (1956).

3.4.2.2. Skin scrapings.

3.4.2.2.1. Recovery and identification of mites.

Small amounts of the skin scrapings were picked using a pair of thumb forceps and put on glass slides. Two drops of 10 % Potassium hydroxide were added to each slide and the tip of a scalpel blade used to break up the skin scabs to hasten digestion of the tissue debris to free the parasites. The preparations were left to stand at room temperature for at least 15 minutes. They were examined with a light microscope at a magnification of X10 and X40 for the presence of mites.

3.4.2.2.2. Presence of fungi.

Analysis of the skin scrapings for the presence of fungi was done in two ways:

3.4.2.2.2.1. Direct smear.

A small amount of each of the samples of the skin scrapings was picked using a pair of flame-sterilised thumb forceps and mounted on a glass slide. The preparation was stained with lactophenol blue and a cover slip laid on top. It was examined under a light microscope for presence of arthrospores.

3.4.2.2.2.2. Laboratory culture:

The skin scrapings were cultured in the laboratory for fungi. Twenty millilitres of constituted Sabouraud's dextrose glucose agar (SDA) were put in each of twenty two petri dishes and left to solidify at room temperature. A pair of sterilised thumb forceps was used to nucleate the SDA with the suspected skin scrapings. The petri dishes were then covered to prevent fungal contamination from the environment and left to stand at room temperature for at least 14 days. They were observed at least once every three days for presence and rate of growth of colonies. The other characteristics of the fungal colonies looked for included the colour at the front and back of the petri dish, texture, topography and whether or not the growth was at the same level as the agar.

A mounted needle sterilised over a flame was used to pick a small amount of the fungal growth from the centre of the colony onto a glass slide. One to two drops of lactophenol blue stain were added and the wet mount properly teased before gently putting a coverslip to spread the hyphae. The slide was examined under a microscope,

first at X35 and then at X400 for presence and morphology of hyphae, macroconidia and microconidia. A guide described by *Libero et al.* (1975) was used to identify the fungi. The hyphae were either septate or non-septate. The shape, nature of margin and the number of microconidia inside each macroconidia were used in characterising the fungi.

3.5. Administration of questionnaires.

Questionnaires (Appendix IV) were administered to gather information on the general management and husbandry practices of donkey farms in the study divisions. The questionnaires were administered in form of interviews with the farm owners or any other person who had stayed on the farm for a long time period to ably give reliable information. The majority of the respondents in the study area could only communicate well in the local ethnic language. To overcome this barrier, each of the animal health assistants in the four divisions was trained on how to appropriately fill the questionnaires in order to obtain the required information. The donkey owners were visited without prior warning to avoid changing the usual conditions in which the donkeys were kept. The questionnaire were administered to each of the 168 farms visited.

Generally, the information derived from the questionnaires included the particulars of the herd owner, the size of herd, donkey functions, management and husbandry practices. During questionnaire administration all the donkeys in a herd were observed for general body condition and gross lesions such as wounds, alopecia and overgrown hooves. The donkey "Bomas" were inspected for the level of hygiene and rated as clean or dirty.

3.6. Administration and evaluation of Ivermectin[R].

This part of the study was carried out eleven months after the cross-sectional study. The herd owners were mobilised as described in subsection 3.2. A total of eight hundred donkeys were brought to the designated centres. It was only the herds in Central and Kyuso that were used to determine the effectiveness of Ivermectin[R]. The considerations for this choice included the differences in the mean egg counts, farming systems and climatic and geographical factors between the two divisions. Furthermore, the divisions were readily accessible. Priority was given to herds that were used in the previous cross-sectional study. However, these could not provide enough sample sizes. Thus, random numbers were used to select "new" herds. Fifty and thirty herds were selected for follow up in Kyuso and Central divisions respectively.

Prior to administering the drug, the selected donkeys were restrained, their body conditions assessed and scored and the body weights as well as clinical conditions determined. The body weight was estimated using a weigh band (Farmer's Boy [R]) put around the thorax of the donkey, as close to the fore legs as possible, and pulled tight upon the body to measure the heart girth. The height of the donkey at the withers was measured by fixing the tape on the ground and stretching it parallel to the shoulder of the animal. A foot ruler was placed horizontally on the back line of the donkey and used to read off the height of the latter from the band. Both the heart girth and height measurements were used to determine the approximate body weight of the donkey from the nomogram (Eley and French, 1993). For donkeys which were less than two years or those whose height was less than 90 cm, only the heart girth was used to estimate the

body weight.

The clinical conditions of the donkeys were assessed by taking the pulse rates and rectal temperatures, palpating the superficial lymph nodes for their sizes, determining the respiratory rates and auscultation of the heart and the chest. The clinical examination was done to rule out presence of signs of ill health in the pre-treated donkeys.

The animals were inspected for ticks which if present, were picked and preserved in 70 % alcohol. A pre-treatment faecal sample was obtained from the rectum of each of the animals as described in subsection 3.2.2(a).

Ivermectin^{R} (MSD-AGVET-Holland) was administered sub-cutaneously in front of the shoulder at a dosage rate of 200 microgram per kilogram body weight to all the randomly selected donkeys using gauge-eighteen needles. Before the animals were taken away by the owners, they were observed for up to ten minutes for any side effects due to the drug. All treated donkeys in the selected herds in Kyuso and Central divisions were followed until their epg fell below five hundreds. The donkeys were kept by the owners in their usual environmental conditions and on the same diet.

The epg for each faecal sample was determined using the modified McMaster technique described in subsection 3.2.3.1(b). Since the herd sizes were too small, each treated donkey acted as its own control. Fresh faecal samples were picked from the treated donkeys at three and four day-intervals in Central and Kyuso divisions respectively and their egg counts determined. The donkeys were also each time observed for the presence of ectoparasites.

The division-specific and herd-specific percent effectiveness of the drug against

worms was determined using the function described by Duncan *et al.* (1988). That is, the difference between the pre-treatment and post-treatment epg (day eight for Kyuso and day nine for Central) was expressed as a percentage of the pre-treatment epg. A guide by Duncan *et al.* (1988) was used to scale the efficacy of the drug as highly effective (> 90 %), moderately effective (80-90 %), low effect (60-80 %) and ineffective (<60 %).

The pre-treatment positive faecal samples as well as the post treatment negative samples were incubated as described in subsection 3.2.3.1(c). This was done to be able to: (i) characterise the gastro-intestinal nematode species that affect donkeys in Mwingi District, represented by Kyuso and Central divisions and (ii) find out whether the drug had completely eliminated all the egg-laying nematodes.

3.7. Data management

The questionnaire-derived information was synthesised into appropriate variables, coded and stored in a data base file (Dbase IV -Ashton-Tate, 1988; CALIFORNIA, USA). A separate data file was created to store the information on the name of the herd owner as well as the names, location, gross lesions, general health and body conditions of the pre-treatment donkeys. The data on faecal egg counts both at the time of administering Ivermectin^{R} and during the follow up were also stored in this file.

3.8. Data analysis.

Descriptive statistics of the strongyle faecal egg counts and the questionnaire-derived variables were computed using Statistix version 4.0 (1992) analytical software.

The statistics were computed at the district and divisional levels. Pair-wise comparisons of the means were done using Tukey's Honest Significant difference (HSD) test. The student's t-test (parametric) and the Mann-Whitney (non-parametric) test were used to compare the pre-treatment and post-treatment epg to determine the efficacy of Ivermectin^{R} statistically.

3.8.1. Case definition.

The interpretation of the egg counts was done as described for equine nematodiasis in Soulsby (1989). For this analysis, a herd was considered to be positive for gastro-intestinal nematodiasis (coded 1) if the epg of faeces from at least one of its donkeys was above five hundreds. The herd was coded zero if found negative for nematodiasis.

Logistic regression analysis was done to assess any association between herds having nematodiasis and the questionnaire-derived variables. This analysis was done using Biomedical programmes (BMDP-Program Inc., 1993 namely, Stepwise logistic regression) statistical software. An overall logistic model for the district was computed. However, Division-specific logistic models to investigate whether or not there were similar statistically significant explanatory variables for nematodiasis among the divisions could not be computed because of the small sample sizes relative to the large within herd variations. Data for divisions whose mean epg did not differ was pooled and logistic models computed.

Stepwise logistic discriminant analysis (BMDP program Inc.,1993: Program 7)

was done using thirteen questionnaire-derived independent variables and "division" as the dependent variable. The aim of the analysis was to obtain a variate that could maximally differentiate the donkey herds at division level.

CHAPTER FOUR

4.0. RESULTS

4.1. DESCRIPTIVE STATISTICS AND FREQUENCY DISTRIBUTIONS OF QUESTIONNAIRE-DERIVED VARIABLES.

4.1.1. Ownership of donkey herds.

Twenty nine percent of the herds visited belonged to women and seventy one percent to men. However, all donkeys were looked after and used by women. The time periods over which these owners had donkeys ranged from two months to fifty years, with an average of sixteen years. The ages of the owners ranged between twenty two to seventy years, with a mean of forty six years. There were no significant ($P = 0.3450$) inter-divisional differences in the mean ages of the owners as well as in the mean number of years they had owned donkeys.

4.1.2. Characteristics of donkey herds.

The distribution of donkey herd characteristics is summarised in Table II(a). The division-specific sex distribution was 47.7% females and 52.3% males in Central, 42.9% females, 57.1% males in Migwani, 50.9% females, 49.1% males in Kyuso and 67.8% females, 32.2% males in Mumoni. Overall, 53.2% of the donkeys were females while 46.8% were males. Seventeen percent of the sampled donkeys were castrates. The sex ratio of the donkeys was one female to one male in Central, Migwani and Kyuso divisions and two females to one male in Mumoni.

Migwani Division had the largest proportion (85.7%) of herds with two or less

donkeys followed by Central with 80.4%, Kyuso with 73.2% and Mumoni with 46.6%. Mumoni Division with 53.4% had the largest number of herds with three or more donkeys. The proportions for the other divisions were 26.8% in Kyuso, 19.5% in Central and 14.3% in Migwani. The largest herd had seven donkeys and was in Mumoni Division. On the whole, the majority (66.4%) of the herds consisted of two or less donkeys while the other 33.6% had three or more donkeys.

The two oldest donkeys in this study were each forty seven years and were in Central Division. Donkey herds whose average age was equal to or less than two years accounted for 2.1% of all those visited in Migwani, 9.3% in Kyuso, and 11.8% in Mumoni. Central Division did not have any herds in this age category. Overall, 6.5% of the herds had an average age equal to or less than two years. Central Division had the largest proportion (85.7%) of herds whose average ages ranged between two and fifteen years. It was followed by Migwani with 85.4%, Mumoni with 80.9% and Kyuso with 79.1%. Overall, 82.6% of all the donkeys were in this age category. The average ages of 14.3% of the herds in Central, 12.5% in Migwani, 11.6% in Kyuso and 7.3% in Mumoni were 16 years and above. On the whole, 10.9% of all the herds fell in this age group.

At the division level, 8.7% of the donkeys in Central, 15.9% in Migwani, 8.8% in Kyuso and 16.1% in Mumoni were in good body condition. These were 13% of all the donkey herds. On the whole, 40.1% of the study donkeys were in average body condition. Of these, 41.3% were in Central, 44.4% in Migwani, 43.9% in Kyuso and 34.5% in Mumoni. Fifty percent of the donkeys in Central, 39.7% in Migwani, 47.4%

Table II(a): Summary of the descriptive analyses of donkey herd characteristics in Mwingi District categorised by divisions, 1995.

Character		Division									
		Central		Migwani		Kyuso		Mumoni		Overall	
		FR	%	FR	%	FR	%	FR	%	FR	%
Sex	F	21	47.7	27	42.9	29	50.9	59	67.8	134	53.2
	M	23	52.3	36	57.1	28	49.1	28	32.2	118	46.8
Herd size	1-3	37	80.4	54	85.7	36	73.2	41	46.6	168	66.4
	>3	9	19.6	9	14.3	21	26.8	47	53.4	85	33.6
Age (yrs)	<2	0	0	1	2.1	4	9.3	8	11.8	13	6.5
	2-15	36	85.7	41	85.4	34	79.1	55	80.9	166	82.6
	15	6	14.3	6	12.5	5	11.6	5	7.3	22	10.9
BCS	1 [a]	4	8.7	10	15.9	5	8.8	14	16.1	33	13.0
	2 [b]	19	41.3	28	44.4	25	43.9	30	34.5	102	40.3
	3 [c]	23	50.0	25	39.7	27	47.4	43	49.4	118	46.7

KEY: BCS: Body condition score. a: good. b: average. c: poor.
F: female. M: male. FR: frequency. >: greater than. <: less than.

The division-specific mean ages (years) of donkey were 10.55 in Central, 11.9 in Migwani, 8.9 in Kyuso and 8.06 in Mumoni. In general, the donkey ages ranged between 0.3 and 47 years, with a mean of 9.67 years. The results of the analysis of variance of these division-specific mean ages of donkeys in Mwingi District are shown in Table II(b). The overall F-test was highly significant (P = 0.0002). This showed that at least two of these means were statistically different.

TABLE II(b): Summary of the analysis of variance of the division-specific mean donkey ages, Mwingi District, 1995.

Source	DF	SS	MS	VR	P-value
Between Divisions	3	448.509	149.503	5.09	0.0002
Within Divisions	197	5787.82	29.3798		
Total	200	6236.33			

KEY: DF: Degrees of Freedom. SS: Sums of Squares.
MS: Mean of squares. P-value: Probability value.

The summary results of Tukey's Honest Significant Difference (HSD) test are shown in Table II(c). At five percent level of significance, it was only the mean ages of donkeys in Migwani and Mumoni that were significantly different.

TABLE II(c): Summary of Tukey's Honest Significant Difference (HSD) test of the absolute mean age differences of donkeys in Mwingi District, 1995.

Absolute differences between the divisional means

		Division			
Division	Mean	Migwani	Central	Kyuso	Mumoni
Migwani	11.830	-	1.282	2.7845	3.7859*
Central	10.548		-	1.5025	2.5039
Kyuso	9.0455			-	1.0014
Mumoni	8.0441				-

KEY: *: This difference was significant at $\alpha = 0.05$.

The diseases/conditions that were reported by the owners to affect donkeys in Mwingi District are summarised in Table III. They included helminthiasis, wounds, skin cracks, abortion, unthriftiness, stunted growth and an unspecified disease reported to have clinical signs which were similar to those of Trypanosomiasis ("Trypanosomiasis"). Helminthiasis was the single "commonest" disease reported in all the four divisions. It affected 25% of the herds in Central, 15.4% in Migwani, 51.4% in Kyuso and 62.1% in Mumoni. Overall, 41.1% of the herds "commonly" had helminthiasis. Wounds were "common" in Central (2.8%) and Mumoni (1.7%) only. Skin cracks, abortion, stunted growth, unthriftiness and "Trypanosomiasis" affected 8.3% of the herds in Central,

5.7% in Kyuso and 10.3% in Mumoni. These diseases/conditions affected 6.5% of all the herds visited. The majority (51.2 %) of owners did not report any "common" donkey health problems in their herds.

TABLE III: Summary of the diseases/conditions as seen by donkey owners in Mwingi District, 1995.

Disease/ Condition	Division									
	Central		Migwani		Kyuso		Mumoni		Overall	
	FR	%	FR	%	FR	%	FR	%	FR	%
Helminths	9	25	6	15.4	18	51.4	36	62.1	69	41.1
Wounds	1	2.8	-	-	-	-	1	1.7	2	1.2
Others	3	8.3	-	-	2	5.7	6	10.3	11	6.5
None	23	63.9	33	84.6	15	42.9	15	25.9	86	51.2

KEY: Others included skin cracks, abortion, "trypanosomiasis", unthriftiness and stunted growth.
FR: Frequency.
Helminths: Helminthiasis.

4.1.3. Presence of ectoparasites

Ticks were the only ectoparasites that infested donkeys in the study area. The tick distribution in the study herds is summarised in Table IV. The division-specific

prevalence of *Rh. appendiculatus* was 2.2% in Central, 15.9% in Migwani, 14% in Kyuso and 6.9% in Mumoni. These were 9.9% of all the herds inspected. *Rh. pulchellus* infested 89.1% of the herds in Central, 28.6% in Migwani, 50.9% in Kyuso and 64.4% in Mumoni. Overall, 56.9% of the herds were infested with *Rh. pulchellus* alone while 10.3 % had both tick species. Only 22.9% of the herds were not infested with ticks.

TABLE IV: Summary of the descriptive analyses of the division-specific tick species of donkeys in Mwingi District, 1994/95.

	Division									
Tick	Central		Migwani		Kyuso		Mumoni		Overall	
Species	FR	%	FR	%	FR	%	FR	%	FR	%
1	1	2.2	10	15.9	8	14.0	6	6.9	25	9.9
2	41	89.1	18	28.6	29	50.9	56	64.4	144	56.9
3	2	4.3	18	28.6	5	8.8	1	1.1	26	10.3
4	2	4.3	17	27.0	15	26.3	24	27.6	58	22.9

KEY: 1: *Rh. appendiculatus.* 2: *Rh. pulchellus.*
3: 1 and 2. 4: None. FR: Frequency.
Species: Tick species.

4.1.4. Distribution of gross lesions of the skin and skin derivatives.

A summary of the analyses of the distributions of the gross lesions of the skin and skin derivatives of donkeys in Mwingi District is shown in Table V. The lesions included wounds, alopecia and overgrown hooves. The within-division wound prevalences, in descending order, were 11.1% in Migwani, 10.3% in Mumoni, 8.8% in Kyuso and 8.7% in Central. Skin wounds were in 10.0% of all the herds. Alopecia was observed in 2.2% of the herds in Central, 1.6% in Migwani, 3.5% in Kyuso and 5.7% in Mumoni. Generally, 3.6% of the herds had alopecia. Overgrown hooves were commonest in Migwani, with a prevalence of 38.1%, followed by Mumoni with 27.6%, Central with 23.9% and Kyuso with 19.3%. These were 28.0% of all the herds visited.

A combination of wounds and alopecia affected 6.5%, 4.8%, 7.0%, and 9.2% of the herds in Central, Migwani, Kyuso and Mumoni respectively. Overall, this combination was observed in 7.2% of all the herds studied. The prevalence of a combination of overgrown hooves and wounds was 10.9% in Central, 1.6% in Migwani, 3.5% Kyuso, 2.3% in Mumoni and 4.0% in the whole of Mwingi District. Twenty percent of the donkeys with overgrown hooves were lame due to either foot rot or hoof "slippers".

TABLE V: Summary of the descriptive analyses of the gross lesions of the skin and skin derivatives of donkeys in Mwingi District, 1994/95.

	Division									
	Central		Migwani		Kyuso		Mumoni		Overall	
Lesion	FR	%	FR	%	FR	%	FR	%	FR	%
Wounds	4	8.7	7	11.1	5	8.8	9	10.3	25	10.0
Alopecia	1	2.2	1	1.6	2	3.5	5	5.7	9	3.6
O/hooves	11	23.9	24	38.1	11	19.3	24	27.6	70	28.0
1	3	6.5	3	4.8	4	7.0	8	9.2	18	7.2
2	5	10.9	1	1.6	2	3.5	2	2.3	10	4.0
None	20	43.5	27	42.9	33	57.9	38	43.7	118	47.2

KEY: O/hooves: overgrown hooves FR: Frequency
1: wounds and alopecia 2: wounds and overgrown hooves.

4.1.5. Levels of hygiene in the donkey "Bomas".

A summary of the descriptive analyses of the level of hygiene in the "bomas" in Mwingi District is shown in Table VI. The analyses showed that 17.6% of the "bomas" in Central, 18.9% in Migwani, 39.4% in Kyuso and 9.1% in Mumoni were "clean". At the district level, 19.5% of the "bomas" were "clean". "Dirty bomas" were most prevalent in Mumoni Division where they accounted for 90% of all the "bomas"

inspected. The prevalences in the other divisions, in descending order, were 82.4% in Central, 81.1% in Migwani and 60% in Kyuso. In general, 80.5% of the "bomas" were dirty. It was observed that the "bomas" that were shared by donkeys and cattle were the dirtiest.

TABLE VI: Summary of the descriptive analysis of the hygiene status of donkey "Bomas" in Mwingi District, 1995.

	Division									
"Hygiene	Central		Migwani		Kyuso		Mumoni		Overall	
Status"	FR	%	FR	%	FR	%	FR	%	FR	%
"Clean"	6	17.6	7	18.9	13	39.4	5	9.1	31	19.5
"Dirty"	28	82.4	30	81.1	20	60.6	50	90.0	128	80.5

KEY: Clean: "boma" did not have manure in it.
Dirty: "boma" had manure.
FR: Frequency.

4.1.6. Donkey feeds.

The distribution of the different types of donkey feeds in Mwingi District is shown in Table VII. The division-specific proportions of herds that fed on grass alone throughout the year were as follows: 32.4% in Central, 5.1% in Migwani, 6.1% in Kyuso and 1.8%. On the whole, only 9.9% of the herds fed on grass alone throughout the year. Apart from the 7.7% of the herds in Migwani, none of the herds in the other

divisions fed on shrubs alone. Grass and farm crop by-products provided feed to 61.8% of the herds in Central, 87.2% in Migwani, 18.2% in Kyuso and 23.6% in Mumoni divisions, and to 46% of the herds in the entire district. The division-specific proportions of herds that fed on combinations of grass, farm crop by-products and shrubs were 5.9% in Central, 75.8% in Kyuso and 74.5% in Mumoni. This combination was not used in Migwani, although 42.2% of the herds in Mwingi District fed on it.

At the district level, 51.6% of the study herds had "adequate" feed throughout the year. These included 58.8% of the herds in Central 16.7% in Migwani, 24.2% in Kyuso and 83.6% in Mumoni divisions. In contrast, 48.4% of the herds had minimal feed particulary during dry seasons. Within the divisions, 41.2% of the herds in Central, 83.3% in Migwani, 75.8% in Kyuso and 16.4% in Mumoni did not have adequate forage throughout the year.

TABLE VII: Summary of the descriptive analyses of donkey feeds in Mwingi District, 1995.

	Division									
Feed	Central		Migwani		Kyuso		Mumoni		Overall	
Type	FR	%	FR	%	FR	%	FR	%	FR	%
1	11	32.4	2	5.1	2	6.1	1	1.8	16	9.9
2	-	-	3	7.7	-	-	-	-	3	1.9
3	21	61.8	34	87.2	6	18.2	13	23.6	74	46.0
4	2	5.9	-	-	25	75.8	41	74.5	68	42.2
Adequate	20	58.8	6	16.7	8	24.2	46	83.6	80	51.6
Minimal	14	41.2	30	83.3	25	75.8	9	16.4	78	48.4

KEY: 1: Grass. 3: Grass and crop residues. FR: Frequency.
2: Shrubs 4: Grass, shrubs and crop residues.

4.1.6.1. Feeding management of donkeys.

Generally, twenty percent of the donkeys grazed freely, 67% were tethered while 13% were both tethered and grazed freely. In all the divisions, donkeys were left to fend for themselves in the farms during the dry season following crop harvest. All the farms allowed young donkeys to graze with adults. The foals were not weaned until the dams stopped suckling them.

Fifty two percent of the donkeys did not share forage with other large domestic animal species. Twenty nine percent of the herds shared forage with both cattle and goats while 15 % and 4% shared with only cattle and goats respectively. Ninety four percent of the farms did not give mineral supplements while 6 % irregularly gave common salt.

4.1.7. Sources of water for donkey herds.

The sources of water for donkeys in Mwingi District are summarised in Table VIII. These included watering holes, earth dams, rock catchment areas, bore holes and combinations of all these. Watering holes were sources of water to 85.3% of the herds in Central, 73% in Migwani, 22.6% in Kyuso and 98.2% in Mumoni. On the whole, 74.5% of the herds in Mwingi District got water from watering holes. Earth dams provided water to 5.9% of the herds in Central, 18.9% in Migwani and 3.2% in Kyuso. None of the herds in Mumoni got water from earth dams. At the district level, 6.4% of the herds got water from earth dams. The herds whose water source were bore were 2.9% in Central, 8.1% in Migwani and none in Kyuso and Mumoni divisions. Bore hole water was used by 2.5% of all the visited herds. Water from rock catchment areas was used by 5.1% of all the study herds. They were all from Kyuso Division.

Combinations of watering holes, earth dams, boreholes and rock catchment areas were sources of water to 5.9% of the herds in Central, 48.4% in Kyuso and 1.8% in Mumoni. These combinations provided water to 11.5% of the herds in Mwingi District.

TABLE VIII: **Summary of the descriptive analyses of the sources of water for donkeys in Mwingi District, 1995.**

Water Source	Division									
	Central		Migwani		Kyuso		Mumoni		Overall	
	FR	%	FR	%	FR	%	FR	%	FR	%
1	29	85.3	27	73.0	7	22.6	54	98.2	117	74.5
2	2	5.9	7	18.9	1	3.2	-	-	10	6.4
3	1	2.9	3	8.1	-	-	-	-	4	2.5
4	-	-	-	-	8	25.8	-	-	8	5.1
5	2	5.9	-	-	15	48.4	1	1.8	18	11.5

KEY: 1: Watering holes. 2: Earth dams 3: Bore hole. 4: Rock catchment.
5: Combinations of 1, 2, 3 and 4.
FR: Frequency.

4.1.8. Deworming of donkeys.

The analysis of deworming of donkeys in Mwingi District are summarised in Table IX. Generally, 47.8% of the herds were dewormed at least once in their life time. These included 32.4% of the herds in Central, 51.4% in Migwani, 51.5 in Kyuso and 52.7% in Mumoni divisions. On average, 52.2% percent of the herds in Mwingi District were not dewormed at all. There were 67.6%, 48.6%, 48.5% and 47.3% of such herds

in Central, Migwani, Kyuso and Mumoni divisions respectively.

TABLE IX: Summary of the analysis of deworming of donkey herds in Mwingi District, 1995.

	Division									
	Central		Migwani		Kyuso		Mumoni		Overall	
Deworming	FR	%	FR	%	FR	%	FR	%	FR	%
Yes	11	32.4	19	51.4	17	51.5	29	52.7	76	47.8
No	23	67.6	18	48.6	16	48.5	26	47.3	83	52.2

FR: Frequency.

4.1.9. Availability of veterinary support services.

The analysis of the availability of veterinary support services to donkeys in Mwingi District is summarised in Table X. The division-specific proportions of the study herds whose owners indicated that could have access to veterinary services were 79.4% in Central, 89.2% in Migwani, 93.9% in Kyuso and 96.4% in Mumoni. On the whole, 90.6% of the herd owners in Mwingi District were aware of the presence of veterinary staff in their areas. On the other hand, 20.6% of the herds in Central, 10.8% in Migwani, 6.1% In Kyuso and 3.6% in Mumoni did not have access to veterinary services. These were 9.4% of all the study herds.

TABLE X: Summary of the analysis of the availability of Veterinary services to donkey herds in Mwingi District, 1995.

	Division									
	Central		Migwani		Kyuso		Mumoni		Overall	
Vet.	FR	%	FR	%	FR	%	FR	%	FR	%
Yes	27	79.4	33	89.2	31	93.9	53	96.4	144	90.6
No	7	20.6	4	10.8	2	6.1	2	3.6	15	9.4

KEY: Vet: Availability of veterinary support services.
Yes: Donkeys with access to veterinary services
No: Donkeys without access to veterinary services.
FR: Frequency.

4.1.10. Breeding of donkeys.

There was no donkey breeding programme at all in Mwingi District. The donkeys bred randomly at watering holes, in markets and in "bomas". The age-at-first-breeding for 22% of the surveyed herds ranged from 2 to 10 years. Sixty eight percent of the herd owners did not know the age at which they first bred their donkeys nor the average gestation periods of these herds. Furthermore, 43% of the herds had a foaling-to-first-conception interval of between two to sixty months. Donkeys in 34% of the herds took thirty six months to conceive after foaling.

4.1.11. Uses of donkeys.

The major uses of donkeys in Mwingi District are summarised in Table XI. Generally, 85.7% of the herds were used for transport only. The corresponding division-specific proportions were 96.9% in Central, 82.4% in Migwani, 89.6% in Kyuso and 81% in Mumoni. The donkeys mainly transported water for domestic use and for sale in towns and shopping centres. The other items transported included sand and stones for construction purposes, farm produce such as maize corn, green grams, sorghum, cassava, mangoes and sugar canes, firewood, charcoal, as well as sick people to health centres. One percent of all the donkeys were used in ploughing alone and were all from Mumoni Division.

Within the divisions, 17.6% of the herds in Migwani and 16.5% in Mumoni were used for both transport and ploughing. These were 10.5% of the total number of herds surveyed. Overall, 0.5% of the herds were used for transport and breeding.

Thirty nine percent of the farms used donkey manure in the gardens. Dry donkey dung was used to light fire and to smoke away bees and poultry ectoparasites. The filtrate from faecal matter boiled in water was used to "treat" fever and oedema in children. Sixty one percent of the farms did not have any use for the manure. Five farms in Kyuso Division bred donkeys for sale and for paying dowry.

TABLE XI: Summary of the analysis of the functions of donkeys in Mwingi District, 1995.

	Division									
	Central		Migwani		Kyuso		Mumoni		Overall	
Function	FR	%	FR	%	FR	%	FR	%	FR	%
1	31	96.9	42	82.4	43	89.6	64	81.0	180	85.7
2	-	-	-	-	-	-	2	2.5	2	1.0
3	-	-	9	17.6	-	-	13	16.5	22	10.5
4	1	3.1	-	-	5	10.4	-	-	6	2.9

KEY: 1: Transport
2: Ploughing
3: Transport and ploughing
4: Transport and breeding for sale.
FR: Frequency.

The summary of the analysis of the estimated daily loads, in kilogrammes, carried by donkeys in Mwingi District is shown in Table XII. In general, 33.8% of the donkeys carried forty or less kilogrammes per day. These included 21.9% of the herds in Central, 54.2% in Migwani, 28.9% in Kyuso and 28.6% in Mumoni. On the other hand, 59.4% of the herds in Central, 43.7% in Migwani, 46.6% in Kyuso, 28.6% in Mumoni and 41.6% in the whole district carried luggage which weighed between 40 and 80 Kgs. Mumoni Division had the largest proportion (42.8%) of herds that carried loads ranging between 80 and 120 Kgs, followed by Kyuso with 17.8%, Central with 3.1% and

Migwani with 2.1%. At the district level, 20.5% of the donkeys carried loads within this weight category. Only Central (15.6%) and Kyuso (6.7%) divisions had donkeys that carried more than 120 Kgs daily. These were only 4.1% in the district.

TABLE XII: Summary of the analysis of the distribution of the daily loads (Kgs) carried by donkeys in Mwingi District, 1995.

	Division									
	Central		Migwani		Kyuso		Mumoni		Overall	
Load(kgs)	FR	%	FR	%	FR	%	FR	%	FR	%
10-40	7	21.9	26	54.2	13	28.9	20	28.6	66	35.8
41-80	19	59.4	21	43.7	21	46.6	20	28.6	81	43.3
81-120	1	3.1	1	2.1	8	17.8	30	42.8	40	20.5
>120	5	15.6	-	-	3	6.7	-	-	8	4.1

KEY: FR: Frequency.

4.2. RESULTS OF LABORATORY ANALYSES.

4.2.1. Skin scrapings.

None of the 22 skin scrapings was positive for mange. Twenty one out of the twenty two (95.5%) skin scrapings were positive for fungal growth. Seventeen of the

donkeys that were less than two years of age.

4.2.2. Faecal samples.

4.2.2.1. Faecal egg count.

A summary of the frequency distribution of the number of eggs per gram (epg) of faeces categorised into 0 to 500 and more than 500 is shown in Table XIII. Donkeys with egg counts that were less than 500 per gram of faeces were 4.7% in Central, 4.2% in Migwani, 25% in Kyuso, 17.6% in Mumoni and 13.3% in the whole district. Using epg values greater than 500 as an indicator of nematodiasis, it was observed that helminthiasis was commonest in Migwani Division with a prevalence of 95.7%. The prevalence in the other divisions was as follows: 95.3% in Central, 82.4% in Mumoni and 75% in Kyuso. It was 82.7% at the district level.

TABLE XIII: Summary of the percent frequency distribution of the number of nematode eggs per gram in Mwingi District, 1994.

	Division				
Epg	Central	Migwani	Kyuso	Mumoni	Overall
0-500	4.7	4.2	25.0	17.6	13.3
>500	95.3	95.7	75.0	82.4	82.7

KEY: Epg: eggs per gram.

4.2.2.2. Characterisation of larvae from the donkey faecal samples.

Only larvae belonging to the genera *Strongylus* and *Trichonema* (*Cyanthostome*) were recovered from the pooled samples from all the divisions. There were no differences in the types of strongyles infecting donkeys in the four divisions. The intestinal cells of the larvae failed to stain adequately. Therefore, it was not possible to characterise the larvae to species level. A summary of the results of the characterisation of the larvae is shown in Table XIV. The larvae of *Strongylus spp* were more, per microscopic field, than those of *Trichonema spp* at all but two levels of epg. The two epg levels were epg > 1000 in Central and epg < 1000 in Migwani. No larvae were recovered from the less than 1000 epg category from Central Division.

TABLE XIV: Summary of the laboratory characterisation of nematode larvae from donkey faecal samples pooled according to egg count and division of origin in Mwingi District, 1994.

Division	Epg category	Strongylus larvae	Trichonema larvae
Central	<1000	-	-
	>1000	++	+++
Migwani	>1000	+	++
	<1000	+++	++
Kyuso	<1000	++	+
	>1000	+++	++
Mumoni	<1000	++	+
	>1000	+++	++

KEY: +: three or less larvae per microscope field.
++: between four and eight larvae per microscope field.
+++: more than eight larvae per microscope field.
Epg: Eggs per gram.

4.3. Results of statistical analyses.

4.3.1. Descriptive statistics and pair-wise comparisons of the division-specific egg counts.

A summary of the descriptive statistics of the egg counts is shown in Table XV.

The division-specific egg counts ranged from zero to 17500 with a mean of 6265.1 for the donkey herds in Central, zero to 18700 with a mean of 6006.1 in Migwani, zero to 28000 with an average of 3483.8 in Mumoni and zero to 13900 with a mean of 3060.5 in Kyuso. At the district level, the egg count per gram of faeces ranged from zero to 28000 with a mean of 4592.1. The median egg counts were less than the means of the egg counts in all the divisions. The standard deviations about the mean egg counts were large.

TABLE XV: Summary of the analysis of the overall and division-specific nematode strongyle egg count per gram of faeces from donkeys in four divisions in Mwingi District, 1994.

	N [a]	Mepg [b]	SD [c]	Range	Median
Central	43	6265.1	4847.8	0.0 - 17500	5100
Migwani	49	6006.1	4569.2	0.0 - 18700	5300
Mumoni	68	3483.8	4949.4	0.0 - 28000	1500
Kyuso	43	3060.5	3234.9	0.0 - 13900	2100
Overall	203	4592.1	4702.7	0.0 - 28000	3000

KEY: a: Number of donkeys sampled c: Standard deviation.
b: Mean eggs per gram

The overall plot of egg counts per gram of faeces was skewed to the right

[Appendix V (a)]. Similarly, all the division-specific histograms of epg were skewed to the right. The histograms for Central and Migwani divisions were less skewed than those of Mumoni and Kyuso divisions. The Wilk-Shapiro/Rankit plot [Appendix V(b)] was concave, with a level of 0.8328. A natural logarithm transformation normalised the data [Appendix V(c)] and achieved a Wilk-Shapiro/Rankit level of 0.9802 [Appendix V(d)].

The summary of the analysis of variance between the division-specific mean epgs are shown in Table XVI(a). At five percent level of significance, the overall F-statistic was highly significant (P = 0.0004). Thus, at least two of the means statistically differed from each other.

TABLE XVI(a): Summary of the analysis of variance for division-specific mean faecal egg counts from donkeys in four divisions of Mwingi District, 1994.

SOURCE	DF	SS	MS	Variance ratio	P-value
Between Divisions	3	4.027+08	1.342+08	6.57	0.0004
Within Divisions	199	4.027+09	2.043+07		
Total	202	4.467+09			

DF: Degrees of Freedom, SS: Sums of Square.
MS: Mean of squares, P-Value: Probability value.

A summary of the results of Tukey's Pair-wise Honest Significant Difference (HSD) test to determine which pair(s) of these means differed are shown in Table

XVI(b). There was no significant ($p > 0.05$) difference between the mean epg for Central (6265.1) and that for Migwani (6006.1). Similarly, the mean epg for Kyuso (3060.5) did not differ ($p > 0.05$) from that of Mumoni (3443.8). However, each of the means of Central and Migwani divisions differed statistically ($P < 0.05$) from that of Kyuso and Mumoni divisions.

TABLE XVI(b): Tukey's pair-wise Comparisons of the division-specific means of faecal egg counts from donkeys in four divisions in Mwingi District, 1994.

Absolute differences between Divisional means

		Divsion			
Division	Mean epg	Central	Migwani	Mumoni	Kyuso
Central	6265.1	-	259	2781.2*	3204.6*
Migwani	6006.1		-	2522.3*	2945.6*
Mumoni	3443.8			-	423.3
Kyuso	3060.5				-

* = These differences were significant at $\alpha = 0.05$.

4.3.2. Logistic regression.

The summary of the results of logistic regression analysis of presence of nematodiasis in donkey herds on the study variables is shown in Table XVII. The

deviance associated with the model was 86.6, with 144 degrees of freedom and a probability value of 1.0000. At 10% level of significance, the sex (male) of the owner, the average age of the donkey herd (less than 2 years), deworming status (dewormed) of the herd, level of hygiene (dirty) in the donkey "boma" and the division were associated with nematodiasis. The herd size, availability of veterinary support services, the source of water for the donkeys and availability of forage were not associated with nematodiasis.

The sex of the donkey owner, deworming of donkeys and the division were negatively correlated with nematodiasis. On the other hand, the herd average age and the level of hygiene in the "boma" were positively correlated with nematodiasis.

Belonging to a male person, having been dewormed and division had a protective effect (OR < 1.0) against nematodiasis. Dirty "bomas" (OR = 3.92) had a strong causal association with nematodiasis. The upper limit for the odds ratios associated with the availability of veterinary services (23.87) and "boma" hygiene (OR = 15.67) were high while those associated with the size of the donkey herd (2.31) and availability of forage (OR = 2.83) were marginal.

A backward stepwise logistic analysis based on change of deviance selected only the sex of the owner, the age of the donkey, level of "boma" hygiene and the division. Further statistical analysis revealed that donkeys which belonged to women were 14.58 (1.12, 189.7) times more likely to have nematodiasis than those owned by men. Donkeys that were kept in dirty "bomas" were 5.07 times more at risk of having nematodiasis than those in relatively clean "bomas". Non-dewormed herds were 3.82 more likely to have nematodiasis than those that were dewormed. Compared to the donkeys in Kyuso

Division, the donkeys in Central Division were at the greatest risk (OR = 3768) of nematodiasis followed by those in Migwani (OR = 14.5) and Mumoni (OR = 4.62). Kyuso was used as the reference division because it had the lowest mean epg of faeces.

TABLE XVII: Summary of overall unweighted logistic regression of nematodiasis on the study variables for Mwingi District.

Variables	Est.	SE.	P-value.	Odds ratio.
Constant	2.62989	2.26074	0.2447	
Sex of donkey owner	-2.21471	1.13270	0.0505	0.11 (0.01, 1.01)[b]
Number in the herd	0.37276	0.23723	0.1161	1.45 (0.91, 2.31)
Donkey age	0.14471	0.07032	0.0396	1.16 (1.01, 1.33)
Deworming status	-1.05037	0.59384	0.0769	0.35 (0.11, 1.12)
Vet. availability	0.56536	1.35118	0.6756	1.76 (0.12, 23.87)
"Boma" hygiene	1.36516	0.70757	0.0537	3.92 (1.34, 15.67)
Water source	0.02200	0.15650	0.8882	1.02 (0.75, 1.39)
Feed availability	-0.40062	0.73491	0.5857	0.67 (0.16, 2.83)
Division	-0.76838	0.38093	0.0437	0.460 (0.22, 0.98)

Deviance: 86.60; P = 1.000.
144 degrees of freedom.

KEY: Est.: Estimate of the variable. SE: Standard error.
P-value: Probability value.
Division: Division where the donkey herd was located.
b: 95 % confidence interval about the odds ratio.

On the basis of absence of significant difference between the division-specific means of epg, the data from Central were pooled with those from Migwani and those from Kyuso with those from Mumoni. A logistic regression analysis was performed on both subsets of data. The model for the combined Kyuso and Mumoni data (Appendix VII) had the sex of the herd owner, the average age and the division of origin of the donkeys as well as the source of water marginally ($P < 0.1$) associated with nematodiasis. Donkeys from Mumoni Division were 6.64 times more likely to have nematodiasis than those from Kyuso that were used as the references. Donkey herds whose average ages exceeded two years were 2.3 times more at risk of nematodiasis than younger herds. There was marginal risk (OR = 1.5) of nematodiasis to donkeys that drunk water from watering holes and earth dams compared to those which got water from boreholes and rock catchment areas.

The estimates of the parameters in the combined model for Central and Migwani (Appendix VIII) were large but not statistically ($P > 0.05$) related to nematodiasis. Backward stepwise logistic regression revealed that availability of grass increased the potential risk for nematodiasis by 22.6 times compared to when grass was scarce.

4.3.3. Discriminant analysis.

The results of the discriminant analysis are summarised in Table XVIII. At five percent level of significance, there were significant ($P < 0.05$) differences between the pairs of canonical variable means for Migwani and Central (6.85), Kyuso and Central (26.55), Kyuso and Migwani (35.53), Mumoni and Central (8.16), Mumoni and Migwani

(17.14) and Mumoni and Kyuso (30.08). Five out of thirteen study variables entered the discriminant function. These were herd size, type of feed, feed availability, source of water and the faecal egg count. The intercepts for all the division-specific functions were negative.

The results of the classification of the herds that had nematodiasis are summarised in Table XIX. An overall percent correct classification of 67.1 percent was achieved. The division-specific classification functions raised the prior probabilities for correct case classification from 25%, which is expected by chance, to 44.1% in Central, 80.6% in Migwani, 71.0% in Kyuso and 70.4% in Mumoni. The overall case misclassification was thirty three percent. The misclassified cases from Central Division were distributed almost equally between Migwani and Mumoni divisions.

TABLE XVIII: Summary of the stepwise discriminant analysis for classification of donkey herds into the four divisions of Mwingi District in 1994.

F-matrix Degrees of freedom = 5 147 (2.21).

	Central	Migwani	Kyuso
Migwani	6.85		
Kyuso	26.55	35.53	
Mumoni	8.16	17.14	30.08

Classification function

	Group			
Variable	Central	Migwani	Kyuso	Mumoni
Number in herd	0.53443	0.39209	-0.49444	1.06909
Type of feed	2.83130	3.67654	2.80393	3.17188
Feed availability	9.17937	6.84793	11.07437	10.39878
Water source	0.51600	0.42419	2.49554	0.49608
Faecal egg count	0.00039	0.00033	0.00008	0.00017
Intercept	-16.10573	-15.63665	-23.51101	-19.98016

TABLE XIX: Jackknifed classification of cases of nematodiasis herds in Mwingi District, 1994.

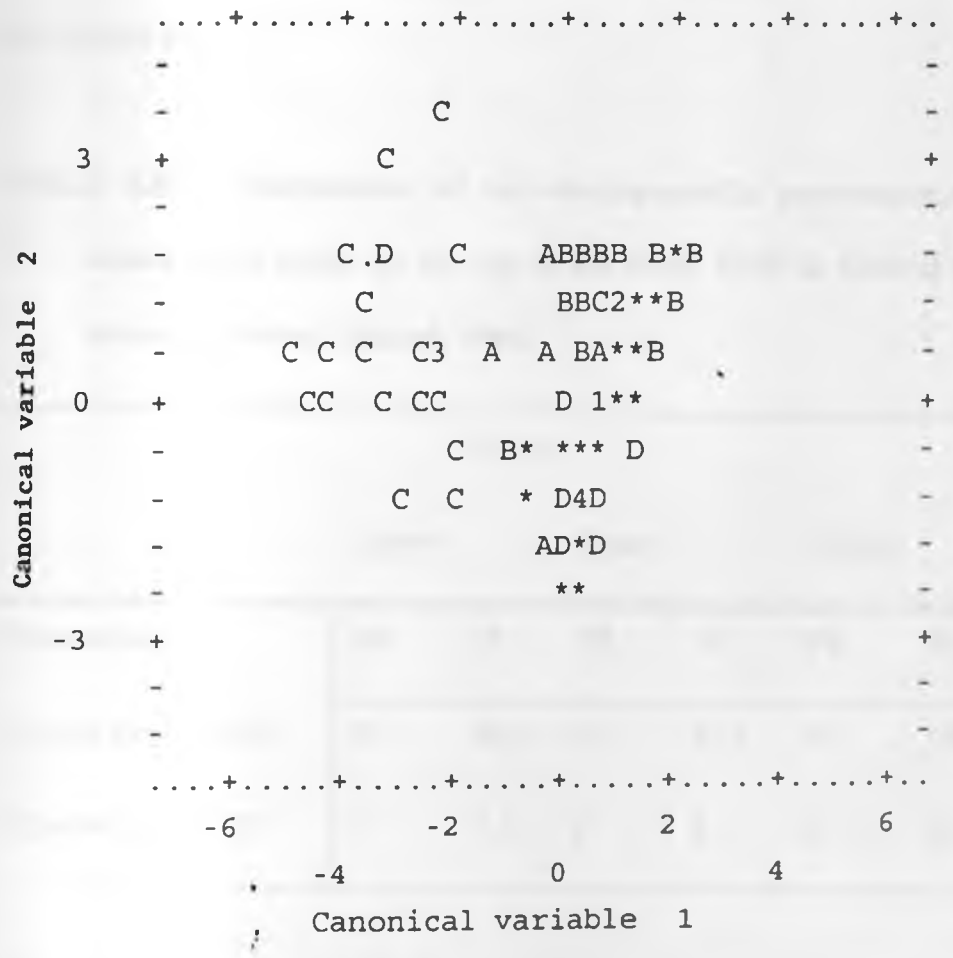
Group	Percent correct	Number of cases classified into -				
		Central	Migwani	Kyuso	Mumoni	Total
Central	44.1	15	9	2	8	34
Migwani	80.6	3	29	0	4	36
Kyuso	71.0	1	2	22	6	31
Mumoni	70.4	8	7	1	38	54
Total	67.1	27	47	25	56	155

The discriminant functions (Appendix IX) computed to differentiate between the divisions whose mean epg differed statistically yielded probabilities that were better than the expected prior probabilities. All the study variables that entered in the functions for Central-Kyuso and Migwani-Mumoni were some of those in the overall function. In addition to some of the factors in the overall model, the function for Central-Mumoni contained sex of the donkey owner and the level of "boma" hygiene while that for Migwani-Kyuso contained age of the donkey.

The scatter plot of canonical variables (Figure 1) showed marked overlap (misclassification) between Central (A) and Migwani (B) and between Central and

Mumoni (D) divisions. Kyuso Division (C) was well differentiated from the other divisions. The positions of the mean values of the canonical variables for the four divisions, that is, 1, 2, 3, and 4, are shown on the scatter plot. The mean value for Kyuso (3) was farther away from those of the other three divisions, which were close to each other.

Figure 1: A scatter plot showing the classification of herd cases of nematodiasis in Mwingi District in 1994.



N O T E: Overlaps of different divisions are indicated by an asterisk(*).

KEY: A: Central, B: Migwani, C: Kyuso, D: Mumoni.

4.4. Evaluation of the effect of Ivermectin[R] on donkey gastro-intestinal nematodiasis in Central and Kyuso divisions in 1995.

4.4.1. Pre-treatment faecal egg counts.

The frequency distribution of the status of nematodiasis in the pre-treatment donkey herds is shown in Table XX(a). Nematodiasis (epg greater than 500) was observed in 92.9% and 91.1% of the herds in Central and Kyuso respectively, with an overall prevalence of 91.8%. On the other hand, 7.1% of the herds in Central and 8.9% in Kyuso were negative for nematodiasis. These accounted for 8.2% of all the herds in this clinical trial.

TABLE XX(a): Distributions of the division-specific pre-treatment status of nematodiasis based on the epg in the study herds in Central and Kyuso divisions, Mwingi District, 1995.

	Division					
	Central		Kyuso		Overall	
Nematodiasis	FR	%	FR	%	FR	%
Positive (epg >500)	39	92.9	51	91.1	90	91.8
Negative (epg 0-500	3	7.1	5	8.9	8	8.2

KEY: epg: eggs per gram. FR: Frequency.

The means and pair-wise comparisons of the means of epg for the donkey herds

in Kyuso and Central divisions that were surveyed in 1994 and later selected for evaluation of the effectiveness of Ivermectin^{R} are shown in Table XX(b). The pre-treatment mean epg for donkeys in Central was 5826.3 while for those in Kyuso was 5160.0. The two means of epg were not statistically ($P > 0.05$) different. At five percent level of significance, there was a statistical difference between the 1994 means of epg of donkeys in Central and Kyuso divisions. The 1995 means of epg in the two divisions were not statistically ($P > 0.05$) different. Furthermore, the within-division mean epg values for 1994 in both divisions were not significantly ($P > 0.05$) different from the pre-treatment means of epg in 1995. However, at ten percent level of significance, the 1994 mean epg for Kyuso Division marginally differed from that of 1995.

TABLE XX(b): A summary of the pair-wise comparisons of the division-specific means of epg for 1994 and 1995 for donkey herds in Central and Kyuso divisions, Mwingi District in 1995.

	Mepg	Central94	Central95	Kyuso95	Kyuso94
Central94	6923.5	-	1763.5	1097.2	4419.0*
Central95	5826.3		-	666.3	2655.5
Kyuso95	5160.0			-	3321.8
Kyuso94	2504.5				-

KEY: * : This difference was significant at $\alpha = 0.05$.
Mepg: Mean eggs per gram.

4.4.2. Drug efficacy

The fall in the means of egg counts per gram (epg) of faeces in Central and Kyuso divisions following Ivermectin^{R} treatment is shown in Figure 2. The mean epg for Central Division fell to under 200 in ninety percent of the donkeys by the sixth day. The mean epg values fell at a fast rate during the first three days before they slowed down over the following three days to near zero by the ninth day post-treatment. In Kyuso Division, there was a fast rate of fall in mean epg in the first four days post-treatment. The rate slowed down over the subsquent four days. By the fourth day following treatment, only 20 percent of the donkeys had egg counts above 500.

The natural logarithms of the mean egg counts per gram (MEPG) for the pre-treatment (day 0) and post treatment donkey faecal samples from Central and Kyuso divisions are shown in Table XXI. The log mean epg of donkeys in Central before treatment was 7.8571 while that on day nine was 4.333. A pair-wise comparison of the log mean epg for before and days after treatment revealed that log MEPG pre-treatment significantly ($p<0.05$) differed from log MEPG on days three, six and nine post-treatment. Log MEPG on day three post-treatment did not differ significantly ($P>0.05$) from log MEPG for days six and nine.

FIGURE 2: GRAPHICAL PRESENTATION OF EPG CHANGES IN DONKEYS OF CENTRAL AND KYUSO DIVISIONS OF MWINGI DISTRICT AFTER IVERMECTIN[R] TREATMENT IN 1995.

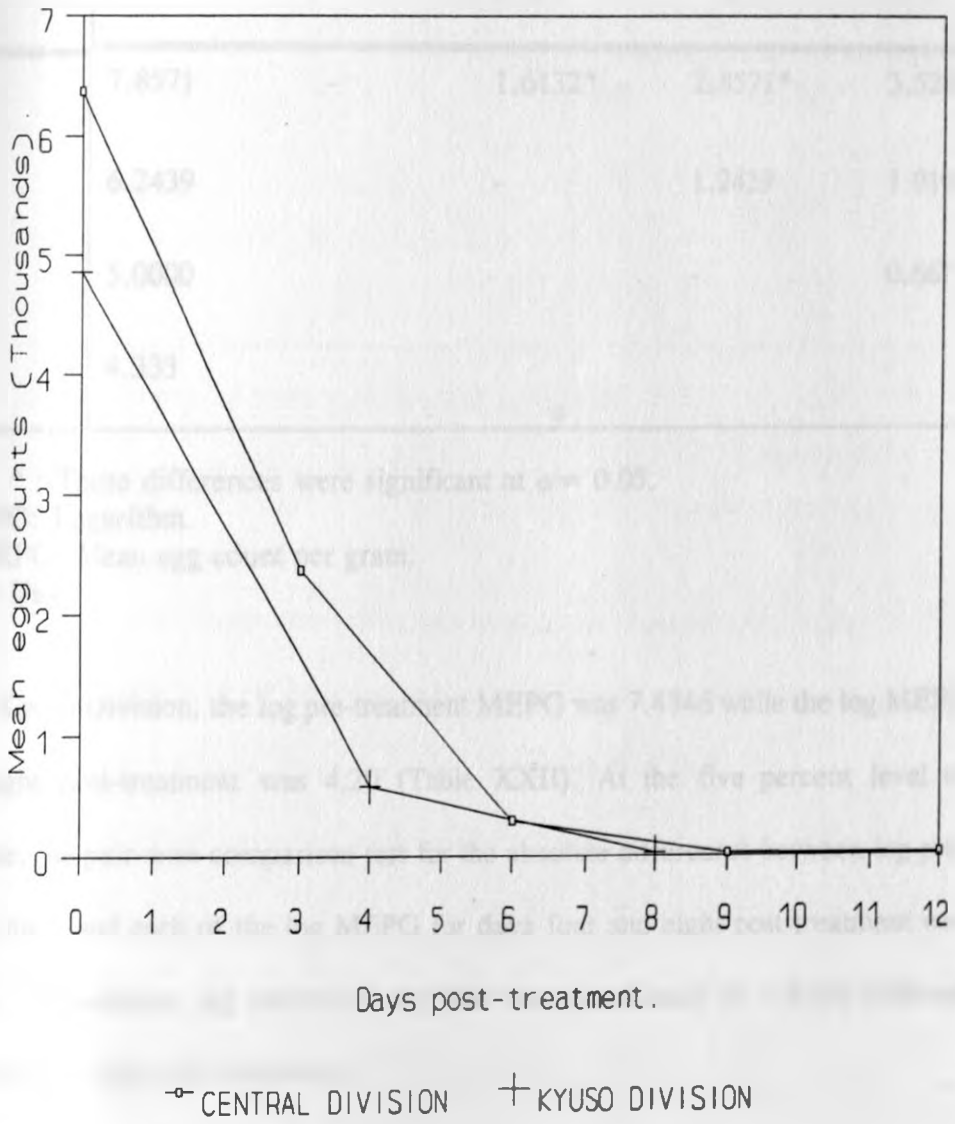


TABLE XXI: A summary of the pair-wise comparison of log MEPG pre-treatment and log MEPG post-treatment of donkeys in Central Division, Mwingi District, 1995.

DAY	LOG (MEPG)	D_0	D_3	D_6	D_9
D_0	7.8571	-	1.6132*	2.8571*	3.5241*
D_3	6.2439		-	1.2439	1.9109
D_6	5.0000			-	0.667
D_9	4.333				-

KEY: * : These differences were significant at $\alpha = 0.05$.
LOG: Logarithm.
MEPG: Mean egg count per gram.
D: Day.

In Kyuso Division, the log pre-treatment MEPG was 7.4746 while the log MEPG on day eight post-treatment was 4.20 (Table XXII). At the five percent level of significance, the pair-wise comparison test for the absolute differences between log pre-treatment mean and each of the log MEPG for days four and eight post-treatment was significant. Furthermore, log MEPG for day four was significantly ($P < 0.05$) different from that of day eight post-treatment.

TABLE XXII: Summary of the pair-wise comparison of log MEPG pre- treatment and log MEPG post-treatment of donkeys in Kyuso Division, Mwingi District in 1995.

DAY	LOG (MEPG) D_0	D4	D_8
D_0	7.4746 -	1.8430*	3.2746*
D_4	5.6316	-	1.4316*
D_8	4.2000		-

KEY: * : These differences were significant at $\alpha = 0.05$.
LOG: Logarithm.
MEPG: Mean egg count per gram.
D: Day.

The percent mean change between the pre-treatment and post-treatment egg counts per gram of faeces (efficacy) of donkeys in Central Division on day nine was 99.7% while that of donkeys in Kyuso Division on day eight was 99.5%.

The results of the paired t-test for statistical difference between pre-treatment and post-treatment within-division means of epg are shown in Table XXIII. The absolute differences between the means were highly significant (P = 0.00001) for both Central (8.04 compared to 2.12) and Kyuso (7.13 compared to 2.07) divisions.

TABLE XXIII: A student's paired t-test for the differences between the within division pre-treatment and post-treatment means of faecal egg counts per gram of faeces from donkeys, 1995.

	Division	
	Central	Kyuso
Pre-treatment mean	6369.8	5028.3
Post-treatment mean	20.9	22.8
Test mean difference	6348.9	5021.1
Standard error	789.5	704.47
T-test value	8.04	7.13
Degrees of freedom	42	56
Probability value	0.00001	0.00001

The summary of the test of the differences between the pre-treatment and post treatment median egg counts of donkeys in Central and Kyuso divisions are shown in Table XXIV. The estimated normal approximations for Central (5.705) and Kyuso (6.705) were greater than the critical $Z_{(0.05)} = 1.96$. Therefore, there was a very strong ($P = 0.00001$) statistical difference between the pre-treatment (MED_0) and the post-treatment (MED_x) median egg counts per gram in donkeys in both Central and Kyuso divisions.

TABLE XXIV: Summary of the Wilcoxon signed rank test for differences between median egg counts per gram of faeces before and after treatment with Ivermectin^R (1995).

	Central	Kyuso
Wilcoxon Signed rank test for	MED_0-MED_9	KED_0-KED_8
Sum of negative ranks	0.0000	0.0000
Sum of positive ranks	946	1596
Normal approximation (Z-value).	5.705	6.705
Two tailed P-value for Z-value	0.00001	0.00001
Total sum of values that were tied	12	27

KEY: MED_0 : Mean of egg counts before treatment.
MED_9 : Mean of egg counts on day nine post-treatment.
KED_0 : Mean of egg counts before treatment.
KED_8 : Mean of egg counts on day eight post treatment.

4.4.3. Characterisation of nematode adult worms and larvae from pre- treatment faecal samples of donkeys in Central and Kyuso divisions, 1995.

The adult worms recovered from stool included *S. vulgaris, S. edentatus, S. equinus* and *Trichonema spp,* with *S. edentatus* as the predominant species among the large strongyles. The larvae that were recovered belonged to *S.vulgaris, S.edentatus, Cyanthostomum coronatum, C. tetracanthum, C. radius.* Larvae of *Cyanthostomes* were

predominant. The pool of samples that were negative for nematode eggs following treatment did not yield any larvae even after incubation.

4.4.4. Ectoparasites.

All the donkeys examined in Kyuso Division and 42% from Central Division were infested with *Rh. pulchellus* ticks. It was not possible to quantify the level of tick infestation during the follow up period but it appeared to decrease markedly following Ivermectin^{R} treatment.

CHAPTER FIVE

DISCUSSION AND CONCLUSIONS

Over eighty percent of the homesteads in Mwingi District had at least one donkey each (Mwingi District livestock production office). However, the number of donkeys in the district appeared to fall short of the local needs. This shortage was exemplified by the high initial cost of acquiring donkeys, the constant and widespread overloading of the available donkeys and the large number of people, mostly women and children, who still carried heavy loads on their heads whenever they failed to hire donkeys.

The cost of a one-year old donkey was four thousand Kenya shillings while an adult female could cost up to ten thousand shillings. Liquid cash was often difficult to get. Thus, donkeys were mostly acquired through battering cattle. The unbalanced donkey ownership ratio (2:1) between men and women in Mwingi District could be attributed to the high cost of acquiring a donkey since most women did not have cattle and therefore could not afford donkeys. Those women who owned donkeys mostly had males because they were relatively cheaper to acquire. Financially poor homes could not afford a donkey.

There was a tendency for relatively richer farmers with large pieces of land to own more donkeys than the poorer ones. The increased need for donkeys on such farms was mainly associated with increased farm workloads. This general observation was also recorded by Wilson (1981) in sub-Saharan Africa. Kakuyu Location in Mumoni Division

had the largest percentage of herds with at least three donkeys each. This was because the location had the poorest road network and received relatively more rainfall because of its location on the windward side of the Mumoni hills. This high rainfall supported more crop agriculture and hence the increased need for donkey transport to take farm produce to homesteads and marketing centres.

Wilson (1981) recommended that the maximum load carried on backs of donkeys should not exceed one third of the body weight of the donkey. Most adult donkeys in Mwingi District weighed between 120 kgs and 150 kgs and carried at least 80 kgs of load on their backs. This meant that the donkeys were overloaded. Similarly, Aluja and Lopez (1991) had observed such overloading of donkeys in Mexico. Donkeys in Mwingi District pulled carts whose weight exceeded that recommended by Inns (1980). The two possible reasons why donkeys were often overloaded were that the donkey herds were relatively small for the amount of work they had to do per day coupled with the owners avoiding many trips since the distances to and from markets and/or water sources were usually very long. Despite the fact that the majority of donkeys worked for two to three hours, work overload coupled with extensive movement exerted considerable stress upon them.

Overloading and poor health have been reported to cause retarded growth, gradual reduction in productivity, early withdrawal from work and early mortalities in donkeys (Aluja and Lopez, 1991; Mohammed, 1991; Khallaayoune, 1991). Thus, these could probably be the causes of reduced average donkey life expectancy, of less than ten years, recorded in the present study. This average life expectancy was relatively low compared to thirty seven years reported for donkeys in the United Kingdom (Svendsen, 1989) and

eleven years in Turkey, Egypt, Jamaica, Peru and Ecuador (Svendsen *et al.*, 1985 cited by Bliss, 1989). In this study, the significant division-specific mean donkey age difference recorded in Mumoni and Migwani divisions was probably due to the relatively short survival rates of donkeys in Khatse Location in Mumoni Division. A combination of heavy helminthiasis, underfeeding and lack of access to veterinary support services could explain the low donkey average life expectancy of seven years reported in Khatse Location. The locational animal health assistant could not possibly cover much of the area because of logistic constraints, with transport as the major limitation.

The finding that 82.7% of the study herds had gastro-intestinal nematodiasis and yet only 46.7% of them showed poor signs of health supported the observations by Soulsby (1989) who noted that donkeys developed tolerance towards these gastro-intestinal nematodes. However, the lush grass and shrubs, which were plenty during the rainy season when this cross-sectional survey was conducted, probably boosted the nutritional status and hence the immunity of the donkeys to these parasites. This kept many of them in average-to-good body conditions inspite of the heavy worm burdens and stress from work overload.

All the donkeys in the district fed on grass throughout the year. However, forage became scarce during the dry season and farm crop residues such as maize stover, maize cobs and/or shrubs were fed to donkeys to offset the deficit. The high human settlement in Central and Migwani divisions, compared to Kyuso and parts of Mumoni, reduced the communal grazing areas available to the donkeys. Thus, there were high proportions of herds with inadequate forage in the former divisions despite the high rainfall. The

scarcity of forage associated with dry seasons and lack of enough grazing areas could explain the high proportion of donkey herds in Mwingi District reported to have inadequate feed availability throughout the year. The fact that sixty percent of the herds remained in average body condition during the dry season which followed when the forage was very scarce and of poor quality, reflected the hardy nature of donkeys which has already been reported by Dill *et al.* (1980).

Although most of the herd owners visited had on average owned and looked after donkeys for over sixteen years, they all lacked the basic skills in donkey management and husbandry. As a result, donkeys had severe wounds, heavy tick infestation and low reproductive efficiencies. The latter were characterised by delayed ages at puberty, two to ten years instead of the optimal 18 months (Weipers, 1978), long foaling-to-conception (up to three years) intervals in thirty seven percent of the herds visited and low percentages of herds having donkeys of two years and below. None of the surveyed donkeys from Central Division was less than two years of age and this was further evidence of low reproductive efficiencies and/or low survival of the young ones.

Aluja and Lopez (1991) and Mohammed (1991) had reported that inadequate nutrition caused lowered reproductive performance in donkeys in Mexico and Ethiopia respectively. Thus, in Kyuso Division, which received the lowest mean annual rainfall and had the least amount of forage, donkeys foaled once in every five to six years compared to those in Mumoni which had more forage and foaled every three to four years. In Mwingi District, these health problems, especially nutritional deficiencies and the related conditions, probably resulted from lack of awareness about donkey husbandry

and management principles such as proper feeding and health care. Kumwenda *et al.* (1991) blamed ignorance to be responsible for the high prevalences of such preventable diseases and conditions in donkeys in Malawi.

Although only 1.2% of the study donkey herds in Mwingi District were reported by the owners to "commonly" have wounds, this was an understatement since as high as 21.2% of the herds had wounds at the time of this survey. The wounds were mainly (60%) caused by fights and biting among the donkeys during mating and when in market centres. The other causes included poorly strapped, rough and heavy uncushioned luggage packed in synthetic sacs, scratching by thorny vegetation, tethering, cruelty and malice. Poor loading methods were also reported by Yilma *et al.* (1991) to cause wounds in donkeys in Ethiopia. Scratches caused by vegetation were common during the harvesting season when the donkeys walked through narrow paths. The increased prevalence of bite wounds during the rainy season (Mwingi District veterinary office) could be attributed to redundancy since most donkeys did not work when the owners tilled the gardens. The donkey wound problem occurred equally in all the divisions as there were no significant differences noted in its prevalences.

Contrary to reports by Onyango (1990), tick infestation, particulary by *Rhipicephallus pulchellus*, was present in donkeys in Mwingi District throughout the year. The prevalence increased during the rainy seasons. However, the ticks were not known to spread diseases among the donkeys (Mwingi District veterinary office-Unpublished information). It was not possible to establish why tick prevalences in general and of *Rh. pulchellus* in particular, in Central, Mumoni and Kyuso herds were higher

than that in Migwani herds.

Austwick (1972) associated ectoparasite bite wounds with infection with fungi. This observation could explain the close similarities in the distribution of attachment sites of ticks and alopecia lesions from which dermatophytes were recovered. It was also possible that the breaks in the skin caused by scratches from thorny vegetation during and soon after the rainy seasons created portals for fungal infection. The relatively higher prevalence of *Trichophyton* species than the other fungal species in donkeys in Mwingi District was in line with the findings by Blood and Radostits (1989) that *Trichophyton spp* were the commonest fungi that affect donkeys. Fungal infections were predominantly (90.5%) observed in donkeys that were at least fifteen years of age. These findings agree well with those of Pascoe (1981) who reported that fungal infections were common in unthrifty and old donkeys. The percent rate of 9.5% infection in the younger, stunted and unthrifty donkeys (less than two years) could be associated with the poorly developed and/or compromised immune system (Blood and Radostits, 1989).

The relatively higher weighted prevalence of overgrown hooves in donkeys in Mumoni Division compared to the prevalences in the other three divisions in Mwingi District could not be explained from this study. However, the stony paths/roads could have predisposed the donkeys to laminitis, resulting in overgrown hooves (Blood and Radostits, 1989).

Donkeys that were older than two years were given 15 to 20 litres of water per day while the younger ones got half this amount. Only one percent of the herds surveyed had unlimited access to water sources. Water from river beds and bore holes was salty

while that from earth dams was very dirty and sometimes smelly. This meant that most donkeys did not have enough water to drink.

Donkeys in Mwingi District were used for transport, ploughing and breeding. As for ploughing, the donkeys cleared only one third of an acre per day due to poor health resulting from underfeeding, heavy parasitism and overwork. Some of the donkeys would refuse to plough to nib grass. Furthermore, the donkeys first fetched overloads of water from long distances before they ploughed. Donkeys were muzzled to prevent them from grazing during work. This restriction further stressed the donkeys and reduced their work output. There was a gradual reduction in work output which started when the donkeys reached twelve years of age.

The high prevalence of nematode eggs recorded during the cross-sectional survey and the follow up later compared very well with the observations by Falvey (1985), Wells (1985) and Bolbol and Saleh (1987), that helminthiasis was a real and constant threat to the health of working donkeys. Inspite of Mwingi District being dry for the greater part of the year, there was a general build up of gastro-intestinal nematodes in the donkeys. The likely reasons for this build up included failure to deworm the infected herds which contaminated the environment and, as Wakelin (1984) and Pandey and Eysker (1989) reported, became constant sources of re-infection to the donkeys, poor hygiene and very low levels of nutrition (Scot, 1988; Mattioli *et al.*, 1994).

Kyuso Division, which received low rainfall, had a relatively low level of infection as indicated by the low mean of the epg. These results seemed to be consistent with the observations made earlier by Round (1968), English (1979b) and Soulsby (1989)

that desiccation promoted death of free-living infective larvae of gastro-intestinal nematodes and hence led to low levels of infection.

The high prevalence of nematodiasis in donkeys within fifteen to twenty kilometres from the divisional/locational headquarters of the study areas suggested a worse picture of the disease in the deeper areas of Mwingi District. The reasons to support this hypothesis included poor infrastructure and lack of transport which rendered some donkey herds almost inaccessible to animal health workers, the general lack of interest/adequate training in donkey health among the local veterinary staff, ignorance among the herd owners that donkeys could suffer from heavy inapparent worm burdens and the belief amongst them that donkeys could never heal even after treatment.

Since this was a prevalence study, it was not possible to establish the patterns of passing out of gastro-intestinal nematode eggs from infected donkeys. For the same reason, it was not possible to establish the actual risk factors which could explain the statistical differences observed between the means of the egg counts in Central and Migwani divisions and those from Kyuso and Mumoni divisions. This was because the levels of donkey management and husbandry practices in all the divisions were virtually the same. However, the high amount of rainfall in Central and Migwani divisions which favoured development of more infective nematode larvae could account for these differences. Similar hypotheses have been advanced by Hansen and Perry (1990) and Hutchinson *et al* (1989). It is worthy noting that the means of epg of the divisions which received almost the same amount of rainfall per year did not differ statistically. Furthermore, there were more herds with high egg counts in Kakuyu Location, which

received more rainfall than in Khatse Location, which was in a rain shadow. However, a well designed prospective study is required to verify this observation.

The large standard deviations about the means of epg which were observed in this study were consistent with the over dispersion of helminth infections in populations as suggested by Wakelin (1984). The skewness to the right in the overall and division-specific distributions of epgs bore out the findings by Anderson and May (1980) that the majority of parasites in natural parasitic infections tended to occur in a few hosts and a few parasites to occur in the majority of hosts in populations.

Since postmortem examination was not done, it was not possible to establish why, within the same herds, some donkeys had egg counts of zero while others had very high epg values. However, Round (1968), Dunn (1978), and Soulsby (1989) have suggested that this could be due to one or a combination of factors. These factors include fluctuations in worm egg output, presence of non-egg-laying stages of worms, differences in individual susceptibility as well as in the consistency and volume of faeces passed. Furthermore, Round (1968) found out that these differences could be caused by the "time period over which the eggs were allowed to float in the McMaster slide".

Strongyloides and *Parascaris spp* eggs were observed in faeces of foals and not in faeces from adult donkeys. This differential age susceptibility to these nematodes agreed with the results described by Lyons *et al.* (1973). Similarly, the diversity of *Strongylus* and *Trichonema spp* recorded in this study was comparable to that reported in Chad (Graber, 1970), Zimbabwe (Pandey and Eysker, 1989) and Morocco (Khallaayoune, 1991). The finding of these gastro-intestinal nematode species in donkeys

in all the four divisions of Mwingi District was in line with observations by Fowler (1989), Sewell (1991) and Yilma *et al.* (1991) that donkey nematodes, particularly *Cyanthostomes*, did not generally differ much over wide geographical areas. Correlatively, the higher numerical representation of *Strongylus spp* than *Trichonema spp* observed following incubation of faeces was similar to what Yilma *et al.* (1991) reported in donkeys in Ethiopia. Although *Trichostrongylus* was not obtained in this survey, it has been reported to commonly occur in donkeys in Zimbabwe (Pandey and Eysker, 1991).

The positive associations obtained between gastro-intestinal nematodiasis and each of donkey age and dirty "boma" showed that if all the other factors in the model were held constant, nematodiasis increased by 0.14471 and 1.36516 for a unit increase in donkey age and level of dirtiness of the "boma" respectively. The marginal potential risk (OR = 1.89) of nematodiasis in donkeys whose average age was at least two years compared to the younger ones was consistent with the findings by Round (1968) and Duncan (1974) that equine strongyle infections were not age specific.

Donkeys kept in unhygienic "bomas" were 3.92 times more likely to suffer from gastro-intestinal nematodiasis than those in relatively clean "bomas". This compared well with the findings of Dunn (1978), Herd (1986a) and Hutchinson *et al.* (1989) who concluded that keeping equine in dirty premises predisposed them to nematodiasis. In this study, sixty five percent of the farms visited did not clear donkey premises of manure while only thirty five percent did so irregularly and inadequately. The manure was piled at the bases of the "boma" hedges. This manure was probably the major source of nematode infections to donkeys since Thomas (1982) and Mattioli *et al.* (1994) reported

that accumulated faecal material promoted development and survival of nematode larvae. Although the movements of the nematode larvae from the filth in the "bomas" to the lush vegetation along the perimeter of the "bomas" were not examined in this study, it was likely that infective larvae climbed and quested for donkeys on this vegetation. It is highly probable that donkeys got infected when they grazed on this vegetation.

Deworming donkeys was negatively associated with nematodiasis. This inverse relationship was expected since proper deworming of donkeys has been reported to reduce contamination of pasture with nematode eggs (Dunn, 1978; Herd, 1986a,b). This in turn reduced the risk of infection and re-infection of donkeys. In this survey, donkey herds that were not dewormed were 3.82 times more likely to suffer from gastro-intestinal nematodiasis than those that were dewormed. Lack of deworming as a risk factor for equine nematodiasis is well documented by Dunn (1978), Herd (1986b), Hutchinson *et al.* (1989) and Fowler, (1989). However, forty eight percent of all the surveyed herds were dewormed and yet 82.7% of them had gastro-intestinal nematodiasis (epg > 500). Similarly, Migwani, Kyuso and Mumoni divisions had high prevalences of nematodiasis despite the high percentage of herd owners who indicated that they dewormed their donkeys. This unexpected scenario could be attributed to irregular deworming, underdosing and/or drug resistance. Donkeys were only dewormed when they looked sick and/or passed worms. Yet, it was observed during this survey that several donkeys carried heavy worm burdens without necessarily looking unhealthy or passing worms in the faeces. Furthermore, only twenty percent of the herds were dewormed by animal health staff while the other eighty percent were treated by the

owners using drugs bought from the veterinary staff or from local drug shops. This meant that many donkeys were probably underdosed since their body weights were not properly estimated nor were their conditions assessed before treatment.

The significance of donkeys belonging to women as a potential risk factor (OR = 14.6) for nematodiasis was possibly a proxy for poor hygiene in the "bomas" and/or inadequate grazing areas fro the donkeys. This is because it was observed during this survey that such donkeys lacked enough grazing areas and were therefore rotationally tethered in the same "soiled" areas after very short rest periods. This probably created areas of intense larval challenge and hence the associated high risk for nematodiasis.

The positive associations that were observed between gastro-intestinal nematodiasis with each of Central, Migwani and Mumoni, while negatively associated with Kyuso, implied that donkeys in these divisions had increased levels of nematodiasis compared to those in Kyuso. This was also reflected by the high risk potential for nematodiasis for herds in Central (OR = 3768), Migwani (OR = 14.5) and Mumoni (OR = 4.62) compared to those in Kyuso Division. Similarly, donkey herds in Mumoni Division were 6.64 times at risk of nematodiasis than those in Kyuso. These observations could possibly be explained by the differences in climatic factors, particulary rainfall, between the divisions. Further studies need to be designed to delineate the effects of these hypothesised factors on gastro-intestinal nematodiasis.

The probability values associated with each of herd size, availability of veterinary support services and feed were insignificant while the odds ratios for nematodiasis had wide confidence intervals with significant upper limits. The latter suggested a strong

simple biological association between these factors and nematodiasis in the herds. Thomas (1982) reported high stocking density to be a risk factor for helminthiasis in animals (such as donkeys) which passed fibrous faecal material. The faecal material took long to disintegrate completely and thus, sheltered the infective larvae and favoured their survival. This could explain the observed positive association [OR = 1.49 (0.91,2.31)] between herd size and nematodiasis.

The positive correlation between availability of veterinary support services and nematodiasis suggested that as the services became available, the level of nematodiasis increased. This was logical since eighty percent of the herd owners who knew about the availability of these services in the areas were either not aware that the veterinary staff could attend to donkeys or they could not afford the veterinary charges. Moreover, most owners sought veterinary assistance only when the donkeys passed worms and/or were visibly unthrifty. Furthermore, some of the animal health staff lacked adequate and effective skills in treating donkey diseases. Thus, there was no effective veterinary attention towards the donkeys.

The high potential risk (OR = 22.6) for nematodiasis in herds in Central and Migwani divisions when grass was plentiful (during the rainy seasons) probably reflected the protection provided by grass cover, to the infective larvae against the harmful ultra-violet rays from the sun, which increased their survival (English, 1979a). By grazing on this grass, the donkeys were at a high risk of getting gastro-intestinal nematodiasis.

Although a good level of classification of the case herds was achieved in discriminant analysis, there was an overlap of donkey herds from Central, Migwani and

Mumoni. This suggested that these herds shared some of the study characteristics. Since all the components of the discriminant functions were either directly or indirectly related to climatic factors, particulary rainfall, it seemed reasonable to conclude that the clear differentiation of Kyuso from the other divisions showed that it had peculiar variables. For example, it received the least amount of rainfall. The similarity of climatic factors for Kyuso Division and Khatse Location in Mumoni Division could probably explain the six herds from Kyuso which were misclassified into Mumoni Division.

Evaluation of Ivermectin^{R}.

During the follow-up of the herds initially surveyed in Mwingi District, an evaluation of the effectiveness of Ivermectin^{R} against gastro-intestinal nematodes was carried out in Central and Kyuso divisions. Low responses of forty one percent in Kyuso Division and forty four percent in Central Division, of the previous contact donkey herds were achieved. This was either due to lack of proper flow of information or the herd owners were working in their gardens since it was the planting season. In addition, four previous contact donkeys died of unconfirmed causes. They all had very high faecal egg counts at the time of the initial survey.

It was not possible to establish whether the *Ascarid*, tape worm as well as the *Gasterophillus spp* infections observed in the pre-treatment donkeys were missed at the time of the initial cross-sectional survey or were acquired thereafter. The 2% prevalence of *Gasterophilus* infection that was observed in the present study was much lower than the 97.5% reported by Pandey *et al.* (1992) in Morocco.

Nematodiasis was a bigger problem in the pre-treatment donkeys in Central Division than in those in Kyuso Division. This was indicated by the higher pre-treatment overall mean of epg for donkeys in the former than in the latter division. This was despite the lower number of donkeys that was sampled in Central Division.

The lower mean egg count per gram of faeces for Central Division after eleven months following the initial survey probably resulted from the awareness that was created among the herd owners. This is because there was an increased tendency to deworm after the owners had been shown worms in the donkey faeces during the initial survey and/or received the results of the laboratory faecal analysis. The significant ($P < 0.1$) increase in the mean epg for Kyuso over the same period, despite similar sensitisation, could not be explained. However, the higher amount of rainfall (Mwingi District agriculture office) that was received compared to the previous year probably favoured increased survival of the infective larvae and hence the higher levels of gastro-intestinal nematodiasis.

The high efficacy of Ivermectin^R against egg-laying gastro-intestinal nematodes observed in this study was similar to that reported by Pereira *et al.* (1991) and Lihua *et al.* (1994). However, the average 8.5 days it took the epg to fall below 100 in this study was markedly less than the 8.9 weeks reported by Lihua *et al.* (1994). This faster action of Ivermectin^R was due to lack of previous exposure of the gastro-intestinal nematodes in Mwingi District to the drug. This in turn rendered them fully susceptible to Ivermectin^R. The passing of whole parasites in faeces within three days following treatment agreed with earlier observations by Slocombe and Cote (1984).

The uneven rate of fall of mean epg post-treatment in Central and Kyuso divisions

could either be due to differences in the rate at which effective levels of the drug diffused into the gut lumen to paralyse and dislodge the egg-laying nematodes (Merck veterinary manual, 1986) or due to the frequency of faecal sampling. Differential susceptibilities of the nematodes to the drug were not likely causes since the worms had not previously been exposed to Ivermectin^{R}.

The similar effectiveness of Ivermectin^{R} against the gastro-intestinal nematodes at the division level meant that its efficacy was not affected by the differences in husbandry and management levels as well as in geographical factors between the two divisions. The lack of difference in efficacy at the herd level was probably because the gastro-intestinal nematodes were Ivermectin^{R}-naive.

It was not possible to follow up donkeys for long enough to find out whether Ivermectin^{R} was effective against encysted *Cyanthostome* larvae. For, whereas Love *et al.* (1995) found *Cyanthostome* larvae fully susceptible to ivemectin^{R}, Eysker *et al.* (1992), Klei *et al.* (1993) and Lihua *et al.* (1994) reported resistance of these larvae to the normal and higher therapeutic doses of Ivermectin^{R}.

None of the donkeys was sacrificed to find out whether or not there were gut luminal strongyles that had resisted the drug. However, since the pooled post-treatment faecal samples that were negative for worm eggs did not yield any larvae on incubation, it could be concluded that Ivermectin^{R} probably cleared all the egg-laying nematodes.

The large and small gastro-intestinal nematode species that were observed in the present study were similar to those Ngatia and Kuria (1991) recovered from donkeys at Kabete, Kenya. The predominance of *S. edentatus* among the large strongyles had also

been reported in Zimbabwe (Pandey and Eysker, 1989). Contrary to an earlier study by Love *et al.* (1992) in the United kingdom, none of the pre-treatment herds with gastro-intestinal nematodiasis in the present study had diarrhoea although *Cyanthostomes* predominated. Considering the high epg values and the potentially fatal lesions that were previously observed by Ngatia *et al.* (1991) in donkeys infected with similar parasites, the absence of diarrhoea did not mean that the donkeys in Mwingi District were any safer.

CONCLUSIONS.

Within the limits of the present study, the diseases/conditions that afflicted donkeys in Mwingi District were ranked in descending order as helminthiasis, underfeeding, tick infestation, skin wounds, overgrown hooves and fungal infections. It was not possible to establish the effects of *S. edentatus, S. vulgaris, S. equinus, Cyanthostome coronatum, C. trancathum, C. radius, Strongyloides, Ascarid spp. Gasterophilus intestinalis,* coccidial oocyst, tape worms, *Rh. pulchellus* and *Rh. appendiculatus* on the health and productivity of the donkeys in the district.

Donkeys were given a relatively low economic and social status by the veterinary staff in Mwingi District, and were therefore often excluded from the livestock production and health programmes for the other domestic species. Given the social economic importance of donkeys highlighted in the present study, a Donkey Health Programme focusing on their breeding and survival should be initiated at the district and country level to correct this negative attitude of veterinarians and owners towards donkeys. The

veterinarians and owners should be educated about proper donkey management and husbandry practices in order to minimise the occurrence of the preventable diseases/conditions that afflict donkeys.

Soft loans should be extended to women (the main beneficiaries) in the district to enable them acquire and regularly deworm donkeys. This would promote a high multiplication and increased survival of donkeys, which would in turn make them cheaper to acquire.

Prospective studies should be designed in order to:

(i) Establish the bionomics of gastro-intestinal nematode larvae.

(ii) Establish the patterns of infections of the donkeys with these nematodes.

(iii) Determine the effect of gastro-intestinal nematodes on the health and performance of donkeys in Mwingi District.

(iv) Clinically evaluate other affordable and readily available antihelmintics such as levamisole since Ivermectin^{R} is very expensive.

(v) Attempt to isolate the active ingredients in the herbal preparations used to treat worms in Mwingi District.

CHAPTER SIX

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APPENDICES

APPENDIX I: SAMPLE SIZE DETERMINATION

Assumptions:

- prior gastro-intestinal nematode prevalence (P) = 0.5;
- allowable error (L) = 0.05;

Substituting for P, Q and L in the formula $N = 4PQ/L^2$

where 4 = the square of the Z (1.96) value,

N = sample size required, Q = 1-P,

$N = (4 * 0.5 * 0.5)/(0.05)^2$

$= 400.$

APPENDIX II: BODY "CONDITION SCORING" OF DONKEYS.

CONDITION SCORE	REMARKS
VERY POOR	Emaciated, ribs, spine and tuber coxae prominent.
BELOW AVERAGE	Spine prominent, dull coat.
AVERAGE/GOOD	Spinous processes palpable but not prominent, firm muscle cover, shinning coat.
OVER FAT	Spinous processes not easily palpable, shinning coat and intact skin

C. McCARTHY (1989). Extraction from the professional handbook of the donkey.

APPENDIX III: ESTIMATION OF DONKEY AGES USING TEETH ERUPTION AND TEETH WEAR.

AGE (YEARS)	REMARKS
2.5	Permanent central pair of Incisors.
3.5	Permanent lateral pair of Incisors.
4.5	Permanent corner pair of Incisors.
5	Corner Incisors just in wear.
6	Teeth show shallow infundibulum.
8	Dental star appears in central Incisors.
11	infundibulum of central and middle Incisors becoming shallow. Incisors are quite long and dental star apparent.
14	Pronounced triangular shape of teeth
15 to 20	Infundibulum disappears from the central Incisors. Teeth are triangular.

The Donkey Sanctuary, UK. cited by Fowler J. W. (1989); The professional handbook of the donkey.

APPENDIX IV: ON-FARM VISIT QUESTIONNAIRE.

A SURVEY OF GASTRO-INTESTINAL NEMATODIASIS AND ECTOPARASITOSIS OF DONKEYS IN MWINGI DISTRICT.

A) Particulars of the donkey owner:

Name..... Age..... Sex.....

Division.....Location.....Village.....

Level of formal education attained.....

Time spent owning donkeys.....years/months.

B) **Particulars of the donkey herd.**

Total number of donkeys in the herd.....

Name sex age function (if transport, nature of goods).

.....

General condition of the herd .... good/average/poor.

Any gross lesions observed:

Name of donkey lesion (1, 2, 3, 4) probable cause.

....

[1: wound; 2: alopecia; 3: overgrown hooves; 4: other (specify)].

Other animals kept together with donkeys..... Yes/No.

species number

....

C) **General management:**

I) **Disease control:**

i) Deworming ....Yes/No. Timing.....

Frequency.....

Drug in use.....

ii) Vaccination..Yes/No. Diseases vaccinated against.....

Type(s) of vaccines.....

ii) Any prophylactic treatments ...Yes/No.

Types and dosages.....

iv) Availability of veterinary services.....

Common diseases observed and treatment given.....

II) Hygiene

i) Waste/manure disposal ..... Yes/no.

disposal site.....

use(s) of manure.....

ii) Feeding site.....v.clean/average/dirty.

iii) Sleeping/holding site.....clean/dirty.

Do the young ones share premises with adult....yes/No.

Any other animals sharing the site with donkeys..Yes/No.

Species and approximate age of such animals.....

III) **Breeding:**

Source of sires.....

Approximate age at first breeding.....(Years).

Approximate gestation period.....(Months).

Foaling interval.....(Months).

Foaling to first breeding.....(Days/Weeks/Months).

IV) **Feeding:**

Diet.....Grass/crop residues/other (please specify).

Method of feeding....left on own/Zero grazed/tethered.

Time of feeding.....morning/afternoon/evening.

Time spent feeding (Per day).....(hours).

Do the young ones graze with the adults.....Yes/No.

Other animal species sharing forage with donkeys.....

Feed availability throughout the year.....

Mineral supplementation: .....Yes/No.

Type and frequency.....

VI) **Watering**:

Source(s) and quality.....

Quantity given (ltrs)....Adults.....Young.

D) **Other information:**

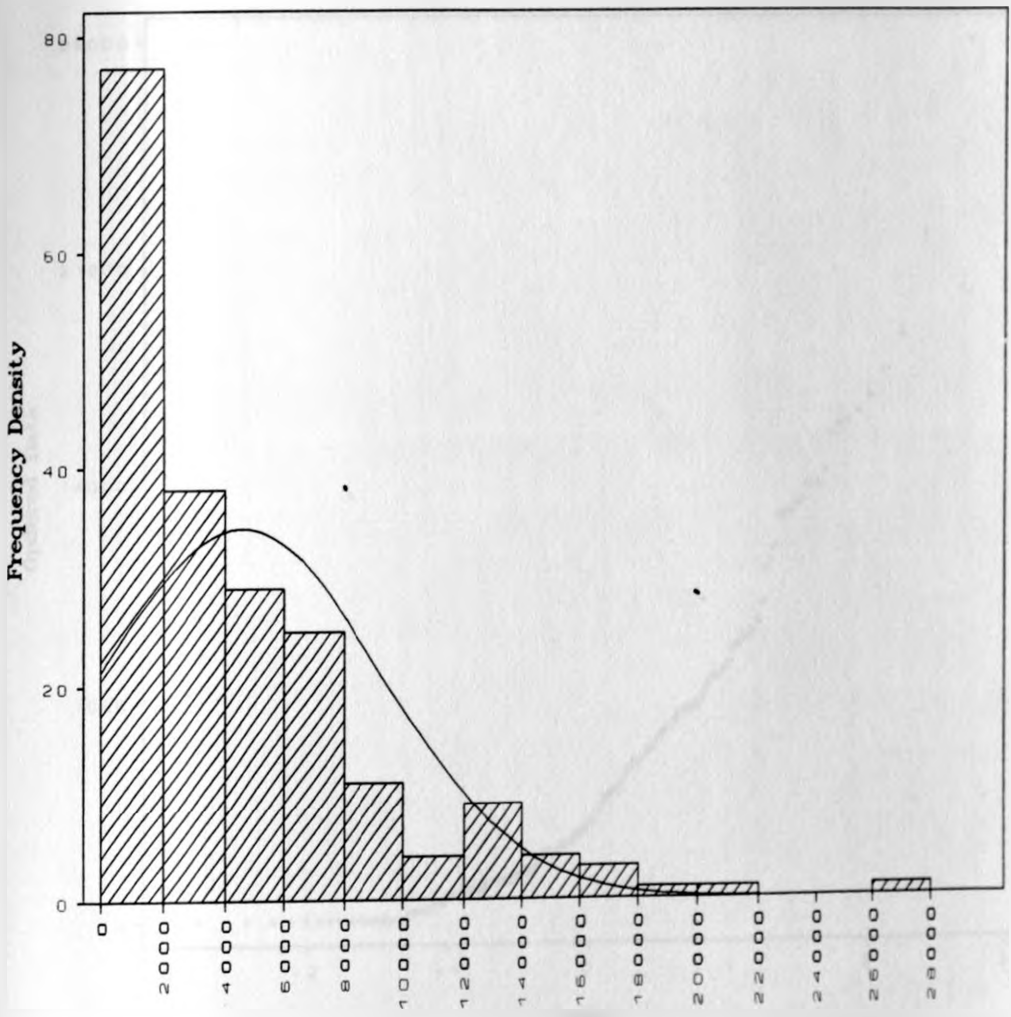
Approximate working hours per day.....

Approximate workload per day.....(Kgs/Acres).

Usual retirement age and fate of donkey.....

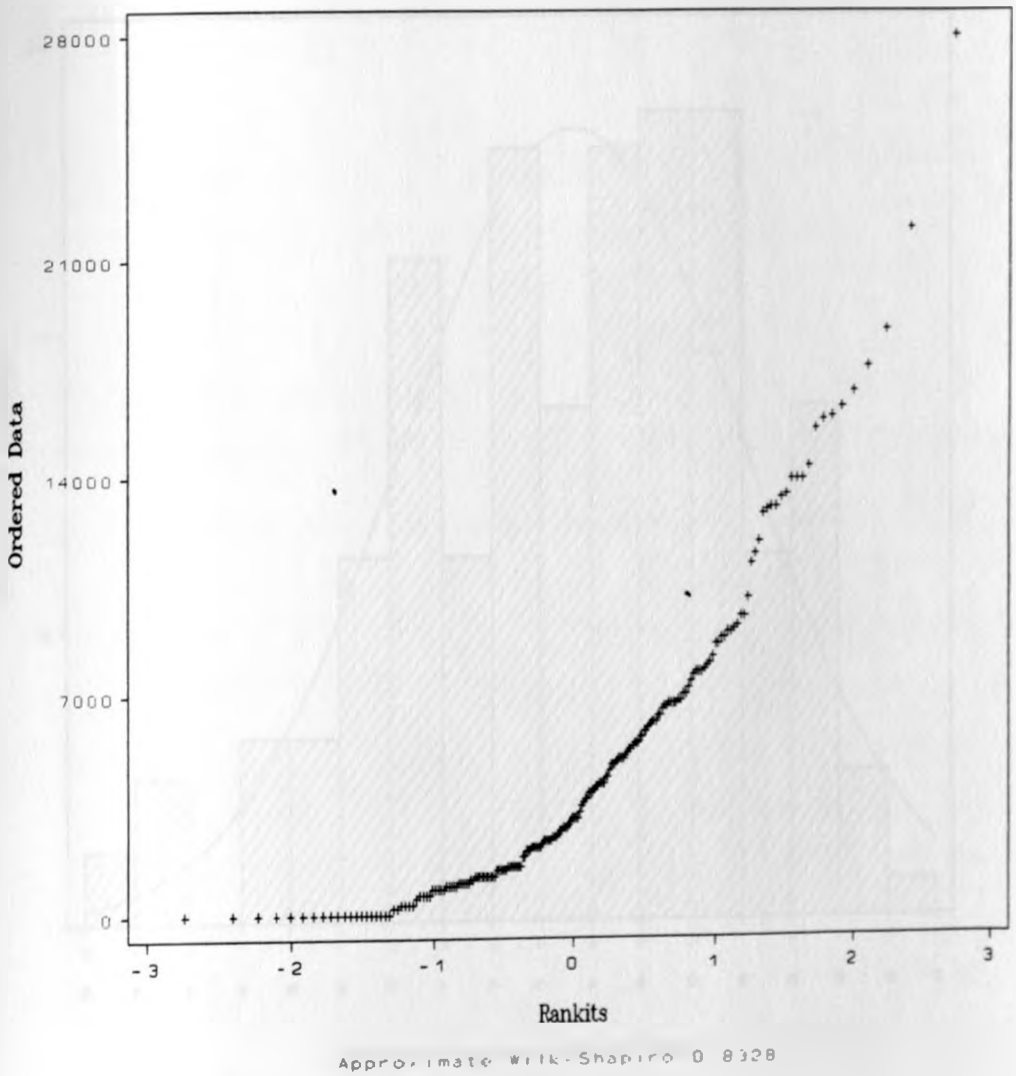
Nature of roads/paths used by donkey..(Stony/Sandy/Soft).

APPENDIX V(a): OVERALL FREQUENCY DENSITY DISTRIBUTION OF STRONGYLE EGG COUNTS PER GRAM OF FAECES FROM DONKEYS IN MWINGI DISTRICT, 1994.

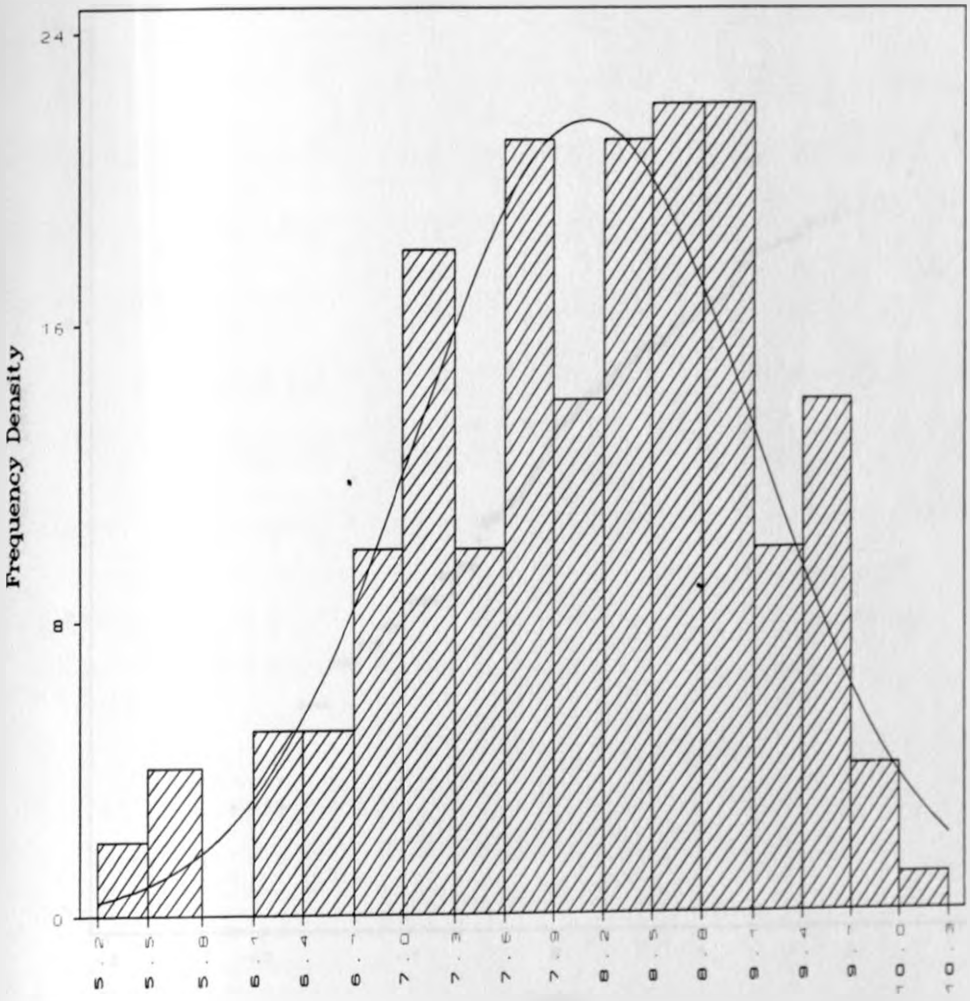


Egg count per gram of faeces

APPENDIX V(b): OVERALL WILK-SHAPIRO/RANKIT PLOT OF STRONGYLE EGG COUNTS PER GRAM OF FAECES FROM DONKEYS IN MWINGI DISTRICT, 1994.

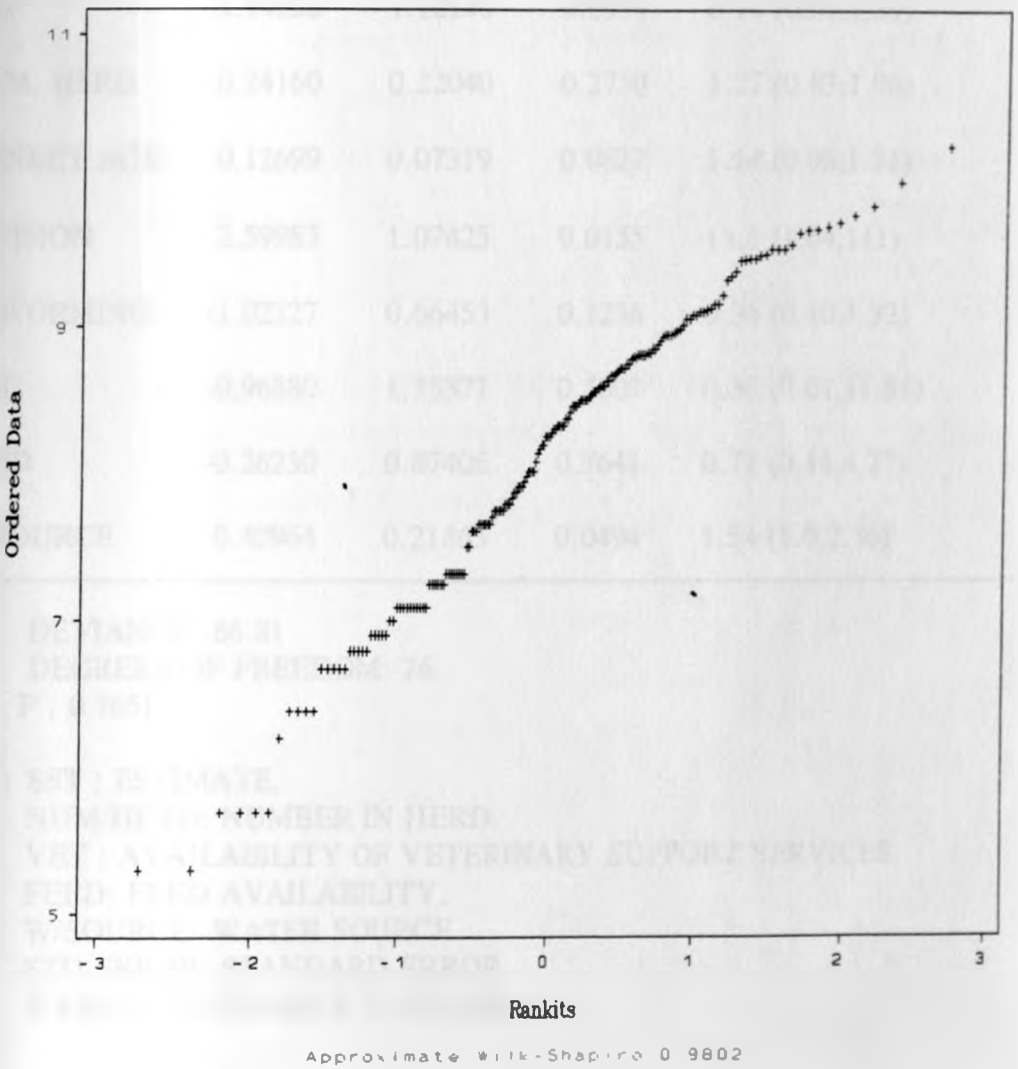


AAPENDIX V(c): OVERALL DISTRIBUTION OF THE NATURAL LOGARITHMS OF THE STRONGYLE EGG COUNTS PER GRAM OF FAECES FROM DONKEYS IN MWINGI DISTRICT, 1994.



Logarithm of egg count /gram of faeces.

APPENDIX V(d): OVERALL WILK-SHAPIRO/RANKIT PLOT OF THE NATURAL LOGARITHMS OF STRONGYLE EGG COUNTS PER GRAM OF FAECES FROM DONKEYS IN MWINGI DISTRICT, 1994.



APPENDIX VI: SUMMARY RESULTS FROM MUMONI-KYUSO SUB-SET LOGISTIC REGRESSION OF NEMATODIASIS IN DONKEYS IN 1994.

PREDICTOR	EST.	STD. ERROR	P-VALUE	ODDS RATIO
CONSTANT	-7.14670	4.12857	0.0834	
SEX	-1.94828	1.16140	0.0934	0.14 (0.01,1.39)
NUM. HERD	0.24160	0.22040	0.2730	1.27 (0.83,1.96)
DONKEY AGE	0.12699	0.07319	0.0827	1.14 (0.98,1.31)
DIVISION	2.59983	1.07425	0.0155	13.5 (1.64,111)
DEWORMING	-1.02327	0.66453	0.1236	0.36 (0.10,1.32)
VET	-0.96880	1.75377	0.5807	0.36 (0.01,11.81)
FEED	-0.26230	0.87406	0.7641	0.77 (0.14,4.27)
W/SOURCE	0.42964	0.21865	0.0494	1.54 (1.0,2.36)

DEVIANCE: 66.81 .
DEGREES OF FREEDOM: 76.
P : 0.7651.

KEY: EST : ESTIMATE.
NUM/HERD: NUMBER IN HERD.
VET : AVAILABILITY OF VETERINARY SUPPORT SERVICES.
FEED: FEED AVAILABILITY.
W/SOURCE: WATER SOURCE.
STD.ERROR: STANDARD ERROR.
P-VALUE: PROBABILITY VALUE.

APPENDIX VII: SUMMARY RESULTS FROM MWINGI-MIGWANI SUBSET LOGISTIC REGRESSION OF NEMATODIASIS IN DONKEYS IN 1994.

PREDICTOR	ESTIMATE	STD. ERROR	P-VALUE
CONSTANT	24.0094	115.863	
SEX OF OWNER	-7.95507	40.2883	0.8435
DONKEY AGE	0.01973	0.14407	0.8911
DIVISION	-6.96338	35.0836	0.8427
DEWORMING	-8.33415	34.4926	0.8091
FEED AVAIL	-1.63810	105.534	0.9876
WATER SOURCE	9.82931	99.8598	0.9216
NUMBER IN HERD	6.91738	23.1323	0.7649
VET.	-8.11163	58.6698	0.8900

KEY: VET: AVAILABILTY OF VETERINARY SUPPORT SERVICES.
FEED AVAIL: FEED AVAILABILITY.
STD. ERROR: STANDARD ERROR.
P-VALUE: PROBABILITY VALUE.

APPENDIX VIII: SUMMARY OF THE STUDY VARIABLES IN THE DISCRIMINANT FUNCTIONS WHICH BEST CLASSIFIED THE HERD CASES INTO THE FOUR (OVERALL) DIVISIONS (MWINGI, MIGWANI, KYUSO AND MUMONI) AND BETWEEN DIVISIONS WHOSE MEAN EGG COUNTS DIFFERED STATISTICALLY IN 1994.

STUDY VARIABLE	OVERALL	CENTRAL-KYUSO	CENTRAL-MUMONI	MIGWANI-KYUSO	MIGWANI-MUMONI
HERD SIZE	+	-	+	-	+
DIET	+	-	-	+	-
FEED AVAILABILITY	+	-	+	+	+
WATER SOURCE	+	-	-	+	-
EGG COUNT	+	+	+	-	+
SEX OF DONKEY OWNER	-	-	+	-	-
"BOMA" HYGIENE	-	-	+	-	-
DONKEY AGE	-	-	-	+	-
PERCENT CORRECT CLASSIFICATION	67.1	81.5	73.5	83.6	82.2

N.B: + : variable entered.
- : variable not entered.